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CHAPTER 10 - STEAM AND POWER CONVERSION SYSTEM

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CHAPTER 10 - STEAM AND POWER CONVERSION SYSTEM

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CHAPTER 10 - STEAM AND POWER CONVERSION SYSTEM

10.1 SUMMARY DESCRIPTION

10.1.1 General Description

The steam and power conversion system is designed to remove heat energy from the reactor coolant in two steam generators and to convert it to electric power via the turbine-generator. The main condenser transfers heat that is not utilized in the cycle to the circulating water system. The condensate is heated through low-pressure feedwater heaters and deaerated in the direct-contact-type deaerating heater. From this heater, the feedwater is driven by feedwater booster and feedwater pumps to the steam generators through the high-pressure feedwater heaters.

A full-flow/partial-flow condensate polishing system is available to maintain feedwater quality. A blowdown system operates continuously to maintain steam-generator water chemistry.

A system flow diagram is shown on Figure 10.1-1. The cycle heat balance at turbine rated (guaranteed) power is shown on Figure 10.1-2. The maximum 812
dependable performance of the plant will be demonstrated through testing. The turbine-generator has the capability for increased output at valves wide open (VWO). The cycle heat balance at VWO is shown on Figure 10.1-3. 812

A summary of important design and performance characteristics is given in Table 10.1-1 and Table 10.1-2. Safety-related components include the main steam isolation valves, the main steam atmospheric pump valves, the main steam safety valves, and the main feedwater isolation valves. Refer to Table 10.1-2 for identification of other safety-related features.

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10.1.2 Protective and Safety-Related Features

10.1.2.1 Loss of External Electrical Load and/or Turbine Trip

Upon loss of load, the turbine control system provides for fast closing of the turbine valves. Depending on the magnitude of the load reduction, a steam bypass control system dumps excess steam into the condenser and, if required, to atmosphere. If one of the operating main feedwater pumps trips or if a large load reduction greater than approximately 65% of full load and the reactor power is greater than 75% of full load, an automatic reactor power cutback is initiated. The turbine control and bypass equipment is non-safety-related.

If the condenser is not available to receive steam, ASME code class safety valves and atmospheric dump valves are available on the main steam piping. The atmospheric dump valves are remotely operated from the control room and can be throttled manually to control the steam flow.

The turbine control system is capable of controlling the speed of the turbine-generator upon full load rejection so as not to activate the overspeed trip of the emergency governor system.

10.1.2.2 Overpressure Protection

Safety valves are provided on the main steamlines for overpressure protection in accordance with the ASME Boiler and Pressure Vessel Code, Section III.

10.1.2.3 Loss of Main Feedwater Flow

The auxiliary feedwater system is designed to provide feedwater to the steam generators for the removal of decay heat whenever the main feedwater system is not available. In the event of low water level in a steam generator, the

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auxiliary feedwater system provides feedwater to the steam generators. Refer to Subsection 10.4.9 for a discussion of the auxiliary feedwater system.

10.1.2.4 Turbine Overspeed Protection

The speed of the turbine-generator is normally controlled by the turbine protection and control system. In addition, there are two independent 536 systems, one electronic and one mechanical, to protect against overspeed. These systems are designed to trip the turbine, shutting off steam supply to the turbine inlets, to limit the maximum speed below 120% of design speed.

Power actuated check valves are provided for the moisture separator drains and extraction steamlines to some of the feedwater heaters. These check valves are closed upon turbine trip to prevent backflow of steam to the turbine resulting from subsequent pressure reduction.

10.1.2.5 Turbine Missile Protection

Refer to Subsection 3.5.1.3.

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TABLE 10.1-1 (Sh. 1 of 6)
STEAM AND POWER CONVERSION SYSTEM
PERFORMANCE CHARACTERISTICS

Design and Performance Characteristics	Value	
Main steam system operating pressure/ temperature, at main turbine inlet, GL* psia/°F (kg/cm^2A/°C)	1042/549.6 (73.3/287.6)	812
Main steam flow, GL/VWO**, 10^6 lb/hr (kg/hr)	12.72/13.42 (5.77/6.08)	812
Main turbine throttle flow, GL./VWO, 10^6 lb/hr (kg/hr)	12.13/12.84 (5.50/5.82)	812
Main condenser pressure, in HgA (mm)	1.5 (38.1)	812
Feedwater temperature, GL/VWO, °F (°C)	450/455.3 (232/235)	812
Main turbine-generator output, GL/VWO, MWe	1049.9/1099.6	812
Guaranteed generator rating, GL MVA	1213	
Nuclear Steam Supply System, Full Power Operation		
Rated NSSS power, MWt	2,825	
Steam generator outlet pressure, psia (kg/cm^2 A)	1,077 (75.7)	812
Steam generator inlet feedwater temp, °F (°C)	450 (232)	
Steam generator outlet steam moisture, %	0.25	
Quantity of steam generators per unit	2	
Flow rate per steam generator, 10^6 lb/hr (kg/hr)	6.36 (2.88)	812

Applied to 95% RCS flowrate
* At guaranteed load
** Valves wide open 812

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TABLE 10.1-1 (Sh. 2 of 6)

Turbine-Generator	Value
Turbine type	Tandem-compound, six-flow
Quantity of turbine elements per unit	1 high pressure 3 low pressure
Operating speed, r/min	1,800
Moisture Separator Reheater (MSR)	
Stages of reheat	2
Stages of moisture separation	1
Quantity of MSRs per unit	2
Main Condenser	
Type	Single pressure, three shell
Quantity, per unit	1
Condensing capacity, Btu/hr (kcal/hr)	6.239×10^9 (1.5722×10^9)
Circulating water flow rate, gal/min (m^3/hr)	788,484 (178.8×10^3)
Circulating water temperature rise,*** °F (°C)	15.8 (8.8)

*** Based on circulating water inlet temperature of 68.9°F (20.5°C)

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TABLE 10.1-1 (Sh. 3 of 6)

Condenser Vacuum Pumps	Value
Type	2-stage water ring
Quantity	4
Hogging capacity, each, standard ft^3/min (m^3/min)	1,600 at 10 in. HgA (45.3 at 25.4 cm HgA)
Motor hp, each	100
Speed, motor/pump, r/min	1,800/514
Steam Jet Air Ejectors	
Quantity	Two 50% first-stage One 100% second-stage
Motive fluid source	Main steam
Holding capacity	75 cfm at 1.0 in. HgA (2.1 m^3/min at 2.54 cm HgA)
Condensate Pumps	
Type	Vertical, canned motor-driven
Rated conditions	
Flow, gal/min (m^3/hr)	6,400 (1451.5)
Total head, ft (m)	1,100 (335.3)
Motor hp (kW)	2,380 (1,775)
Quantity per unit	4 (one standby)

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TABLE 10.1-1 (Sh. 4 of 6)

Feedwater Heaters	Value
High Pressure	
No. 7	
Quantity per unit	2
Duty, Btu/hr (kcal/hr)	412.64×10^6 (103.99×10^6)
No. 6	
Quantity per unit	2
Duty, Btu/hr (kcal/hr)	361.76×10^6 (91.16×10^6) per heater
No. 5	
Quantity per unit	2
Duty, Btu/hr (kcal/hr)	465.55×10^6 (117.32×10^6) per heater
Low Pressure	
No. 3	
Quantity per unit	3
Duty, Btu/hr (kcal/hr)	88.50×10^6 (22.30×10^6) per heater
No. 2	
Quantity per unit	3
Duty, Btu/hr (kcal/hr)	158.18×10^6 (39.86×10^6) per heater
No. 1	
Quantity per unit	3
Duty, Btu/hr (kcal/hr)	140.81×10^6 (35.48×10^6) per heater
Deaerator	
Type	Spray-tray horizontal with two storage tanks
Storage capacity	150,000 gal (567,800 L) below normal water level

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TABLE 10.1-1 (Sh. 5 of 6)

Feedwater Pump	Value
Pump type	Horizontal, centrifugal
Turbine type	multistage condensing
Quantity per unit	3
Rated conditions, pump	
Flow, gal/min (m^3/hr)	16,000 (3,634)
Total head, ft (m)	2,200 (670)
Turbine capability, hp	13,500
Feedwater Booster Pumps	
Type	Vertical, centrifugal, motor-driven
Rated conditions	
Flow, gal/min (m^3/hr)	16,000 (3,634)
Total head, ft (m)	1,300 (397)
Motor hp	7,000
Quantity per unit	3
Startup Feed Water Pump (Motor-Driven)	
Type	Horizontal, centrifugal
Rated flow, gal/min (m^3/hr)	3,500 (795)
Rated head, ft (m)	2,800 (853)
Motor hp	4,900
Quantity per unit	1

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TABLE 10.1-1 (Sh. 6 of 6)

Steam Generator Blowdown Regenerative Heat Exchangers	Value
Duty, Btu/hr (kcal/hr)	35.6×10^6 per pair (8.97×10^6)
Quantity per unit	4 (two pairs)
Steam Generator Blowdown Nonregenerative Heat Exchangers	
Duty, Btu/hr (kcal/hr)	12.1×10^6 per pair (3.05×10^6)
Quantity per unit	2
Steam Generator Blowdown Flash Tank	
Steaming rate, lb/hr (kg/hr)	72.625 (33)
Outlet steam pressure, psia	312 (22 kg/cm^2)
Quantity per unit	1

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TABLE 10.1-2 (Sh. 1 of 2)

STEAM AND POWER CONVERSION SYSTEM DESIGN CHARACTERISTICS

Item	Safety-Related	Comments
Main Steam Piping	Yes	Piping is safety-related from steam generators up to and including the MSIV room penetration anchor. The remainder of the piping is non-safety-related.
Main Steam Isolation Valves	Yes	
Main Steam Atmospheric Dump Valves	Yes	
Main Steam Safety Valves	Yes	
Steam Generator Blowdown System	Yes	System is safety-related from the steam generators up to and including the MSIV room penetration anchor. The remainder of the system is non-safety-related.
Main Turbine	No	
Generator	No	
Turbine Protection System	No	
Reheat Steam System	No	
Condenser	No	
Turbine Steam Dump System	No	
Turbine Gland Seal System	No	
Condenser Vacuum System	Yes	System is safety-related from the condenser off-gas containment isolation valve up to and including the check valve inside the containment. The remainder of the system is non-safety-related.

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TABLE 10.1-2 (Sh. 2 of 2)

Item	Safety-Related	Comments
Circulating Water System	No	
Condensate System	Yes	The condensate storage tank boundaries and aux feedwater pump related piping are safety-related. The remainder of the system is non-safety-related.
Feedwater System	Yes	System is safety-related from the steam generators up to and including the MSIV room penetration anchor. The remainder of the system is non-safety-related.

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Steam and Power Conversion System
Flow Diagram

Figure 10.1-1

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Heat Balance at Guaranteed Condition

Figure 10.1-2

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Heat Balance at Valves Wide Open

Figure 10.1-3

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10.2 TURBINE-GENERATOR

The function of the turbine-generator is to convert thermal energy into electric power.

10.2.1 Design Bases

10.2.1.1 Safety Design Bases

The turbine-generator serves no safety function and has no safety design bases.

10.2.1.2 Power Generation Design Bases

The following is a list of the principal design bases:

The turbine-generator is designed for the following conditions:

a. Turbine-generator output, kW [redacted] 812

b. Throttle flow, lb/hr (kg/hr) [redacted] 812

c. Steam conditions at throttle:

Pressure, psia (kg/cm^{2}A) [redacted] 812
Temperature, °F (°C)
Moisture content, %
Enthalpy, Btu/lb (kcal/kg) 812

d. Exhaust pressure, in. HgA (mm) [redacted]

e. Stages of reheat [redacted]

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f. Stages of feedwater heating [redacted]

These conditions correspond to the guaranteed reactor rating (100% load) as shown in Table 10.2-1.

[redacted]

10.2.1.3 Codes and Standards

The turbine-generator and associated equipment is designed and manufactured in accordance with General Electric Company (GE) standards and specifications.

System components are designed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels; ANSI B31.1, Code for Pressure Piping; TEMA and HEI Standards for Heat Exchangers; NEMA Standards; IEEE Standards; Hydraulic Institute Standards, and regulations of the National Board of Fire Underwriters.

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10.2.2 Description

The GE turbine-generator is designated TC6F-43 and consists of a turbine, a generator, moisture separator-reheaters, excitor, controls, and auxiliary 527
subsystems. The major design parameters of the turbine-generator are presented in Tables 10.2-1 and 10.2-2. Details of system components are also presented in this section.

10.2.2.1 Turbine-Generator Description

The turbine is an 1800rpm, tandem-compound, six-flow, reheat unit with [redacted] last stage buckets. The turbine includes one double-flow high-pressure turbine, three double-flow low-pressure turbines, and two moisture separator-reheaters with two stages of reheating. The direct-driven generator is conductor cooled and rated at 1213 MVA at 22 kV, 3-phase, 60 Hz. Other related system components include a complete turbine-generator bearing lubrication oil system, a turbine Protection and control(TPC) system, a 536
turbine gland seal system (refer to Subsection10.4.3), a turbine generator supervisory instrumentation (TGSI) system, overspeed protective devices, turning gear, a generator hydrogen and seal oil system, a stator cooling water system, and digital excitation system. The excitation system consists of silicon controlled rectifiers, digital triple voltage adjuster and 435
excitation transformer.

10.2.2.2 Turbine-Generator Cycle Description

Steam from the main steam system enters the high-pressure turbine through four stop valves and four governing control valves. Crossties are provided both upstream and downstream of the stop valves to provide pressure equalization with one or more stop valves closed. A portion of the main steam is used for second-stage reheat of the steam supply to the low-pressure turbines. [redacted]

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10.2.2.3 Automatic Controls

Automatic controls provide control of turbine speed and acceleration through

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the entire speed range, with several discrete speed and acceleration rate settings. The automatic control system includes control of load and loading rate from no load to full load, with continuous load adjustments and discrete loading rates. Should it become necessary to remove the generating unit from the primary automatic controls, the manual control of speed and load takes over, thus allowing continued operation of the turbine-generator.

10.2.2.3.1 Turbine Protection and Control(TPC) System 536

The TPC is comprised of electrical and hydraulic components. Typically, the electrical devices provide the machine interface and control logic, while the hydraulic devices provide high-pressure fluid to hydraulic cylinders to position the steam-controlling valves to regulate the flow to the unit.

a. System Description

The TPC system provides manual and automatic control, protection, 536 and monitoring for the turbine-generator during normal operation of the unit. Specifically, it will measure critical unit parameters, make and implement decisions, and regulate the position of the turbine main steam control valves to startup, load, unload and shutdown the unit. The system also includes built-in features to automatically protect the turbine-geneator against abnormal operating conditions of overspeed, loss of oil, overheating, etc., which can be monitored and tested while the turbine-generator unit is in normal operation.

b. Major Functions

The TPC is designed to perform the following critical functions: 536

1. Speed and load control

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2. Normal and emergency overspeed control
3. Unit protection
4. Turbine valve positioning
5. Turbine monitoring
6. Supervisory control with calculated rotor stresses

Triple-redundant digital control processors and protective logic circuitry are used in the primary system to implement the closed-loop control and protective functions necessary for safe operation of the turbine-generator in a conventional manner. This redundant circuitry provides fault-tolerant operation of the turbine-generator unit for malfunctions within the primary control hardware, and allows on-line maintenance for the primary system without need for shutting down the unit. Two modern computer-driven displays, two keyboards & trackball mouses and one backup panel are used for 536
operator interface with the TPC system. This operator-interface equipment interacts with the primary control and protective functions and with the supervisory functions to provide highly accessible control, display, and monitoring features to the plant operator for running the turbine-generator. The automatic turbine startup (ATS) functions are located mainly in the operator interface station and conduct automatic operation of the turbine. 536

Inputs from redundant sensors are examined for validity and voted to protect against sensor drift or other potential malfunctions. The voted control calculations are performed. The controller outputs are also voted to eliminate control commands that may be erroneous due to a component failure. Logic outputs are voted via two-out-of-three contact arrangements. Control action of the main control valve actuators is the result of the sum of the output currents from the triply redundant controllers. Process variable voting is thus extended to the triple-coil servovalve with the first single-point failure being the mechanical servovalve itself. Provisions are also made for on-line replacement of servovalves.

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The triply redundant architecture, with total independence between control channels (including input sensors and output drivers), therefore allows uninterrupted operation in the presence of one main channel malfunction. The TPC system can continue to operate if one or more steam valves malfunction. 536

The triply redundant controllers are identical, with the components of each being fully interchangeable. Any one controller can be shut down and removed from the system without prejudicing system operation. Individual power sources are provided for each controller. Furthermore, cabinet arrangement facilitates system maintenance by providing sufficient space for on-line component repair.

10.2.2.3.1.1 <u>Speed Control Function</u>

The governor speed control is fully coordinated with the trip system and is capable of controlling speed accurately over the entire speed range from turning gear to a speed high enough to test the protective overspeed trip devices.

Multiple speed feedback signals are derived from redundant sensors mounted around a toothed wheel attached to the turbine shaft. A separate probe is provided for each of the triple-redundant electronic governor channels, and the toothed wheel and the speed probes are both located at the turbine front standard.

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[redacted]

[redacted] 536

Discrete acceleration reference signals are also selected.

[redacted]

Three methods of line speed matching are available:

a. [redacted] 536

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[redacted]

b. [redacted] 536

c. [redacted] 536

10.2.2.3.1.2 <u>Load Control Function</u>

The basic purpose of the load control function is to accept input signals from other functions of the TPC system and to use these signals in conjunction with 536 functions internal to the load control function to compute flow reference signals for the flow control function. Switching signals indicating operating conditions are also supplied to other parts of the TPC system. 536

The load control functions may be grouped as follows:

a. Sensing functions are provided to detect and generate signals proportional to parameters that affect loading of the unit.

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b. Limiting functions are provided to electrically constrain the flow reference signals in response to signals from the sensing circuits, from the speed control function, or from devices detecting the state of plant components.

c. Computing functions are provided to generate flow reference signals for the valve sets, considering the desired load signal, the limiting functions, and the speed error signal from the speed control function.

d. Logic functions are provided to ensure that necessary permissives have been satisfied prior to changes in mode of operation, to communicate status information between the load control function and other elements of the TPC system, and to provide switching signals to devices in the TPC system. 536

Since each of the described functions of the load control function may involve more than one of the basic generalized functions listed above, each description involves a discussion of the appropriate functions (sensing, limiting or computing) as well as the logic functions involved.

The load control functions are as follows:

a. Load reference
b. Loading rate
c. Load runbacks
d. Valve position limit
e. Load setbacks
f. Main/throttle steam pressure limiter
g. Control valve test bias and stage pressure feedback
h. Valve references

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10.2.2.3.1.2.1 Load Reference

The load reference is a value corresponding approximately to current desired load (at rated throttle steam pressure). The load control function changes the load reference at the selected loading rate towards the selected target load.

The load reference may be changed by any of the following sources, by changing the target load:

a. The target load being lowered or raised at the operator interface station in semiautomatic or automatic modes. 536

b. Increase or decrease signals generated by the automatic or manual speed match functions and which may be received from a remote source when some remote form of operation has been selected.

Displays on monitors will indicate operating mode, load, target load, load 536
reference, and loading rate.

Certain abnormal conditions require that the load reference be run back in the decreasing load direction. These runbacks are discussed in Subsection 10.2.2.3.1.2.3.

10.2.2.3.1.2.2 <u>Loading Rate</u>

The loading rate function imposes a rate-of-change limit for the load reference signal. Any loading rate [redacted] may be selected by the operator via the operator interface station when operating in the 536
semiautomatic mode. The selected rate is applied in both load-increasing and load-decreasing directions. Fast decreases (2.2%/sec) may be performed by

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switching the rapid unload function into service. Load-increasing and load-decreasing messages will be displayed as appropriate at the operator interface 536
station. The "At Target Load" message will be displayed when the desired load is reached.

When operating in automatic mode, the operator imposes a loading rate limit on the operator interface station. This loading rate limit is used by the automatic 536
turbine startup (ATS) load function to limit the calculated loading rate, which was arrived at considering rotor stresses.

10.2.2.3.1.2.3 Load Runbacks

Logic is incorporated to reposition the load reference when certain abnormal operating conditions are detected. Runbacks must be initiated by a signal from the power load unbalance, if the load reference signal exceeds a preset load limit, or by a signal from plant communications indicating that abnormal plant conditions require a reduction in load.

The load runback is enabled by a pulsed or continuous-contact closure. Continuous-contact closure will run the load set down from rated load [redacted]. The maximum rate of change of the load reduction is [redacted]. The minimum pulse length is [redacted] Load increase demands are interrupted during load runbacks.

10.2.2.3.1.2.4 Valve Position Limit

A valve position limit (VPL) function is provided in the TPC system to limit 536
steady-state opening of the controlling valves to limit steam flow. An additional feature in a runback of the load reference to a point 2% above the setting of the valve position limit such that when the limit is lifted, it does not allow a sudden load increase.

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10.2.2.3.1.2.5 Load Setbacks

Four load setback inputs are available that will set the valve position limit signal back upon a external contact closure. Upon loss of one of the feedwater pumps, a turbine setback command signal from the reactor power cutback reduces the load to a given level (approximately 60% of reactor power).

The four setbacks have separately adjustable valve position limit levels and setback rates to provide for various contingencies. Several external signals may be associated with each of the four variable-rate load setbacks. These variable-rate setbacks have a range of 0.5%/sec to 10%/sec. The setback levels have a range of essentially 0% to 100%.

YGN 3&4 use only one setback rate selected at [redacted] Again, this condition will be indicated on the operator interface station. An externally provided signal which initiates a setback must be cleared before NORMAL conditions are reestablished. 536

10.2.2.3.1.2.6 Throttle Steam Pressure Limiter (TSPL)

TPC equipment is supplied with a proportional throttle steam pressure limiter. 536
The throttle pressure limiter is used to protect the turbine against an excessive decrease of throttle pressure by closing the control valves when the throttle pressure falls below a preset level. The pressure setpoint is adjustable from zero to rated pressure (0 to 100%) by pressing the Increase/Decrease function on the operator interface station. 536

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The INCREASE/DECREASE selection is provided in the control room at the operator interface station. The TSPL function is always enabled by the operator interface station. 536

The regulation of this circuit is fixed at 10%. A signal proportional to throttle steam pressure is generated by triple-redundant pressure transducers and compared to the adjustable present level. When the throttle steam pressure falls below the setpoint, pressure-limit limiting will be indicated, and the flow reference signal to the control valves is limited to the value permitted by the level of the throttle steam pressure. Also, the stage pressure feedback will be switched out.

Note : Main steam pressure limiter is referred to as throttle steam pressure limiter on nuclear units. Both limiters perform similar functions and the above description applies to either one.

10.2.2.3.1.2.7 Control Valve Testing

a. Control Valve Test Bias

The control valve test bias function combines the speed error, load reference, and stage pressure feedback signals to continuously compute a bias signal. This signal is added to the control valve reference signal during control valve tests. The addition of this bias signal will cause the control valve reference to be the same before and after stage pressure feedback is switched in. Subsequent changes in the stage pressure signal due to the tested valve being closed will cause control valve reference to change and open the appropriate control valves during the test. The bias signal is removed simultaneously with removal of stage pressure feedback upon the completion of a control valve test.

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b. Stage Pressure Feedback

Stage pressure feedback is only incorporated in the TPC system 536
during control valve testing to maintain near-constant turbine output. A pressure transducer generates an electrical signal proportional to first stage pressure. During control valve testing, the valve to be tested is commanded closed. This causes an increase in first-stage pressure feedback, which will automatically open the control valves that are not under test. This action is performed to compensate for the increase in pressure and to maintain near-constant load during testing.

10.2.2.3.1.2.8 <u>Valve References</u>

Two valve references are generated to produce flow reference signals for the control valves and the intercept valves by combining appropriate variables. The flow reference for the #2 main stop valve bypass valve is obtained in the flow control function. For the control valve reference, the speed error and the load reference are combined. During control valve testing, the stage pressure feedback and the control valve test bias will also be added to form the control valve reference. The speed error, the load reference, and appropriate bias values are added to form the intercept valve reference.

Regulation values for the valve sets are as follows:

Main stop valve: [redacted]

Control valves: [redacted]

Intercept valves: [redacted]

The valve references thus produced are then subject to the limits discussed under Subsections 10.2.2.3.1.2.4, 10.2.2.3.1.2.5, and 10.2.2.3.1.2.6.

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10.2.2.3.1.3 Flow Control Function

The four turbine control valves, three of the six intercept valves, and the single main stop valve #2 bypass valve are designed to operate on closed loop position control. The remaining main stop valves, three intercept valves, and intermediate stop valves operate on open loop control resulting in either a fully open or fully closed position.

a. Position Regulation

[redacted] 536

536

[redacted]

b. Steam Valve Testing

The control circuitry for the steam valves includes provisions for testing each valve separately while the unit is operating under load. The tests are initiated from the operator's control panel, and will cause each valve to ramp closed individually to verify free operation. [redacted], each steam valve will be tripped closed (by solenoid action) to exercise the

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hydraulic actuator mechanism and verify the integrity of the trip system.

The combined intermediate valves (CIVs) consist of one intercept valve (IV) and one intermediate stop valve (ISV). Each pair is tested by closing the intercept valve first, followed by closing the intermediate stop valve. The opening sequence is in reverse order, the ISV first, then the IV.

10.2.2.3.1.4 Chest or Rotor-Shell Warming

Control valve chest or rotor-shell warming may be performed while the close valves speed target is selected and the speed is less than 200 rpm. Such warming is a manual function and is conducted from the operator interface 536
station.

[redacted] 536

[redacted] 536

ROTOR-SHELL WARMING - This selection permits admission of warming steam to the high-pressure rotor. The control valves are wide open.

CHEST WARMING - This selection permits admission of warming steam to the control valve chest only. The control valves are closed.

[redacted] 536

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[redacted]

10.2.2.3.1.5 Power/Load Unbalance

A rate-sensitive power/load unbalance (PLU) function is provided to initiate fast closing of the control valves and intercept valves under load rejection conditions that might lead to rapid rotor acceleration and consequent overspeed.

[redacted]

[redacted]

[redacted]

[redacted]

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A test is provided to check the functioning of the PLU logic during a simulated loss of load. The test is conducted under load without affecting the turbine output.

Loss of current signal (2/3) or reheat pressure signal (2/3) does negate PLU action and will be annunciated. Turbine load should be reduced to a level from which rejection of that load will not result in actuation of the overspeed trip.

10.2.2.3.1.6 Operation on Loss of Load

If the unit is running at maximum load (valves wide open) and suddenly the load on the generator is lost, the following events will take place in rapid succession.

a. The PLU relay will switch the load reference to zero and start running the target load reference back toward zero load.

b. The turbine will accelerate at its maximum rate.

c. The control valves and intercept valves will close at the maximum rate by means of the fast-acting solenoid valves.

d. The entrained steam between the valves and the turbine, in the turbine casings, and in crossover and extraction lines will expand within approximately 1.5 sec.

e. The turbine speed will level off at a speed approximately 0.5% to 1% below the overspeed trip setting when the entrained steam has ceased expanding and will start decreasing gradually at a rate depending on auxiliary load left on the generator.

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f. When the speed has decreased to approximately 102%, the intercept valves will start to reopen under speed control. The energy stored in the reheated (or in the intermediate piping) will be gradually bled off at a rate sufficient to maintain the rotor speed and supply the auxiliary load still connected to the generator as well as the no-load losses in the unit.

g. When the reheat pressure has dropped to 40% of full-load pressure, the PLU relay will reset, reconnecting the normal load reference to the system. By this time the target load reference has been run down to its no-load value.

h. After the reheat pressure has bled down, the unit is running at a few rpm above its rated speed, ready to be synchronized.

10.2.2.4 Turbine Protection

Equipment is provided for protecting the turbine-generator from hazardous operating conditions by tripping or unloading the turbine as appropriate. The main function of the turbine trip system is to check the validity of the trip demand signals and to ensure trip action results in immediate response to a valid trip demand. Redundant electrical transmission is employed to send valid trip signals from the control/protection cabinet to redundant trip devices in the turbine front standard.

The following requirements are met by the turbine trip system:

a. Each trip input is applied to a triply redundant protection system. Two-out-of-three majority voting is conducted within the protection system to (1) prevent spurious turbine trips and (2) enhance protection system operation on an actual turbine trip.

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b. Electromechanical trip devices are on-line testable using appropriate lockout devices. Redundant trip systems in this area protect the turbine while one system is under test. Thus, the entire protection system, from signal input to actual trip device, has on-line test capabilities.

c. Electronically signaled trips are initiated by contact closures. Loss of trip system power is annunciated.

d. Contacts representing the actuation of any trip function or alarm device (where applicable) are available for computer monitoring and/or annunciation.

The following list specifies conditions that initiate a turbine trip. A detailed derivation of the source of the trip-initiating signal is also provided.

a. [redacted]

b. [redacted]

c. [redacted]

d. [redacted]

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e. [redacted]

f. [redacted]

g. [redacted]

h. [redacted]

i. (Deleted) 1

j. [redacted]

k. [redacted]

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l. [redacted]

m. [redacted] 88

Direct mechanical trip features include the following:

a. [redacted]

b. [redacted]

c. [redacted]

10.2.2.4.1 Emergency Overspeed Trip

[redacted]

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10.2.2.4.2 Sequential Tripping and Prevention of Motoring

Any trip signal that trips the turbine should also cause shutdown of the generator. The recommended means of shutting down the generator after a turbine trip is by the sequential tripping circuit. The circuit uses closed end limit switches from all steam valves and a reverse power relay as permissives for automatic opening of the generator circuit breaker. The reverse power relays ensure that all sources of steam to the turbine, including extraction lines, are reduced below the amount required to produce overspeed before the breaker is opened. Certain critical electrical system faults require that the generator breaker be opened immediately upon sensing the fault. Critical electrical system faults are those which require instantaneous opening of the generator breaker to prevent serious and certain damage to the generator or switchyard equipment. A 3-second time delay is associated with the reverse power relay. Introduction of an additional time delay in the sequential trip circuit is sometimes desired, but this results in increased motoring of the turbine generator. The generator may motor for extended periods as long as sufficient field is applied to keep the generator in step. Motoring may cause the turbine exhaust hood and last-stage buckets to overheat. With all steam flow shut off, the effectiveness of the exhaust hood sprays to prevent overheating is greatly reduced. Therefore, the time delay that permits motoring should be limited to the following values dependent on condenser pressure experienced during motoring:

a. Condenser pressure equal to or less than 4 in. Hga   5 min

b. Condenser pressure greater than 4 in. Hga   90 sec

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Note that certain generator trips that use the sequential trip circuit require a more limiting time delay.

On some turbine trips it is often desirable to reduce speed quickly, and in such circumstances an additional customer time delay in the sequential trip circuit should be bypassed so the generator breaker is immediately opened after valve closure and reverse power. Typical of this condition are trips due to low vacuum, high vibration, or thrust bearing failure. It should be recognized that the sequential trip circuit does not have as its primary function the prevention of motoring, although it serves that purpose in event of a turbine trip. Sequential tripping provides for an orderly shutdown from a single tripping signal and prevents a rapid rise in speed that would occur if the generator breaker were opened prematurely.

10.2.2.4.3 Steam Valve Closure

All steam valves are arranged in pairs such as a main stop valve and associated control valve or an intermediate valve and associated intercept valve. There are four pairs of valves for the high-pressure turbine and two pairs of valves for each low-pressure turbine making a total of ten pairs of steam admission valves. Each stop valve, control valve, and intercept valve (20 total) is actuated by either of two overspeed trip systems. The four control valves on the high-pressure turbine and one intercept valve on each low-pressure turbine are also modulated by the speed governing system. Closure of either valve in a pair stops the steam flow from that source and therefore a single valve failure would not prevent the turbine overspeed trip from functioning.

10.2.2.4.4 28-Volt and 125-Volt DC Trip Systems

The backup overspeed trip and the trip caused by loss of the primary and backup speed signals are initiated by 28-volt dc trip logic system. This

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system is used for turbine vital trips, which include the backup overspeed trip. A 125-volt dc trip system is also used for customer trips and several turbine protective trips. As further protection there is a "cross trip" logic employed that allows all trips originating in the 28-volt dc logic to initiate a trip by the 125-volt dc system. Conversely all trips originating in the 125-volt dc logic will initiate a trip in the 28-volt dc system. The output trip signals from these two voltage levels energize separate and individual solenoid valves, which in turn drain the high-pressure hydraulic fluid from all the turbine steam admission valve actuators.

10.2.2.5 Other Protective Systems

In addition to the previously mentioned devices, other protective features of the turbine and steam system are the following:

a. Safety valves on the moisture separator-reheaters to protect the high-pressure turbine from overpressure in the event of a stop and control valve or combined intermediate valve malfunction.

b. With the exception of the last two low-pressure heaters, each steam extraction line is equipped with a nonreturn valve to protect the turbine from overspeed due to reverse flow in case of a turbine trip.

c. Exhaust casing rupture diaphragms to protect the low-pressure turbines from overpressure in case of loss of condenser vacuum.

10.2.2.6 Plant Loading and Load Following

The turbine-generator is intended to be baseloaded, but is designed to match or exceed the transient load following capabilities of the NSSS. The turbine control system is designed to provide protection to the turbine by tripping

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the turbine for certain predetermined conditions as discussed in Subsection 10.2.2.4. The turbine is tripped upon reactor trip. The reactor protection system provides two separate signals of reactor trip to the turbine control system.

10.2.2.7 Inspection and Testing Requirements

Major system components are readily accessible for inspection and are available for testing during normal plant operation. Controls and protective devices associated with each turbine-generator component will be tested regularly. Various turbine trips will be tested in sequence prior to unit startup.

The schedules for testing and inspection of the various system components are developed as part of the plant operating procedures discussed in Section 13.5.

10.2.3 Turbine Disk Integrity

10.2.3.1 Materials Selection

[redacted] Tramp elements are controlled to the lowest practical concentrations consistent with obtaining adequate initial and long life fracture toughness for the environment in which the parts operate. [redacted] Since actual levels of FATT and Charpy-V notch energy vary depending upon the size of the part, the location within the part, etc., these variations have been taken into account in accepting specific forgings for use in turbines for

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nuclear application. Charpy tests essentially in accordance with Specification ASTM A-370 are included.

10.2.3.2 Fracture Toughness

Suitable material toughness is obtained through the use of the materials described above to produce a balance of adequate material strength and toughness to ensure safety while simultaneously providing high reliability, availability, and efficiency during operation. [redacted]

[redacted]

10.2.3.3 High-Temperature Properties

The maximum operating temperature of the high-pressure rotor in turbines operating with light water reactors is below the creep rupture range. Creep rupture is therefore not considered to be a significant factor in assuring rotor integrity over the lifetime of the turbine. Basic data are obtained from laboratory creep rupture tests.

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10.2.3.4 Turbine Disk Design

The turbine assembly is designed to withstand normal conditions and anticipated transients including those resulting in an overspeed trip without loss of structural integrity. The design of the turbine assembly meets the following criteria:

a. [redacted]

b. [redacted]

c. [redacted]

10.2.3.5 Preservice Inspection

The preservice inspection program is as follows:

a. Wheel and rotor forgings are rough machined with minimum stock allowance prior to heat treatment.

b. Each rotor and wheel forging is subjected to a 100% volumetric (ultrasonic) examination. Each finish-machined rotor and wheel is subjected to surface magnetic particle and visual examination. Results of the above examination have been evaluated by use of GE

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acceptance criteria. These criteria are more restrictive than those specified for Class 1 components in the ASME Boiler and Pressure Vessel Code, Sections III and V, and include the requirement that subsurface sonic indications be either removed or evaluated to assure that they do not grow to a size which compromises the integrity of the unit during its service life.

c. Finish-machined surfaces are subjected to a magnetic particle examination. No magnetic particle flaw indications are permissible in bores, holes, keyways, and other highly stressed regions.

d. Each fully bucketed turbine rotor assembly is spin tested at or above the maximum speed anticipated following a load rejection from full load.

10.2.3.6 Inservice Inspection

The inservice inspection program for the turbine assembly and valves includes the following:

a. Disassembly of the turbine is conducted during selected plant shutdowns. Inspection of parts that are normally inaccessible when the turbine is assembled for operation, such as couplings, coupling bolts, turbine shafts, low-pressure turbine buckets, low-pressure wheels, and high-pressure rotors, is conducted. This inspection consists of visual, surface, and volumetric examinations.

b. Dismantling of at least one main steam stop valve, one main steam control valve, one intermediate stop valve, and one intercept valve is conducted during selected refueling or maintenance shutdowns, along with a visual and surface examination of valve seats and stems. If unacceptable flaws or excessive corrosion are found in a

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valve, other valves of its type are inspected. Valve bushings are inspected and cleaned, and bore and stem diameters are checked for proper clearance.

c. Extraction steam valves are exercised once a week using a hand air test valve which is located at the nonreturn valve. Movement of the nonreturn valve shaft and counterweight extension will be noted during testing.

10.2.4 Evaluation

Components of the turbine-generator are conventional and are of a type that has been extensively used in other nuclear power plants. Instruments, controls, and protective devices are provided to ensure reliable and safe operation. Redundant, fast actuating controls are installed to prevent any damage resulting from overspeed and/or full load rejection. The control system ensures turbine trip upon reactor trip. Automatic low-pressure exhaust hood water sprays prevent excessive hood temperatures. Exhaust casing rupture diaphragms prevent low-pressure turbine overpressure in the event of loss of condenser vacuum.

Since the steam generated in the steam generators is not normally radioactive, no radiation shielding is provided for the turbine-generator and associated components. Thus radiological considerations do not affect access to system components during normal conditions. In the event of a primary-to-secondary system leak due to a steam generator tube leak, it is possible for the main steam to become radioactively contaminated. Discussions of the radiological aspects of primary-to-secondary leakage are presented in Chapters 11 and 12.

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TABLE 10.2-1

TURBINE-GENERATOR PERFORMANCE DATA

Parameter	Guaranteed Load	Valves-Wide-Open
NSSS thermal output, MWt		
Steam generator outlet pressure, psia (kg/cm^2A)		
Throttle pressure, psia (kg/cm^2A)		
Throttle temperature, °F (°C)		
Main steam flow, 10^6 lb/hr (kg/hr)		
Gross electrical output, MWe		

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* For turbine-generator design purposes only. 812

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TABLE 10.2-2

TURBINE-GENERATOR DESIGN DATA

Supplier	
Unit designation	
Last stage bucket length, in. (cm)	
Design condenser backpressure (average for 3 shells), in. HgA (mm)	
Stages of reheating	
Stages of feedwater heating	
Rotational speed, rpm	
Guaranteed generator rating, MVA	
Generator voltage, kV	
Power factor	
Short circuit ratio	

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10.3 MAIN STEAM SYSTEM

The function of the main steam system (MSS) is to convey steam generated in the steam generators to the turbine-generator system and auxiliary systems for power generation.

10.3.1 Design Bases

10.3.1.1 Safety Design Bases

The portion of the MSS from the steam generator outlet up to and including the main steam isolation valve (MSIV) room penetration anchor is safety-related and is designed to meet the following criteria:

a. The safety-related portion of the MSS is protected from the effects of natural phenomena such as earthquakes, typhoons, floods, and external missiles.

b. The safety-related portion of the MSS is designed to remain functional both during and after a safe shutdown earthquake (SSE), or to perform its intended function following postulated hazards of fire, internal missile, or pipe break.

c. The system safety functions can be performed, assuming a single active component failure coincident with the loss-of-offsite power.

d. The MSS is designed so that the active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components at appropriate times, as specified in the ASME Boiler and Pressure Vessel Code, Section XI.

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e. The MSS uses design and fabrication codes consistent with the quality group classification assigned by Regulatory Guide 1.26 and the seismic category assigned by Regulatory Guide 1.29. The power and control functions are in accordance with Regulatory Guide 1.32.

f. The MSS provides for isolation of the secondary side of the steam generator to deal with leakage or malfunctions and to isolate non safety-related portions of the system.

g. The MSS provides means to dissipate heat generated in the reactor coolant system during the initial phase of plant cooldown following any abnormal plant condition.

h. Flow restrictors are installed in the steam-generator steam outlet nozzles to limit flow in the event of a main steamline break.

i. The MSS is designed to prevent the initiation of or minimize the effects of steam hammer transient.

10.3.1.2 Power Generation Design Basis

The MSS is designed to deliver steam from the steam generators to the turbine-generator system for a range of flows and pressures varying from warmup to rated conditions. The system provides means to dissipate heat during plant step load reductions and during plant startup. It also provides steam to the following:

a. Turbine-generator system second-stage reheaters of MSR
b. Feedwater pump turbines
c. Turbine gland sealing system
d. Turbine bypass system (TBS)
e. Auxiliary steam system

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f. Process sampling system

10.3.2 System Description

10.3.2.1 General Description

The MSS is shown on Figure 10.3-1. The system conveys steam from the steam generators to the turbine-generator system. The system consists of main steam piping, main steam atmospheric dump valves (ADVs), main steam safety valves (NSSVs), main steam isolation valves (MSIVs), and turbine bypass valves. The turbine bypass system is discussed in detail in Subsection 10.4.4.

10.3.2.2 Component Description

10.3.2.2.1 Main Steam Piping

The main steamlines deliver the total rated load-steam flow of 12.72×10^6 lb/hr (5.77×10^6 kg/hr) from the secondary side of the two steam generators to the high-pressure turbine. Each of the main steamlines from the steam generators is anchored at the containment wall and has sufficient flexibility both inside and outside the containment to accommodate thermal expansion. Design of the attachment of the main steam piping to the steam generators includes design considerations that incorporate the allowable nozzle loading moments and stresses for both steam generators operating or out of service. The design of all piping and supports considers all static and dynamic loadings, stresses, and moments arising from normal operation, pressure transients, or pipe rupture. The design of seismic Category I piping and supports considers the loads discussed in Subsection 3.9.3 812

Each main steamline contains four spring-loaded safety valves, one main steam atmospheric pump valve, and one MSIV. All of these valves are located outside the containment and are installed as close as possible to the containment

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wall. Containment penetrations are discussed in Subsection 6.2.4.

Turbine bypass branch connections are located in the main steam header between the MISVs and turbine-generator stop valves as discussed in Subsection 10.4.4. Connections are provided for nitrogen pressurization of the steam generators. Also, sample connections are provided downstream of the steam generator nozzles for determination of steam quality. Branch piping provides steam to the moisture separator reheaters, turbine gland seal systems, main feedwater pump turbines, and turbine bypass system.

Drain lines are connected to the low points of each main steamline and sloped to promote adequate drainage. Drip pots and level control provisions are installed in the drain lines to permit continuous drainage from the main steamline low points.

The main steam piping from the steam-generator outlet up to the MSIV room penetration anchor is inspected and tested in accordance with ASME Code Sections III Class 2 and XI. The rest of the piping is ANSI/ASME B31.1 piping and is inspected and tested in accordance with paragraphs 136 and 137 of ANSI/ASME B31.1.

10.3.2.2.2 Main Steam Isolation Valves

Each of the main steam lines is equipped with one quick-acting main steam isolation valve (MSIV). Each valve has an actuation time of 5 seconds or less against the maximum steam flow for a ruptured steam line and operates automatically in the event of rupture in the main steam piping or associated components either upstream or downstream of the MSIV. They prevent blowdown of more than one steam generator (assuming a single active failure). The valves are designed to fail closed on loss of electrical power. Once isolation is initiated, in response to a main steam isolation signal (MSIS), the valves continue to close. The valves may be manually reopened by the

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operator from the control room depending on plant conditions and plant operating procedures by overriding the MSIS.

Each valve actuator has physically separated and electrically independent redundant hydraulic circuits in order to provide redundant means of closing the valve, which is the required safety-related function.

The MSIVs are installed in the straight piping runs outside the containment. The maximum stress level does not exceed the criteria specified in Subsection 3.9.3.

A mechanistic main steam line pipe rupture is not postulated to occur between the containment penetrations and the MSIVs nor between the MSIVs and the first anchor which acts as a pipe whip restraint downstream from the MSIVs. However, the MSIV room structure and safety-related equipment within the structure are designed to withstand the temperature and pressure effects of a postulated main steamline longitudinal break having a cross sectional area of one square foot.

The bending moment resulting from a main steamline rupture downstream of the anchor point on the MSIV room penetration anchor is absorbed at the anchor point and the MSIV has no appreciable bending moment transmitted to it. The steady-state discharge thrust load from such a break does not cause appreciable nozzle bending or torsion. Axial thrust is resisted and balanced at the penetration anchor. The bending and axial loads resulting from a postulated main steamline break inside the containment are absorbed by the containment penetration, which is designed to withstand pipe collapsing moments and axial thrust.

The MSIVs are thus designed to be protected from and to be fully operable under the loading induced by postulated pipe break anywhere in the main steam system.

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The MSIVs are designed, manufactured, inspected, tested, and certified in accordance with the requirements of the ASME Code, Section III.

The MSIVs are qualified for operability as discussed in Subsection 3.9.3.2.

10.3.2.2.3 Flow Restrictors

The main steam flow restrictors are an integral part of the steam-generator steam outlet nozzles. The main steamline flow restrictors are described in Subsection 5.4.4.

10.3.2.2.4 Main Steam Safety Valves

Each main steamline is provided with four ASME Section III, spring-loaded safety valves located upstream of the main steam isolation valves but outside the containment. The total relieving capacity of these valves is divided equally between the main steamlines and is sufficient to pass the steam flow equivalent to the plant's maximum steam flow.

The safety valve pressure accumulation does not exceed 3% and the maximum pressure while relieving is below the maximum allowable of 10% above the steam-generator design pressure, in accordance with Article NC-7000 of ASME Code, Section III. The design pressure-temperature rating of the main steam piping is 1270 psia (89.3 kg/cm^{2}A) and 575°F (302°C) to match the design conditions for the steam-generator secondary side.

10.3.2.2.5 Main Steam Atmospheric Dump Valves

Main steam atmospheric dump valves (ADVs), one per main steamline, are provided to allow cool-down of the steam generators when the main steam isolation valves are closed or when the main condenser is not available as a heat sink. Each ADV is sized to hold the plant at hot standby while

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dissipating core decay heat or to allow a flow of sufficient steam to maintain a controlled reactor cooldown rate.

The ADVs are of the modulating type allowing the setpoint pressure of the ADVs to be adjusted remotely. The valves are designed to be controlled manually or automatically by steam line pressure and the power to the valves is provided from Class 1E supplies. Local manual actuators are also provided. The atmospheric dump valves are not required to operate for overpressure protection because the steam generators are protected by the main steam safety valves. 1

10.3.2.2.6 Turbine Bypass Valves

A total of eight turbine bypass valves provide capability to dump 55% of rated main steam flow following loss of external electrical load and/or turbine-generator trip. Of this, 40% of rated main steam flow is bypassed to the condenser and 15% of rated main steam flow is dumped to the atmosphere.

This capacity, combined with the reactor power cutback system provides the capability of accepting a generator step load rejection down to plant auxiliary load without tripping the reactor or lifting RCS and/or the main steam safety valves. The turbine bypass system is discussed in Subsection 10.4.4.

10.3.2.3 System Operation

During plant startup, the vacuum pumps are used to establish condenser vacuum. The condenser vacuum system is discussed in Subsection 10.4.2.

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Main steam from the main steam header is then applied to the feedwater pump turbine driver. When the plant is operating above approximately 40% load, the steam for the feedwater pump is shifted to the outlet of the MSR. The feedwater system is discussed in Subsection 10.4.7.

At low power levels, the main steam system provides steam to the turbine gland seal system via the main steam header. This prevents leakage of air into the condenser via the turbine gland seal system. The turbine gland seal system is described in Subsection 10.4.3.

Main steam is supplied to the second-stage reheaters of MSR and extraction steam is supplied to the first-stage reheaters during power operation to raise the plant efficiency. The reheaters are described in Section 10.2.

The coordinated operation of the main steam system, the safety valves, atmospheric dump valves, and the turbine bypass system during a large generator load rejection or loss-of-offsite power situation as described above may also be employed to remove decay heat during normal and abnormal shutdown operations.

Radioactive leakage into the main steam system is detected by the radiation monitor located in the condenser air removal exhaust line and by the steam generator blowdown radiation monitor. The radiological aspects of a major secondary system pipe rupture are discussed in Subsection 15.1.5.

10.3.3 Safety Evaluation

a. The safety-related portions of the MSS are located in the containment and auxiliary buildings. These buildings are designed to withstand the effects of earthquakes, typhoons, floods, external missiles, and other appropriate natural phenomena as described in Chapter 3.

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b. The safety-related portions of the MSS are designed to remain functional both during and after an SSE. Sections 3.7 and 3.9 provide the design loading conditions that were considered. Sections 3.5 and 3.6 provide the hazards analyses to ensure that a safe shutdown can be achieved and maintained.

c. No single failure will compromise the system's safety functions. All vital power can be supplied by either onsite or offsite power systems, as described in Chapter 8.

d. The MSS is initially tested in the program described in Chapter 14. Periodic inservice functional testing is performed in accordance with Subsection 10.3.4.

   Section 6.6 discusses the ASME Section XI inservice inspection requirements that are appropriate for the MSS.

e. Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. All the power supplies and controls necessary for safety-related functions of the MSS are Class 1E, as described in Chapters 7 and 8.

f. Redundant power supplies and power trains operate the MSIVs to isolate safety-related and non-safety-related portions of the system. Branch lines upstream of the MSIVs contain normally closed main steam atmospheric dump valves that modulate open and closed on steamline pressure. The main steam atmospheric dump valves fail closed on loss of electric, hydraulic, or control signal, and the main steam safety valves provide the overpressure protection.

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Accidental releases of radioactivity from the MSS are insignificant due to negligible amount of radioactivity in the system under normal operating conditions. Additionally, the main steam isolation system provides controls for reducing accidental releases, as discussed in Chapter 15, following a steam generator tube rupture.

Detection of radioactive leakage into and out of the system is facilitated by process radiation monitoring (discussed in Section 11.5) and steam generator blowdown sampling (discussed in Subsections 9.3.2 and 10.4.8).

g. Each main steamline is provided with one main steam atmospheric dump valve (MSADV) to permit reduction of the main steamline pressure and to remove stored energy to achieve an orderly cooldown following any abnormal plant condition. The MSADVs are electrohydraulic angle valves. The capability for remote valve operation is provided in the main control room and at the remote shutdown panels.

h. Each steam-generator steam outlet nozzle is equipped with a device to limit steam flow in the event of a downstream pipe break. Refer to Subsection 5.4.4 for a description of the flow-limiting device.

i. The main steam system is designed to prevent the initiation of or minimize the effects of a steam hammer transient.

10.3.4 Inspection and Testing Requirements

10.3.4.1 Preservice Valve Testing

The MSIVs are operationally tested during refueling outages with the hydraulic operator unit to test opening and closing functions. The MSIVs are also checked for closing time before initial startup.

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10.3.4.2 <u>Preservice System Testing</u>

Preoperational testing is described in Chapter 14.
The MSS is designed to include the capability for testing through the full operational sequence that brings the system into operation for reactor shut-down and for main steamline break (MSLB) accidents, including operation of applicable portions of the protection system and the transfer between normal and standby power sources.

The safety-related components of the system, e.g. , valves and piping, are designed and located to permit preservice and inservice inspections to the extent practicable.

10.3.4.3 <u>Inservice Testing</u>

The performance, structural, and leaktight integrity of all system components are demonstrated by continuous operation.

The closure time and the operability of the actuator system for the redundant actuator power trains of each MSIV are checked by fully closing the valve every reactor cold shutdown pursuant to Inservice Test plan. 232

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Additional discussion of inservice inspection of ASME Section III, Class 2 Components is contained in Section 6.6

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10.3.5 Secondary Water Chemistry

10.3.5.1 Chemistry Control Basis

Steam-generator, secondary-side water chemistry control is accomplished by the following:

a. Close control of the feedwater to limit the amount of impurities that can be introduced into the steam generator.

b. Continuous blowdown of the steam generator to reduce the concentrating effects of the steam generator.

c. Chemical addition to establish and maintain an environment that minimizes system corrosion.

d. Preoperational cleaning of the feedwater system.

e. Minimizing feedwater oxygen content prior to entry into the steam generator.

Secondary water chemistry is based on the zero-solids treatment method. This method employs the use of volatile additives to maintain system pH and to scavenge dissolved oxygen present in the feedwater.

PH agents that can be used for pH control of secondary cycle are ammonia, morpholine, ethanolamine or mixed amine(ammonia + ethanolamine). Ethanolamine 626 should be used in the plants employing all ferrous system to minimize corrosion because ethanolamine is lower relative volatility than ammonia. Therefore it makes proper alkaline condition in wet steam area and steam generator. Although the amines are volatile and will not concentrate in the steam generator, they will reach an equilibrium level, which will establish an alkaline condition in the steam generator.

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Hydrazine is added to scavenge dissolved oxygen present in the feedwater. Hydrazine also tends to promote the formation of a protective oxide layer on metal surfaces by keeping these layers in a reduced chemical state.

Both the pH agent and hydrazine can be injected continuously downstream of the condensate demineralizers. These chemicals are added as necessary for chemistry control, and can also be added to the upper steam generator feed line when necessary.

Operating chemistry limits for secondary steam generator water and feedwater and condensate are given in Tables 10.3-1 and 10.3-2.

Three action levels have been defined for taking remedial action when normal ranges are exceeded for control parameters. The associated actions as each action level is exceeded increase in severity from 1 though 3. The normal values presented herein are based on what is routinely achievable in the industry. However, operators should not become complacent if these normal values are met. Any deviations by a plant from its normal values should be investigated. The action levels defined prescribe values of parameters which are consistent with long-term system reliability. Operating below action level 1 values, according to current corrosion information, should permit achivement of design lifetime while avoding corrosive conditions. Action level 2 is instituted when conditions exist which have been shown to result in steam generator corrosion during extended full power (100%) operation. Action level 3 is implemented when conditions exist which will result in rapid steam generator corrosion, & continued operation is not advisable. 4

Action Level 1.

Objective :

To promptly identify & correct the cause of an out-of-normal value without power reduction.

Actions :

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a) Return parameter to within normal value range within one week following confirmation of excursion.

b) If parameter is not within normal value range within one week following confirmation of excursion, go to Action Level 2 for those parameters having Action Level 2 values. The lack of progressive action criteria for many parameters is not intended to imply that remaining outside the normal range is satisfactory. In these cases, other chemical parameter, specifically associated with known corrosion conditions, are utilized for control.

Action Level 2.

Objective :

To minimize corrosion by operating at reduced power while corrective actions are taken. Power reduction should be to a level which will reduce available steam generator superheat and heat flux in the crevices where concentration of aggressive chemicals can occur, while providing sufficient system flow to maintain automatic operation while the source of the impurity is eliminated.

Actions :

a) Reduce power to appropriate level (typically 30% or less) within eight hours of initiation of Action level 2. The objective is to reduce power to the lowest level where automatic feedwater control can be maintained. Power de-escalation can be terminated if the source of impurity ingress is eliminated & parameter values are below Action level 2. Escalation to full power can be resumed once Action Level 1 values are met. 336

b) After an Action Level 2 excursion, consideration should be given to a hot soak or reduction to low power at the next opportunity.

c) Return parameter to within normal value range within 100 hours or go to Action Level 3 for those parameters having Action Level 3 values.

Action Level 3.

Objective :

To correct a condition which is expected to result in rapid steam generator

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c) Return parameter to within normal value range within 100 hours or go to Action Level 3 for those parameters having Action Level 3 values.

Action Level 3. 3

Objective :

To correct a condition which is expected to result in rapid steam generator

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corrosion during continued operation. Plant shutdown will avoid ingress and eliminate further concentration of harmful impurities. The corrective action if shutting down also will allow cleanup of the impurities as a result of hideout return.

Actions :

a) Shutdown as quickly as(within eight hours) safe operation permits and cleanup by feed and bleed or drain and refill as appropriate until normal values are reached. Regardless of the duration of the excursion into Action Level 3, the plant should be taken to hot or cold shutdown. The judgement on maintaining the steam generator in a hot condition or progressing to cold shutdown should be based on the corrosion concern imposed by the specific impurity and the most rapid means to effect clean-up. 336

10.3.5.2 Corrosion Control Effectiveness

Alkaline conditions in the feedtrain and the steam generator reduce general corrosion at elevated temperatures and tend to decrease the release of soluble corrosion products from metal surfaces. These conditions promote the formation of a protective metal oxide film and, thus, reduce the corrosion products released into the steam generator.

Hydrazine also promotes the formation of a metal oxide film by the reduction of ferric oxide to magnetite. Ferric oxide may be loosened from the metal surfaces and transported by the feedwater. Magnetite, however, provides an adherent protective layer on carbon steel surfaces. Hydrazine also promotes the formation of protective metal oxide layers on copper surfaces.

The removal of oxygen from the secondary waters is also essential in reducing corrosion. Oxygen dissolved in water causes general corrosion that can result in pitting of ferrous metals, particularly carbon steel. Oxygen is removed

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from the steam cycle condensate in the main condenser deaerating section and deaerator. Additional oxygen protection is obtained by chemical injection of hydrazine into the condensate stream. Maintaining a residual level of hydrazine in the feedwater ensures that any dissolved oxygen not removed by the main condenser and deaerator is scavenged before it can enter the steam generator.

The presence of free hydroxide (OH^-) can cause rapid corrosion (caustic stress corrosion) if it is allowed to concentrate in a local area. Free hydroxide is avoided by maintaining proper pH control and by minimizing impurity ingress in the steam generator.

In zero-solids treatment, both soluble and insoluble solids are excluded from the steam generator. This is accomplished by maintaining strict surveillance over the possible sources of feedtrain contamination (e.g., main condenser cooling water leakage, air inleakage and subsequent corrosion product generation in the low-pressure drain system). Solids are also excluded, as discussed above, by injecting only volatile chemicals to establish conditions which reduce corrosion and, therefore, reduce the transport of corrosion products into the steam generator. Reduction of solids in the steam generator can also be accomplished through condensate demineralization. In addition to minimizing the sources of contaminants entering the steam generator, continuous blowdown is employed to minimize their concentration. The condensate polishing system and the steam-generator blowdown system are discussed in Subsections 10.4.6 and 10.4.8, respectively.

With the low solid levels which result from employing the above procedures, the accumulation of scale and deposits on steam-generator heat transfer surfaces and internals is limited. Scale and deposit formations can alter the thermal hydraulic performance in local regions to such an extent that they create a mechanism which allows impurities to concentrate to high levels, and thus could possibly cause corrosion. Therefore, by limiting the ingress of

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solids into the steam generator, the effect of this type of corrosion is reduced.

Because they are volatile, the chemical additives will not concentrate in the steam generator, and do not represent chemical impurities which can themselves cause corrosion.

10.3.6 Steam and Feedwater System Materials

This subsection (except for Subsection 10.3.6.3) applies to materials for ASME Section III, Division 1, Class 2 components of the main steam and feedwater systems. No Class 1 and 3 components are contained in the system.

10.3.6.1 Fracture Toughness

The test methods and acceptance criteria of Article NC 2300 of ASME Section III, Division 1, are complied with for materials for Class 2 components.

10.3.6.2 Materials Selection and Fabrication

Information on materials selection and fabrication methods used for ASME Section III, Class 2 components is presented in the following subsections.

10.3.6.2.1 Materials Not Included in ASME Boiler and Pressure Vessel Code, Section III, Appendix I

All pressure-retaining materials comply with one of the material specifications listed in Appendix I of ASME Section III, Division 1.

10.3.6.2.2 Austenitic Stainless Steel Components

For austenitic stainless steel components, the recommendations of Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," Regulatory

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Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel," and Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," are complied with to the extent specified in Appendix 1A and Subsection 5.2.3.

10.3.6.2.3 Cleaning and Handling Class 2 Components

For all ASME Section III, Class 2 components, the recommendations of Regulatory Guide 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants," and ANSI/ASME NQA-2, Part 2.1, "Cleaning of Fluid Systems and Associated Components of Nuclear Power Plants," are complied with as described in Appendix 1A.

10.3.6.2.4 Preheat Temperatures for Low-Alloy Steel and Carbon Steel

The recommendations of Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel," are complied with to the extent specified in Appendix 1A. For carbon steel materials, the preheat temperatures are in accordance with Section III, Appendix D-1000 of the ASME Boiler and Pressure Vessel Code.

10.3.6.2.5 Welder Qualification for Areas of Limited Accessibility

The recommendations of Regulatory Guide 1.71, "Welder Qualification for Areas of Limited Accessibility," are complied with to the extent specified in Appendix 1A.

10.3.6.2.6 Nondestructive Examination Procedure

The nondestructive examination procedures for examination of tubular products conform to the requirements of the ASME Section III, Subsubarticles NC/ND-2550

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10.3.6.3 Codes and Standards

Codes and standards applicable to the main steam and feedwater systems are listed in Table 3.2-5. The main steam system is designed and constructed in accordance with ASME Section III, Class 2 and Quality Group B requirements from the steam generator up to and including the MSIV room penetration anchor. The main feedwater system is designed and constructed in accordance with ASME Section III, Class 2 and Quality Group B requirements from the steam generator up to and including the MSIV room penetration anchor. The remaining piping up to the turbine-generator and auxiliaries meets ANSI/ASME B31.1 requirements.

Feedwater control valves and feedwater flow elements conform to ANSI/ASME B16.34 and ANSI/ASME B31.1, respectively.

For a discussion of conformance with the regulatory guides, refer to Section 1.8 and Subsection 5.2.3.

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TABLE 10.3-1

RECOMMENDED OPERATING CHEMISTRY LIMITS FOR
SECONDARY STEAM GENERATOR WATER [(a)]

Variable	Normal Specification *	Action Level I	Action Level II	Action Level III	
pH	≥ 9.0	-	-	-	626
Cation Conductivity	≤ 1.0 μmhos/cm	> 1.0	> 2	> 7	200
Chloride	≤ 20 ppb	> 20	> 100	-	
Sodium	≤ 20 ppb	> 20	> 100	> 500	
Sulfate	≤ 20 ppb	> 20	> 100	-	

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a. The downcomer and hot leg blowdown are the normal. Surveillience locations and both should be sampled. Chemistry should be controlled based upon the more restrictive of the two samples.

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TABLE 10.3-2

RECOMMENDED OPERATING CHEMISTRY LIMITS FOR FEEDWATER AND CONDENSATE

Variable	Normal Specifications *	
pH (Feedwater)		
All-ferrous/copper system	8.8 - 9.2	
All-ferrous system	≥ 8.8 - 10.0**	626
Conductivity*** (Intensified cation) (Feedwater)	≤ 0.2 µmhos/cm	
Hydrazine+ (Feedwater)	> 20 ppb	
Dissolved Oxygen		
(Feedwater)	≤ 5 ppb	
(Condensate)++	≤ 10 ppb	
Sodium*** (Feedwater)	≤ 3 ppb	
Copper+++ (Feedwater)	≤ 2 ppb	
Iron (Feedwater)	≤ 20 ppb	

* Normal specifications are those which should be maintained during proper operation of secondary systems.

** During periods of condensate demineralizer operations, the pH of an all-ferrous system can be controlled to a lower normal value of 9.0, with corrective action required at < 9.0.

*** Conductivity and sodium are diagnostic parameters. These values were set as a means of addressing steam purity concerns. It is realized that lower values will be needed to meet the blowdown limitations in Table 10.3-1.

\+ The hydrazine range applies to feedwater/condensate system downstream of the normal chemical addition point.

++ The condensate abnormal limit is 10-30 ppb but the requirement for immediate shutdown does not apply even if the problem is not corrected within 100 hrs.

+++ Analysis not required for ferrous systems.

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Figure 10.3-1

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Figure 10.3-1

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Figure 10.3-1

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10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

10.4.1 Main Condenser

The main condenser is the steam-cycle heat sink. During normal operation, it receives and condenses low-pressure turbine exhaust steam, feedwater pump turbine exhaust steam, steam-generator blowdown, and turbine bypass steam. The main condenser is also a collection point for other miscellaneous steam cycle flows, drains, and vents.

The main condenser is utilized as a heat sink in the initial phase of reactor cooldown during a normal plant shutdown.

10.4.1.1 Design Bases

10.4.1.1.1 Safety Design Bases

The main condenser has no safety function.

10.4.1.1.2 Power Generation Design Bases

a. The main condenser provides a heat sink for the exhaust steam from the turbine-generator, and the feedwater pump turbines, and for other cycle flows.

b. The main condenser accommodates at least 40% of the rated main steam flow which is bypassed directly to the condenser by the turbine bypass system.

c. The main condenser releases noncondensable gases from the condensing steam through the condenser vacuum system, as described in

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Subsection 10.4.2. This minimizes the occurrence of erosion and corrosion within the secondary system.

d. The main condenser hotwell provides storage for 5 minutes of maximum condensate flow.

10.4.1.1.3 Codes and Standards

The main condenser is designed in accordance with the applicable codes and standards identified in Table 3.2-5.

10.4.1.2 System Description

The main condenser is a single-pressure, three-shell, single-pass surface condenser. Each shell is located beneath its respective low-pressure turbine. The tubes in each shell are oriented transverse to the turbine-generator longitudinal axis.

The condenser shells have divided waterboxes. Each shell has two bundles, each of which is connected to the waterboxes. Each shell is divided into two hotwells longitudinally by a vertical partition plate. The condensate pumps take suction from these hotwells.

The condenser shells are located in pits below the turbine building operating floor and are supported above the turbine building foundation.

Expansion joints are provided between each turbine exhaust opening and steam inlet connection of the condenser shells. The three shells are interconnected by steam equalizing lines in the steam regions. Two low-pressure feedwater heaters are located in the neck of each shell. Piping is installed for hotwell level control and condensate sampling.

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During normal operation, exhaust steam from the low-pressure turbines is directed downward into the condenser shells through exhaust openings in the bottom of turbine casings and is condensed. The condenser also receives auxiliary flows, such as feedwater heater vents and drains, feedwater pump turbine exhaust, and turbine gland seal system drains.

During the initial cooling period after plant shutdown, the main condenser removes decay heat from the reactor coolant system via the turbine bypass system. The main condenser receives at least 40% of the rated main steam flow through the turbine bypass valves. The bypassed steam is distributed over the condenser tubes by spray headers. These conditions are accommodated without increasing the condenser backpressure to the turbine alarm setpoint or exceeding the allowable turbine exhaust temperature. Provision is made to reduce the bypass steam pressure before exhausting into the condenser distribution manifold. The spray pipes are provided to avoid steam impinging on the condenser tubes.

The condenser is provided with tube-sheets designed to minimize seawater inleakage. However, in the event of seawater inleakage into the main condenser, the condenser may remain in operation, provided the feedwater chemistry is maintained within acceptable limits. Thus, the condenser can be operated at rated flow if the amount of leakage is within the capability of the condenser polisher to remove the impurities and maintain the feedwater chemistry. If the inleakage is beyond the capability of the condensate polisher, the affected hotwell is isolated by closing the condensate hotwell isolation valve the circulating water inlet and outlet valves supplying cooling water to the affected hotwell.

Circulating water leakage occurring within the condenser is detected and alarmed in the control room by monitoring the condensate leaving each hotwell.

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This information permits determination of which tube bundle has sustained the leakage. Steps may be taken to isolate and dewater that bundle and its waterboxes and, subsequently, repair or plug the leaking tubes.

In the event of primary-to-secondary tube leakage, radioactive contaminants will be present in the steam generator. Radioactive concentrations in the hotwell are given in Section 11.1.

During normal operation, there is no gaseous hydrogen going to the main condenser. In the event of a steam generator tube leak, minute quantities of gaseous hydrogen are carried over to the main condenser. Hydrogen removal is noted in Subsection 10.4.2.

Hotwell level controls provide automatic makeup or rejection of condensate to maintain a normal level in the condenser hotwells. On low water level in a hotwell, the makeup control valves open and admit condensate to the hotwell from the condensate tank. When the hotwell is brought to within normal operating range, the valves close. On high water level in a hotwell, the condensate reject control valve opens to divert condensate from the condensate pump discharge (downstream of the steam packing exhauster) to the condensate storage tank or condenser overboard pump can be used to discharge excess condensate to the Turbine Building Drain System; rejection is stopped 520
when the hotwell level falls to within normal operating range. Rejection of hotwell condensate to the condensate storage tank may be manually overridden upon an indication of high hotwell conductivity. Operator action can therefore prevent transfer of contaminants into the condensate storage tank in the event of a condenser tube failure.

Both the air inleakage and the noncondensable gases contained in the turbine exhaust are collected in the condenser and removed by the condenser vacuum system.

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If a condenser hotwell ruptures, the flooding will not jeopardize the safe shutdown of the plant. At no time would the water enter the primary or secondary auxiliary building. The only access to any of these building from the turbine building is sufficiently above the turbine building basement elevation. Since there is no safety-related equipment in the turbine building, none could be affected.

10.4.1.3 Safety Evaluation

The main condenser serves no safety function and has no safety design bases.

10.4.1.4 Test and Inspections

The condenser shells are hydrostatically tested in accordance with applicable codes and standards after erection. The condenser shells, hotwells, and waterboxes are provided with access openings to permit inspection and repairs.

10.4.1.5 Instrument Application

Condenser hotwell level is monitored and manually controlled by transferring condensate to and from the condensate storage tank. Level is indicated locally and in the main control room. High and low level are annunciated in the main control room. 520

Condenser pressure is monitored and high condenser pressure is annunciated in the main control room. High condenser pressure will trip the main turbine.

Conductivity of the condensate leaving each hotwell is sampled and monitored. This provided a means of detecting and locating condenser tube leaks.

Condenser temperature is monitored in the suction lines to the condensate pumps.

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10.4.2 Condenser Vacuum System

10.4.2.1 Design Bases

10.4.2.1.1 Safety Design Basis

The condenser vacuum system has no safety function with the exception of the system portion from the condenser off-gas containment isolation valve, which has a safety function to close upon receipt of a containment isolation actuation signal, up to and including the check valve inside the containment.

10.4.2.1.2 Power Generation Design Basis

The condenser vacuum system is designed to establish and maintain the condenser shell side vacuum by continuously removing noncondensable gases and air.

10.4.2.2 System Description

The condenser vacuum system consists of four 33-1/3% capacity mechanical vacuum pumps and one 100% capacity steam jet air ejector (SJAE) unit, shown on Figure 10.4-1.

The vacuum pump capacity meets or exceeds the capacity recommended in the Heat Exchange Institute's "Standards for Steam Surface Condensers," 8th Ed. All four pumps perform the hogging (startup) functions; with three of the four pumps operated for condenser evacuation when the SJAE is out of service. All components are nonseismic and are designed in accordance with Regulatory Guide 1.26, Quality Group D.

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After the turbine steam seals are established, all pumps initially remove the air from the main condenser to draw down the pressure of the condenser and low-pressure turbine casings. During normal operation, an SJEA continuously removes the noncondensable gases to maintain the condenser vacuum conditions. In the event of excessive air inleakage, all four mechanical vacuum pumps are automatically activated.

A high condenser pressure alarm annunciates in the control room if the pressure reaches approximately 2.56 in. (65mm) HgA. The turbine will trip if the condenser vacuum system cannot maintain the condenser pressure below 7.5 in. (191 mm) HgA. The effects of a loss of condenser vacuum are discussed in Subsection 15.2.5. 149

The condenser vacuum system is also designed to remove noncondensable gases at times when the turbine bypass system is in operation, such as during hot shutdown. If the condenser vacuum system malfunctions and the condenser becomes unavailable, the reactor coolant system heat rejection is accommodated by the main steam atmospheric dump valves.

In order to detect primary-to-secondary leakage in the steam generators, the mixture of water vapor and noncondensable gases discharged by the SJAE unit and/or the mechanical vacuum pumps are controlled and monitored in accordance with 10 CFR 50, Appendix A, General Design Criteria 60 and 64. Conformance to General Design Criteria 60 and 64 is discussed in Subsections 3.1.2.51 and 3.1.2.55, respectively. In case of high radiation in the system discharge, the contaminated exhaust gases are automatically discharged into the containment building normal sump area by booster fan. The liquid effluent is directed to the turbine building drains, of which a radiological evaluation appears in Section 11.2. The gaseous effluent radiological evaluation appears in Section 11.3.

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The potential for explosive mixtures in the condenser vacuum system of pressurized water reactor plants does not exist.

10.4.2.3 Safety Evaluation

The condenser vacuum system has no safety function with the exception of the system portion from the condenser off-gas containment isolation valve, which has a safety function to close upon receipt of the containment isolation actuation signal (CIAS), up to and including the check valve inside the containment.

10.4.2.4 Tests and Inspections

The condenser vacuum system is tested and inspected in accordance with the applicable codes and standards before operation. Periodic inservice tests and inspections of the condenser vacuum system are performed in conjunction with the scheduled maintenance outages.

The condenser vacuum system standby equipment is cycled periodically to ensure availability.

10.4.2.5 Instrument Applications

The vacuum pumps are controlled from the main control room and maintain condenser pressure below 5 in. (127 mm) HgA. Pressure and flow indicators are provided for local indication. Radioactivity of the effluent from the condenser off-gas is continuously monitored by the radiation monitoring system for steam generator tube leak detection. The isolation valve for condenser off-gas to the containment can be manually controlled in the main control room. However, this containment isolation valve is automatically opened upon receipt of a high radiation signal from the radiation monitoring system and is automatically closed upon receipt of the (CIAS).

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10.4.3 Turbine Gland Sealing System

The turbine gland sealing system prevents air leakage into and steam leakage out of the main turbine and out of feedwater pump turbine drives.

10.4.3.1 Design Bases

10.4.3.1.1 Safety Design Basis

The turbine gland sealing system has no safety function because it provides sealing action of conventional steam and air leakage between the turbine shells or the exhaust hood and the atmosphere.

10.4.3.1.2 Power Generation Design Basis

a. The turbine gland sealing system is designed to prevent air leakage into and steam leakage out of the casings of the main turbine and steam-generator feedwater pump turbines.

b. The turbine gland sealing system condenses the leakage steam, returns the condensate to the condenser, and exhausts the noncondensable gases to the atmosphere.

10.4.3.2 System Description

The turbine gland sealing system (see Table 10.4-1 and Figure 10.4-2), consists of the following:

a. Automatic steam inlet and dump regulators with manual bypass valves for startup and emergency operation.

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b. Steam packing exhauster, two 100% capacity blowers with separate suction and discharge valves.

Within shaft seals, steam would leak out of the high-pressure casings during normal operation due to the high-pressure (HP) steam inside the high-pressure turbine. Similarly, without shaft seals air would leak into the low-pressure (LP) casings due to the near vacuum conditions inside the LP turbines during normal operation.

Also, the turbine gland sealing system returns the air-steam mixture to the steam packing exhauster. The steam is condensed by condensate flow from the condenser hotwell, and the drains are returned to main condenser hotwell.

When the normal steam supply is not available, sealing steam is provided by the auxiliary boiler. Also, during turbine-generator startup, sealing steam is supplied from the auxiliary steam header. During low-load operation, however, sealing steam is provided from the high-pressure leakage connections of the main steam control valves and the main steam system or the auxiliary steam header for both the high-pressure and the low-pressure turbine glands. 344

When turbine-generator load rises, the required steam to seal the HP turbine glands decreases, and the HP glands begin to leak steam rather than using steam. The excess steam is directed to the condenser to maintain a constant HP gland steam pressure. When the turbine-generator has been brought up to full pressure, the auxiliary boiler steam source is closed and the auxiliary steam provides the sealing normally. 344

A suitable motor-operated bypass valve around the steam seal unloading valve is provided to take care of emergency conditions. Also, relief valves are included to protect the system from misoperation.

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10.4.3.3 Safety Evaluation

The turbine gland sealing system has no safety function and therefore a safety evaluation is not provided.

10.4.3.4 Tests and Inspection

The turbine gland sealing system is in continuous operation, and therefore, the system condition can be monitored at all times by the plant operators.

10.4.3.5 Instrumentation Applications

A pressure regulator is provided to maintain steam seal header pressure by providing signals to the steam seal spillover valve and the steam supply valve from the main and auxiliary steam header. Also, local and control room displays are provided and consist of indicating and alarm devices which monitor steam seal header pressure, temperature, and flow.

10.4.4 Turbine Bypass System

10.4.4.1 Design Bases

The turbine bypass system has no safety functions. The turbine bypass system, operating in conjunction with the reactor power cutback system (Subsection 7.7.1.1.6), is designed to accomplish the following functions:

a. Accommodate load rejections of any magnitude without tripping the reactor or lifting primary or secondary safety valves.

b. Control NSSS thermal conditions to prevent the opening of safety valves following unit trip

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c. Maintain the NSSS at hot zero power conditions.

d. Control NSSS thermal conditions when it is desirable to have reactor power greater than turbine power, e.g., during turbine synchronization.

e. Provide pressure limiting control during the loss of one-out-of-two operating feedwater pumps.

f. Provide a control element assembly (CEA) automatic motion inhibit (AMI) signal when turbine power and reactor power fall below selected thresholds; provide AMI signal below 15% reactor power to block automatic control of the reactor below this power level.

g. Provide a means for manual control of reactor coolant system (RCS) temperature during NSSS heatup or cooldown.

h. Provide for operation of the turbine bypass valves in a manner that minimizes valve wear and maintains controllability.

i. Provide for operation of the turbine bypass valves in a sequence which, by proper arrangement of valving to the condenser, limits the flow imbalance between condenser shells to the flow capacity of one valve when all turbine bypass valves and condenser shells are available.

j. Include redundancy in the design so that neither a single component failure nor a single operator error results in excess steam releases.

k. Provide a condenser interlock that blocks turbine bypass flow when unit condenser pressure exceeds a preset limit.

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10.4.4.2 System Description and Operation

10.4.4.2.1 General Description

The turbine bypass system consists of the steam bypass control system, the turbine bypass valves, and the associated piping and instrumentation. The steam bypass control system is described in Subsection 7.7.1.1.5.

10.4.4.2.2 Piping and Instrumentation

A typical turbine bypass system consisting of eight turbine bypass valves located in lines branching from downstream of the main steam header and discharging to the main condenser or atmosphere is shown on Figure 10.3-1.

10.4.4.2.3 Turbine Bypass Valves

The turbine bypass valves are air-operated valves with a combined capacity of 55% of the total full power steam flow at normal full power steam generator pressure of 1070 psia (75.2 kg/cm^{2}A). The valves are normally controlled by the steam bypass control system but are capable of remote or local manual operation. When operating automatically, the valves modulate full open or full closed in a minimum of 15 seconds and a maximum of 20 seconds. In response to a quick-opening signal from the steam bypass control system, they open within 1.5 seconds. In response to a closing signal from the steam 3 bypass control system, they are designed to close in 5 seconds. The system is capable of controlling at flows as low as 44,000 lb/hr (19,960.4 kg/hr) in order to permit operation at hot standby during precore hot functional testing.

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10.4.4.2.4 System Operation

The turbine bypass system takes steam from the main steam header upstream of the turbine stop valves and discharges it directly to the main condenser and/or to the atmosphere, bypassing the turbine-generator. During normal operation, the bypass valves are under the control of the steam bypass control system, as discussed in Subsection 7.7.1.1.5. During cooldown or hot shutdown, the turbine bypass valves may be actuated individually from the main control room to regulate steam generator pressure and reactor coolant temperature change.

The valves in the turbine bypass system are designed to fail closed to prevent uncontrolled bypass of steam to the condenser. Should the bypass valves fail to open on command, the main steam safety valves provide main steamline overpressure protection. The main steam atmospheric dump valves provide a means for controlled cooldown of the reactor. The main steam safety valves and main steam atmospheric dump valves are described in Subsection 10.3.2.2.

When the condenser is not available as a heat sink, an interlock prevents opening or, if opened, closes the turbine bypass system valves. The main steam safety valves and main steam atmospheric dump valves are used to control the load transient if the bypass valves are disabled. Because the ASME Code safety valves provide the ultimate overpressure protection for the steam generators, the turbine bypass system is defined as a control system and is designed without consideration for the special requirements applicable to protection systems. Failure of this system will have no detrimental effects on the reactor coolant system.

10.4.4.3 Safety Evaluation

This system is non-safety-related.

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10.4.4.4 Tests and Inspections

Before the turbine bypass system is placed in service, all system valves are tested to confirm opening and closing times. The bypass steamlines are initially tested hydrostatically to confirm leaktightness. The bypass valves may be tested while the main turbine is in operation. All system piping and valves are readily accessible for inservice inspection. Each bypass valve is equipped with isolation valves as required to facilitate maintenance. All system piping is inspected and tested in accordance with paragraphs 136 and 137 of ANSI/ASME B31.1.

10.4.4.5 Instrumentation Application

The control system for the turbine bypass system is described in Subsection 7.7.1.1.5. The control system for the reactor power cutback system is discussed in Subsection 7.7.1.1.6.

10.4.5 Circulating Water System

The circulating water system (CWS) provides cooling seawater for the removal of the waste heat from the main condenser and rejects this heat to the Yellow Sea as a heat sink.

10.4.5.1 Design Bases

The design bases are as follows:

a. The CWS supplies cooling water at a sufficient flow rate to remove heat from the main condenser under all conditions of power plant loading.

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b. The CWS is designed to supply the condenser with an adequate amount of seawater to maintain condenser backpressure within design limits.

c. The CWS is designed to alarm in the control room in the event of gross leakage into the condenser pit to notify operators of flooding in the turbine building. 204

d. The CWS is designed to operate safely and reliably with variation in seawater level.

Codes and standards applicable to the CWS are listed in Table 3.2-5.

10.4.5.2 System Description

The CWS consists of the circulating water pumps with piping, valves, and instrumentation. In addition, the following auxiliary systems are provided:

a. waterbox priming system,
b. condenser tube cleaning system.

The CWS is shown schematically on Figure 10.4-3. The circulating water pumps take suction from the intake structure and pump the circulating water into the discharge channel through the condensers. The system incorporates means of conserving power by reducing the number of pumps in operation during periods of low water temperature. The six 16-2/3% capacity circulating water pumps per unit are vertical, wet-pit type, single-stage, centrifugal pumps driven by electric motors.

The pumps are provided with motor-operated valves at their discharge to permit isolation of a pump when it is out of service.

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Motor-operated butterfly valves are provided at each circulating water pump discharge and in each of the circulating water lines at their inlet and outlet from the condenser shells to allow isolation of a faulted line.

The system is designed with cross-connected discharge piping from the circulating water pumps. The circulating water piping is constructed of epoxy-lined carbon steel piping and reinforced concrete conduits. The intake concrete conduit is located between the intake structure and the turbine building wall, where it is connected to steel piping on the condenser inlet. On the condenser outlet, the steel pipe connects to the concrete conduit that is routed back to the sea. The steel piping is embedded in the concrete using a thimble to ensure sealing at the interface. Piping 4 inches and smaller is Monel (70 Ni-30 Cu). Piping 6 inches (15 cm) through 24 inches (61 cm) is rubber-lined carbon steel.

In consideration of flooding due to a failure in a portion of the CWS in the yard area (such as the intake structure or buried pipe), the yard is graded in the direction to provide drainage of the water away from the power block. Therefore, safe shutdown capability will not be compromised by flooding of the yard area.

The plant is designed to accommodate turbine building flooding. In consideration of a failure of the circulating water system piping in the turbine building, flood level instrumentation has been provided in the condenser pit high-high level alarm based on a two-out-of-three logic. This system has been incorporated in the plant design to protect personnel and equipment. However, no credit is taken for this instrumentation for the design basis turbine-building flooding event. 204

In the design-basis turbine-building flooding event, postulated failure in the circulating water system piping is assumed to allow all six circulating water pumps to discharge seawater to the turbine building at runout flow. The

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turbine building basement is assumed to fill with water and the flood level in the turbine building is assumed to continue to rise until the outflow from the building equals the maximum inflow. This outflow occurs through permanently installed louvered panels located at the grade elevation. Seawater leaving the building and entering the yard will flow in the direction of the yard grade which is back to the intake channel. Thus a steady-state flood level is established in the turbine building, and it is not necessary to isolate the flooding source to protect safe shutdown functions. Important parameters and other information about the design-basis turbine-building flooding event are presented in Table 10.4-2.

In addition to the design of louvered panels to accommodate flooding outflow, the plant design also ensures that water trapped in the turbine building will not intrude into safety-related areas of the plant. All access openings between the turbine building and safety-related buildings are located above the design-basis flood level (el. 104 ft 6 in.). In addition, all penetrations below the design-basis flood level in the walls between the turbine building and adjoining buildings are sealed against flooding. Thus, through the use of passive design features and with no requirement for operator action to isolate flooding sources, the plant is designed to achieve safe shutdown following design-basis internal flooding in the turbine building.

The condenser area sumps and the oily waste sump pump are used to prevent the turbine building overflowing, however, these pumps do not perform a safety-related function. The condensate demineralizer sump, which is a sealed sump, is also affected.

The condenser waterbox priming system using two 100% capacity mechanical vacuum pumps and a vacuum control tank is provided to assist in maintaining siphon in the system and to remove noncondensable gases from the waterboxes.

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Water carryover to the vacuum pumps is precluded by an automatic control which shuts off flow in the riser in response to high water level. The pumps run continuously and are protected from over-vacuum and dead-ending by a vacuum breaker. During plant operation the water vapor and noncondensable gases removed from the condenser waterboxes are discharged to the atmosphere as they are not radioactive.

During normal plant operation, chlorination of the circulating water and the condenser tube cleaning system are continuously operated. Chlorination is used to control biological growth inside the condenser tubes and the growth of marine organisms in the intake structure. The condenser tube cleaning system maintains condenser efficiency to the design levels by removing bio-fouling, sediment, corrosion products, and scaling. Specially engineered, oversized, sponge rubber balls constantly circulate throughout the condenser, wiping the tube inner walls clean. The condenser tube cleaning system is provided to ensure condenser cleanliness by continuously removing any type of fouling that may be deposited in the condenser tubes. In addition, self-cleaning filters are provided at the water-box inlet lines.

The circulating water system is designed to prevent any inflow of radioactive material into the circulating water. Circulating water passing through the main condenser is at a higher pressure than the st. am on the condensing side. Therefore, any leakage, such as from the main condenser tubes, would be from the circulating water into the shell side of the main condenser.

Small leaks around valves and fittings are detected by level alarms in the condenser pit sump. Large leaks due to pipe or expansion joint failure would be indicated in the control room by both a gradual loss of vacuum and by level alarms with high- high condenser pit water level switches. 204

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10.4.5.3 Safety Evaluation

The circulating water system is non-safety-related. No safety evaluation is required.

10.4.5.4 Tests and Inspections

The performance and structural and leaktight integrity of all system components are demonstrated by continuous operation. All active components of the system are accessible for inspection during plant power generation. The circulating water pumps are tested in accordance with standards of the Hydraulic Institute. Performance, hydrostatic, and leakage tests are performed on the circulating water butterfly valves in accordance with the American Water Works Association Code 504 for rubber-seated butterfly valves.

10.4.5.5 Instrument Application

The circulating water (CW) pumps are controlled from the main control room where pump status is indicated. CW pump trip is annunciated in the main control room. Local pressure indicators and pressure transmitter with a remote indication in the main control room are provided for the CW pump discharge lines.

The CW pump discharge valves and the condenser CW inlet/outlet valves are also controlled from the main control room where valve status is indicated. The CW pump discharge valves are automatically opened 45% immediately after their associated pumps are started and can be fully opened by manual when 4 pumps or more than 4 pumps are running. The CW pump discharge valves will automatically close when their associated pump stops. 204

Condenser inlet and outlet CW pressures are indicated locally. Condenser inlet and outlet CW temperatures are indicated locally and are input to the plant computer. Intake water level is indicated and low level is annunciated

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in the main control room. Level gages are provided locally at each condenser outlet waterboxes. High level alarms for the condenser pit and the priming tank and low level alarms for the condenser water boxes are provided in the main control room.

10.4.6 Condensate Polishing System

10.4.6.1 Design Bases

The condensate polishing system at YGN 3&4 removes dissolved and suspended impurities from the condensate to maintain the polished water chemistry within the following limits:

a.	Sodium (as Na^+)	≤ 1.0 ppb
b.	Chloride (as Cl^-)	≤ 0.15 ppb
c.	Silica (as SiO_2)	≤ 1.0 ppb
d.	Cation Conductivity	≤ 0.2 μmhos/cm @ 25°C
e.	Iron (as Fe)	≤ 1.0 ppb
f.	Suspended Solids	≤ 1.0 ppb
g.	pH (at 25°C)	6.8 - 7.2
h.	Sulfate (as SO_4^{-2})	≤ 0.2 ppb

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The system is designed to continuously treat the full condensate flow supplied from the condensate system. However, the system may be operated in the full-flow mode, partial-flow mode, and by-pass mode. The system is also designed to operate during each startup in a "recirculation cleanup" mode to remove corrosion products from the secondary water system.

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All pressure vessels except the hot water tank are designed and constructed in accordance with ASME Section VIII. The hot water tank is designed and constructed in accordance with ASME Section IV.

This system is classified as non-safety-related, Quality Group D, seismic Category III.

10.4.6.2 <u>System Description</u>

10.4.6.2.1 <u>General Description and System Operation</u>

The condensate polishing system can be divided into two subsystems: the polishing system and the external resin regeneration system.

The polishing subsystem for each unit consists of five parallel cation exchanger vessels followed by five parallel mixed-bed ion exchanger vessels. Each combination of a cation exchanger vessel and mixed-bed ion exchanger vessel has a capability to process one-fourth of the full condensate flow. As a minimum, one set of the vessels is maintained on standby condition. As a result, the system can remain in continuous operation without reducing the process capability during all plant operation modes.

In order to ensure that a condensate polishing vessel is always on standby and to minimize the possibility of introducing regenerant chemicals into the feedwater train, the exhausted resin from the condensate polishing vessels is transferred to the external resin regeneration subsystem.

Separate regeneration tanks are provided for the cation and mixed bed ion exchanger vessels. The regeneration subsystem for the cation exchanger vessels consists of two cation regeneration and hold tanks.

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The regeneration subsystem for the mixed-bed polishers consists of four vessels including resin separation and cation regeneration tank, anion regeneration tank, resin mixing and hold tank, and intermediate resin storage tank.

The regeneration sequence is automatic, following manual initiation by the operator. The regeneration subsystem also includes sulfuric acid and caustic storage facilities, dilution water supply, hot water tank, and a control panel for monitoring regeneration as well as the status of individual polishing vessels.

Regeneration waste is discharged to the condensate polishing area sump and transfered to the centralized wastewater treatment system through the chemical wastewater pond for waste treatment and disposal. If the radioactivity level of the waste in the condensate polishing area sump exceeds the set limit, the waste is diverted to the liquid radwaste system after neutralization (pH 5.8 ~ 8.6) is completed in chemical wastewater ponds with caustic or acid, injected from the chemical storage tanks of the condensate polishing demineralizer system. The pH of the waste will be controlled at the LRS high TDS tank, evaporator feed tank, and evaporator before it is entered into the SRS concentrate tank. 1

10.4.6.2.2 Component Description

10.4.6.2.2.1 General

All service vessels and regeneration tanks of the system are provided with manholes to permit periodic inspection of the vessel internals. Vessels also include a sufficient number of sight glasses to enable plant operators to determine resin levels and interfaces.

Design maximum pressure for all vessels and piping except for regeneration equipment is the shutoff head of the condensate pump. Vessel internals are capable of withstanding this head as a differential pressure.

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10.4.6.2.2.2 Cation Exchanger Vessel

Each of five cation exchanger vessels has a capacity of 25% full condensate flow. The main function of the vessels is to remove pH agent from the 626 condensate and to provide primary filtration. The vessels are fabricated from carbon steel and are lined with 3/16-inch (4.76-mm) rubber.

10.4.6.2.2.3 Mixed-Bed Ion Exchanger Vessel

The mixed-bed ion exchanger vessels remove ionic impurities including chloride ion and provide additional filtration capabilities. Each vessel has a 3-foot (91-cm) minimum resin bed depth. The vessels are fabricated from carbon steel and are lined with 3/16-inch (4.76-mm) rubber.

10.4.6.2.2.4 Cation Regeneration and Hold Tanks

The cation regeneration and hold tank collects spent resin from the cation exchanger vessel and regenerate it with the sulfuric acid. The cation regeneration and hold tank holds the regenerated cation resin until it is transported to the standby cation vessel. The tanks are fabricated from carbon steel and are lined with 3/16-inch (4.76-mm) rubber.

10.4.6.2.2.5 Mixed-Bed Regeneration Tanks

The tanks included are the resin separation and cation regeneration tank, the anion regeneration tank, the resin mixing and hold tank, and the intermediate resin storage tank. The tanks are fabricated from carbon steel and are lined with 3/16-inch (4.76-mm) rubber.

10.4.6.2.2.6 Sulfuric Acid and Caustic Storage and Feed System

The system consists of the sulfuric acid and caustic bulk storage tanks, day

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tanks and metering pumps. A hot water tank is also provided to supply caustic dilution water.

During regeneration, the metering pumps deliver precise quantities of chemicals from the day tanks to the cation and anion regeneration tanks as determined by the automatic control system. When the day tank level becomes low, the chemical is delivered from the bulk storage tank to the day tank by gravity. The regeneration chemicals are diluted to approximately 5% by weight before being introduced into the regeneration tanks.

The acid and caustic day tanks are sized for two complete regenerations of a cation and mixed bed ion exchanger vessel combination. The acid and caustic bulk storage tanks are sized for minimum 30 days of storage based on the expected regeneration frequency.

10.4.6.2.2.7 Sampling System

The sampling system is provided for monitoring polishing vessel effluent chemistry. The sampling system includes a sample sink with instruments for measuring cation conductivity, specific conductivity, and pH and also provisions for collecting grab samples.

10.4.6.3 Safety Evaluation

The condensate polishing system is a non-safety-related system and is not required for the safe shutdown of the plant.

10.4.6.4 Testing and Inspection

All equipment is inspected and tested in accordance with the applicable equipment specifications and codes. The equipment manufacturer's recommendations and station practices are considered in determining required

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maintenance.

10.4.6.5 Instrument Application

A local control panel (LCP) is provided for monitoring and controlling the condensate polishing system. The acid and caustic metering pumps are controlled from this panel and deliver precise quantities of chemicals from the day tanks to the regeneration tanks as determined by the automatic control system. Acid and caustic dilution water flow is indicated locally. High/low conductivity for the regenerant concentration is annunciated at the LCP. Low dilution water flow trips the acid and caustic metering pumps. Low level in the acid and caustic day tanks trips the respective metering pump and low level in either tank is annunciated on the LCP. Pressure, differential pressure, temperature, and flow indicators; flow totalizers; and flow recorders for cation and mixed bed ion exchanger vessel are provided on the LCP.

Condensate total flow through each cation and mixed-bed ion exchanger vessel is indicated on the LCP. High differential pressure through any cation or mixed bed ion exchanger vessel is annunciated. Cation exchanger vessel and mixed bed ion exchanger vessel outlet conductivity and pH are monitored at the sample sink. Chlorine and sodium can be monitored by taking grab samples. The cation vessel or mixed bed ion exchanger vessel is put into the standby mode by a high conductivity signal from either the cation vessel or the mixed bed ion exchanger vessel. Individual ion exchanger vessel is manually removed from service when either the level of impurities in the effluent or the differential pressure exceeds specified limits, or after a specified amount of fluid has been processed.

A system trouble alarm is provided in the main control room to alert any abnormal condition to the plant operator.

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10.4.7 Condensate and Feedwater Systems

The condensate and feedwater systems provide heated feedwater to the steam generators. The systems have the capability of maintaining the proper feedwater inventory in the steam generator during plant load changes. The portion for the condensate storage facilities of the condensate system is discussed in the Subsection 9.2.6.

10.4.7.1 Design Bases

10.4.7.1.1 Safety Design Bases

The systems are designed to meet the following criteria:

a. The feedwater lines are designed so that failure in this piping has minimal effects on the reactor coolant pressure boundary (RCPB).

b. The feedwater lines are designed so that the postulated failure of any feedwater supply piping does not prevent the safe shutdown of the reactor.

c. The main feedwater isolation valves and piping from the MSIV room penetration anchors to the steam generator nozzles are designed to withstand the effects of a safe shutdown earthquake (SSE).

d. Components and piping are designed, protected from, or located to protect against the effects of high- and moderate-energy pipe rupture, whip, and jet impingement.

e. These systems are designed such that adverse environmental conditions such as typhoon, floods, and earthquakes do not impair its safety function.

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f. The loss of offsite power to the system does not prevent the safe shutdown of the reactor.

g. The feedwater system is designed to prevent the initiation of or minimize the effects of water hammer transient.

10.4.7.1.2 Power Generation Design Bases

The systems are designed to meet the following criteria:

a. The condensate and feedwater systems are designed to provide feedwater to the steam generator at the required temperature and pressure during all phases of operation including steam generator refilling following draining or dry layup.

b. Extraction lines and feedwater heaters are designed to minimize the possibility of water induction to the main turbine and to limit main turbine overspeed due to entrained energy in the extraction system.

10.4.7.2 System Description

The condensate and feedwater systems consist of the piping, valves, pumps, heat exchangers, controls, instrumentation, and the associated equipment that supply the steam generators with heated feedwater in a closed steam cycle using regenerative feedwater heating. The systems are shown on Figure 10.4-4. The portion of the feedwater system, from the MSIV room penetration anchors located at upstream of the main feedwater isolation valves to the steam generator inlet nozzles, is nuclear safety-related and designed in accordance with the requirements of ASME Section III, Class 2 components.

The other portion of the condensate and feedwater systems is non-safety-related and is designed in accordance with ANSI/ASME B31.1.

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The main condenser hotwells receive condensate makeup from the condensate storage tank. Refer to Subsection 9.2.6 for discussion of the condensate storage facilities.

The main portion of the feedwater flow is condensate pumped from the main condenser hotwells by the condensate pumps. There are four 33-1/3% capacity vertical centrifugal condensate pumps per unit with motor drives and common suction and common discharge headers. Three pumps are normally in operation and the fourth pump can be manually started if one condensate pump trips. The condensate pumps take suction from the condenser hotwell and pump condensate through the condensate polishing system, the steam jet air ejector condensers, the steam packing exhauster, and the low-pressure feedwater heaters, including the deaerator to the two deaerator storage tanks.

The two lowest pressure feedwater heaters are installed in the main condenser necks. The No. 3 feedwater heater is vertical. All the low-pressure heaters, except the deaerator, are of the closed type and have integral drain coolers. Low-pressure feedwater heater No. 4 is the direct-contact deaerating feedwater heater.

Three stages of low-pressure feedwater heaters are arranged in three trains. Each train of these low-pressure feedwater heaters is provided with motor-operated isolation valves.

The drains from the three low-pressure feedwater heater No. 3 shells cascade in three parallel trains through the respective feedwater heater No. 2 and No. 1 shells and then flow to the three main condenser shells. Low-pressure feedwater heaters have drain lines to allow direct discharge to the main condenser shells.

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The condensate, after passing from the main condenser through the low-pressure feedwater heaters and deaerator, is fed to the feedwater booster pumps suction.

There are three 65% capacity feedwater booster pumps and three 65% capacity feedwater pumps. During normal operation, two feedwater booster pumps take suction from the deaerator storage tanks and discharge feedwater flow to the suction of respective two feedwater pumps. Two feedwater pumps supply the feedwater to the two steam generators through three stages of high-pressure feedwater heaters. All the feedwater booster pumps and one of the feedwater pumps are motor-driven and the other two feedwater pumps are turbine-driven. All the feedwater pumps have independent variable-speed control units.

The driving steam for the two feedwater pump turbines is supplied from the hot reheat steamline during normal operation and from the main steam header at low load or overload operation such as single feedwater pump train operation.

Two parallel trains of high-pressure feedwater heaters with integral drain coolers are used. The drains from the two high-pressure feedwater heater No. 7 shells cascade in two parallel trains through the respective feedwater heaters No. 6 and No. 5. The No. 5 feedwater heaters drain to the deaerator storage tanks through the deaerator. Provisions are made in heater drain lines to allow direct discharge to the main condenser shells.

Isolation valves and bypass valves are provided to allow each train of high-pressure heaters to be removed from service. System operability is maintained with the remaining train.

During unit startup and shutdown, feedwater is supplied to the steam generators by the motor-driven startup feedwater pump. The startup feedwater pump and associated control valve provide feedwater flow at low power levels to increase the operator's ability to control steam-generator levels during

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startup, shutdown, and hot standby condition where low feedwater flow rates are required. The startup feedwater pump can also be used for refilling the steam generators during layup condition.

Feedwater flow to each steam generator is controlled by two feedwater control valves located in the economizer feedwater line and the downcomer feedwater line. Signals from the feedwater control system set the speed of the feedwater pumps and the position of the feedwater control valves.

The main feedwater isolation valves are designed to isolate the feedwater system from the steam generator in the event of a steamline break, feedwater line break, or loss-of-coolant accident (LOCA). This isolation precludes any possibility of radioactivity release from the containment due to a condensate or feedwater pipe break.

Minimum flow control systems are provided to allow condensate, feedwater, and startup feedwater pumps in the condensate and feedwater trains to operate at a sufficient rate to prevent damage to the pumps.

10.4.7.3 Safety Evaluation

a. The feedwater lines are restrained or are separated to the extent necessary to prevent damage to the RCPB in the event of a feedwater pipe rupture. Refer to Section 3.6 for additional discussion on this subject.

b. The feedwater lines are designed and routed so that a single failure will not prevent a safe shutdown of the reactor. Refer to Section 3.6 for information on this subject.

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c. The main feedwater isolation valves and piping between them and the steam generators are designed to meet seismic Category I criteria in accordance with requirements given in Sections 3.7 and 3.9.

d. Components and piping are designed to protect against the effects of high- and moderate-energy pipe rupture as discussed in Section 3.6.

e. Adverse environmental conditions do not impair the safety function of the safety-related portion of this system. Wind and typhoon loadings are discussed in Section 3.3. Flood design is covered in Section 3.4. Seismic design is discussed in Section 3.7. The environmental design of mechanical equipment is covered in Section 3.11.

f. The loss-of-offsite power does not prevent the safe shutdown of the reactor as discussed in Sections 7.4 and 8.3.

g. The feedwater system is designed to prevent the initiation of or minimize the effects of water hammer transients in accordance with requirements given in Section 3.9.

10.4.7.4 Tests and Inspections

ASME Section III, Class 2 piping from and including MSIV room penetration anchor up to the steam generator is inspected and tested in accordance with ASME Sections III and XI. Piping from the condenser hotwell up to MSIV room penetration anchor is inspected and tested in accordance with Paragraphs 136 and 137 of ANSI/ASME B31.1. ASME Section III, Class 2 valves are periodically inservice tested for exercising and leakage in accordance with ASME Section XI, Subsection IWV.

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Each feedwater heater, deaerator storage tank, pump, and valve is shop tested by hydrostatic tests in accordance with applicable codes. Tube joints of feedwater heaters are shop leak tested. Before initial operation, the completed condensate and feedwater systems receive a field hydrostatic test and inspection in accordance with applicable codes. Periodic tests and inspections of the systems are performed in conjunction with scheduled maintenance outages.

Inservice inspections for the portions which are not ASME Section III, Class 2 components are not required unless there is an indication of malfunction somewhere in the system.

10.4.7.5 Instrument Application

The feedwater pumps, feedwater booster pumps, startup feedwater pump, and condensate pumps are all controlled from the main control board (MCB) where pump status is indicated. Low suction pressure of the feedwater pumps, feedwater booster pumps and startup feedwater pump and high discharge header pressure of feedwater pumps and startup feedwater pumps are annunciated. Controls are provided to maintain pump minimum flow (recirculation flow) to prevent feedwater pump damage. The fourth standby condensate pump can be manually started if one of the three operating pumps trips.

Motor driven feedwater pump is tripped when total feedwater flow exceed 140% of design flow, and the operating main feedwater pump is automatically tripped when any one of the following signals exists : 43

a. The associated feedwater booster pump net positive suction head (NPSH) low-low

b. Main steam isolation signal (MSIS)

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c. The associated feedwater booster pump trip

d. Pump discharge valve closed

e. The feedwater pump discharge common header pressure high-high (2 out of 3)

f. Feedwater pump turbine trip signals to protect the turbine-driven feedwater pump

g. Electrical protection signal (only for motor driven pump)

h. Lube oil pressure low-low

Feedwater flow, condensate flow, main steam flow, and steam generator (SG) level are all indicated on the MCB. Redundant, operator selectable, SG level, feedwater, and main steam flow signals are inputted to the feedwater control system (FWCS) to regulate feedwater flow to meet system demands by modulating feedwater pump speed and feedwater control valve position. The following alarm signals from the FWCS are provided to the plant annunciator and to the plant computer:

a. Reactor tripped override
b. SG high level override
c. SG Hi/Lo level
d. SG level channel deviation
e. FWCS in test

The main feedwater isolation valves (MFIV) can be manually opened or closed with control switches located on the MCB. These valves are automatically closed on a main steam isolation signal from the engineered safety features actuation system (ESFAS). The valve control pressure low or hydraulic

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reservoir level low of each MFIV are annunciated on the MCB. The control circuitry for the main feedwater isolation valves is duplicated in order to 71 avoid spurious trip signal in the ILS (Interposing Logic System).

The water inventory in the condensate and feedwater systems is maintained through automatic makeup and rejection of condensate to the condensate storage tank. System makeup and rejection are controlled by the condenser hotwell level controllers.

The system water quality is automatically maintained through the injection of hydrazine and pH agent into the condensate system. The pH agent and hydrazine 626 injection is controlled by the specific conductivity and the hydrazine residuals in the system, which is continuously monitored by the process sampling system.

10.4.8 Steam-Generator Blowdown System

The steam-generator blowdown system (SGBDS) is used in conjunction with the chemical feed portion of the feedwater system and the condensate polishing demineralizer system to control the chemical composition and solids concentration in the feedwater. The design of this system allows for heat recovery by use of flash tanks that return steam to HP heaters and condensate to the deaerator.

10.4.8.1 Design Bases

The blowdown piping and valves, from the steam generators to the MSIV room, including containment isolation valves capable of automatic closure during all modes of normal reactor operation, are safety-related and Quality Group B. The steam-generator shell-side pressure boundary is also safety-related and Quality Group B. Thereafter, the piping, valves, heat exchangers, tanks, filters, demineralizers, and appurtenances are non-safety-related Quality Group D.

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The SGBDS is capable of maintaining the chemical purity of the SGBDS discharge within secondary-side water limits. To maintain steam-generator secondary-side water chemistry criteria, a continuous blowdown from both steam generators is in effect under normal operating conditions. In the event of condenser water leakage, dissolved sodium content in the secondary-side water can be reduced by increasing the blowdown rate.

The SGBDS is capable of accommodating the simultaneous continuous blowdown of one steam generator (63,720 lbm/hr, 28,900 kg/hr) and a high capacity blowdown of the other steam generator. The SGBDS is capable of accepting and processing a continuous blowdown of up to 127,440 lbm/hr (57,800 kg/hr) total while the plant is at power and steam generator chemistry is within abnormal limits. The steam generator blowdown line connected to each steam generator blowdown connection is capable of accommodating a continuous blowdown of 63,720 lbm/hr (28,900 kg/hr) for each steam generator. 812

The blowdown system piping material is compatible with saturated steam and two-phase fluid flow service. All the vessels and tanks in the SGBDS are fabricated in accordance with ASME Code Section VIII requirements. Safety-related portions of the piping fabrication meet ASME Code Section III Class 2. The other portion of the system piping is fabricated in accordance with ANSI/ASME B31.1. The heat exchangers are fabricated in accordance with Tubular Exchangers Manufacturers Association standards.

The SGBDS is designed to reduce the steam-generator secondary-side water radiation level by 90% during design-basis fuel failure concurrent with design-basis steam-generator primary-to-secondary tube leakage.

In case of primary-to-secondary leakage, the blowdown rate from the nonleaking steam generator can remain in the normal operating rage, while the blowdown rate from the leaking steam generator may be increased to maintain the secondary radioactivity level below the technical specification limit.

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Periodically, a high-capacity blowdown is to be used to remove the accumulated sludge on the tube sheet, thus providing further cleaning of steam generator secondary side water.

The design of this system allows recovering a portion of the heat energy contained in the blowdown fluid and by returning it to the secondary system using regenerative heat exchangers.

The SGBDS is also designed to permit recirculation, purification, draining, refilling, nitrogen supply, and chemical addition/mixing for wet and dry layup of the steam generators.

10.4.8.2 System Description and Operation

10.4.8.2.1 General

The SGBDS flow diagram is shown in Figure 10.4-5. The SGBS consists of two subsystems, the blowdown subsystem (BDS) and wet layup subsystem (WLS). The BDS consists of two continuous blowdown (CBD) processing trains and a common high-capacity blowdown (HCBD) processing train. All three trains share the downstream filtering and demineralizing components. The WLS consists of two recirculation trains (one for each steam generator). The WLS shares the BDS filters and demineralizers.

10.4.8.2.2 Component Description

10.4.8.2.2.1 Steam-Generator Blowdown Regenerative Heat Exchanger

The SGBDS regenerative heat exchangers are shell-and-tube-type heat exchangers. High-energy blowdown from the steam generators passes through the shell side and the condensate from downstream of condensate polishers passes through the tubes as the cooling water recovering thermal energy. Blowdown

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temperature is controlled by modulating the condensate flow rate.

10.4.8.2.2.2 SGBDS Nonregenerative Heat Exchanger

The SGBDS nonregenerative heat exchanger is a shell-and-tube-type heat exchanger. The component cooling water system is the cooling water source and flows through the shell side of the heat exchanger. It reduces the blowdown water temperature for the radioactive chemical treatment.

10.4.8.2.2.3 Flash Tanks

Three flash tanks are provided: one high-capacity blowdown (HCBD) flash tank and two continuous blowdown (CBD) flash tanks. The HCBD flash tank collects the HCBD water and supplies the water to SGBDS nonregenerative heat exchanger. The CBD flash tank collects the CBD water and supplies the water to the SGBDS regenerative heat exchanger. The flash tanks are vertical steel pressure vessels equipped with level, pressure, and temperature instrumentation. The tank pressure for each flash tank is modulated by a vent valve. The flash tanks have a nozzle for blowdown, vent pressure relief, and draining and for instrumentation connections.

10.4.8.2.2.4 High-Capacity Blowdown Transfer Pump

The centrifugal HCBD transfer pump provides the motive force to transfer high capacity blowdown from the HCBD flash tank to the SGBDS nonregenerative heat exchanger and mix HCBD water with continuous blowdown water.

10.4.8.2.2.5 Wet Layup Recirculation Pump

The centrifugal wet layup recirculation pumps recirculate steam-generator water to be filtered and purified.

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10.4.8.2.2.6 Filters

Two types of filters are provided. The first type is a prefilter to the demineralizer train, which removes particulates to prevent fouling the demineralizers. The second type is a postfilter on the discharge of the demineralizer train to prevent resin fines from being carried into the condensate system.

10.4.8.2.2.7 Demineralizers

In order to purify the steam-generator blowdown water to a quality that can be returned to the condensate system, a demineralizer train is provided. The train consists of two mixed-bed demineralizers, piping, valves, instrumentation, and controls. One mixed-bed demineralizer is online while the other is on standby.

10.4.8.2.3 System Operation

The normal blowdown, at a rate of 25,200 lbm/hr (11,430 kg/hr) total, normally 812
continues throughout normal plant operation except when HCBD occurs. HCBD is
expected to occur once per week, periodically, or as required. However, if
steam-generator water chemistry is out of predetermined specifications, the
CBD flow rate can be increased up to 127,440 lbm/hr (57,800 kg/hr) total. 812
Periodically, once per week, or as required, HCBD operation is performed at a
flowrate of 1,032,120 lbm/hr (468,160 kg/hr) or 618,840 lbm/hr (280,700 kg/hr) 812
through the cold-leg or the hot-leg nozzles, respectively, of the steam 1
generators to remove sludge accumulated on the steam generator tube sheet.

Abnormal blowdown follows HCBD and continues until the steam generator water quality is within water chemistry specifications.

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Continuous blowdown, either normal blowdown or abnormal blowdown, is discharged to the CBD flash tank. Pressure control valves located in the flash tank vent lines maintain constant CBD flash tank pressure (200 psig). Level control valves located at the downstream of the regenerative heat exchanger maintain constant CBD flash tank level. Flashing steam from the CBD flash tank is normally vented to the high-pressure feedwater heaters 5A and 5B to regenerate latent energy from the vented steam. The normal-blowdown water flows through the regenerative heat exchangers to heat the condensate flowing through the tubes. The heated condensate is returned to the deaerator. Control valves located in the condensate system maintain a constant CBD water temperature (130°F, 54°C) downstream of the regenerative heat exchangers piping.

The component cooling water that flows through the shell side of the non-regenerative heat exchanger further cools the blowdown water. The blowdown water temperature at the exit of the nonregenerative heat exchanger is not controlled. The cooled blowdown water is filtered and demineralized downstream of the nonregenerative heat exchanger. The blowdown water is returned to main condensers A or C.

HCBD, which has a 2-minute duration, is collected in the HCBD flash tank. The pressure control valve vents steam to the main condenser maintaining a constant flash tank pressure 185 psig. The HCBD flow rate is controlled by the HCBD inlet flow control valves. Following HCBD, the HCBD flash tank pressure is depressurized to 5 psig by adjusting the pressure control valve. The blowdown water collected in the HCBD flash tank is pumped to the nonregenerative heat exchanger using the HCBD transfer pump.

The steam generators are maintained in a wet layup condition when the plant shutdown is expected to be long term. After wet layup ceases, the steam generator is drained to the condenser pit sump by gravity or by using the wet layup recirculation pumps until the required water quality is met and the

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desired water level is achieved. The steam generator is refilled by using the feedwater system. When the feedwater system is not available, the auxiliary feedwater system is used.

The steam generators may be kept in a dry condition with a nitrogen blanket, if the shutdown is expected to be short term.

The BDS shall be capable of reducing radioactivity levels in the blowdown stream by 90% during design-basis fuel failure concurrent with design-basis steam-generator primary-to-secondary tube leakage.

In the event of the main condenser tube leakage and concurrent high chloride concentration downstream of the demineralizers and filters, the blowdown water may be discharged to the waste water treatment system through the non-radioactive vents and drains system.

10.4.8.3 Safety Evaluation

The blowdown isolation valves are automatically closed to maintain containment integrity and steam generator water inventory following a postulated accident when a main steam isolation actuation, auxiliary feed water actuation, or containment isolation actuation signal is generated. The outermost containment isolation valves are also automatically closed when high-high level in the HCBD/CBD flash tanks or high radiation level at the exit of the mixed bed demineralizers occurs.

All system piping and components that are part of the containment isolation features or the steam-generator shell-side pressure boundary are designed in accordance with seismic Category I requirements as specified in Section 3.2. For the blowdown line, the seismic Category I portion is extended to the MSIV room wall penetration anchor.

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10.4.8.4 Tests and Inspections

Periodic tests and recalibration will be performed on the radiation monitors in the blowdown processing system. Periodic functional tests of the blowdown system containment isolation valves will be performed to check operability and leaktightness. Periodic visual inspections and preventive maintenance can be conducted as necessary as components are accessible for inspection and maintenance.

10.4.8.5 Instrumentation Application

Radiation monitoring is provided at the outlet of the post-filter as discussed in Section 11.5.

Each CBD flash tank is provided with level and pressure controls. The CBD pressure control valves located in the vent lines are set to open and maintain constant tank pressure. The level control valves located downstream of the regenerative heat exchanger maintain the flash tank water level.

The pressure control valve in the HCBD flash tank vent line maintains the HCBD flash tank pressure constant during HCBD. Following HCBD collection, the tank pressure is gradually lowered by adjusting the pressure control valve set pressure by 5 psig (0.35 kg/cm^2) step changes remotely from a local control panel until the tank pressure reaches 5 psig.

The HCBD pump is interlocked to the HCBD flow control valves so that the pump cannot be started when either of the two inlet flow control valves is open, the HCBD flash tank level is low, or the HCBD flash tank pressure exceeds 10 psig (0.70 kg/cm^2).

High- and low-flow-rate alarms at the exits of the regenerative heat exchangers and in the steam vent piping are provided in the MCR panel to alert

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the operator of potential trouble in downstream piping, or malfunction of the CBD flash tank controls.

High temperature alarms at the exit of the regenerative heat exchangers are annunciated on the MCB to alert the operator of potential malfunction of the heat exchanger. A high temperature alarm at the inlet of the mixed-bed demineralizer is provided on the MCB to annunciate high inlet blowdown water temperature.

High-high, high, and low level alarms for CBD, high-high level alarm for HCBD flash tanks are provided on the MCB to alart the operator of potential HCBD/CBD flash tank trouble. In addition, high- and low-level alarms for HCBD flash tank are provided on the LCP.

10.4.9 Auxiliary Feedwater System

The auxiliary feedwater system (AFWS) supplies feedwater to the steam generators during hot standby conditions and reactor cooldown to the point where the shutdown cooling system (SCS) starts operation, whenever the main feedwater system fails to supply feedwater following any postulated accident. The AFWS can also supply feedwater to the steam generators during the steam-generator wet lay-up refilling mode if the startup feedwater pump is not available.

10.4.9.1 Design Basis

The function of the auxiliary feedwater system is to provide adequate cooling water to the steam generators in the event of a loss of main feedwater. Either of the two auxiliary feedwater subsystems supplying any one or both steam generators provides enough feedwater to cool the unit down safely to the temperature at which the shutdown cooling system can be utilized. The total amount of feedwater required to replace steam vented to the atmosphere and to compensate for shrinkage during cooldown is 300,000 gallons (1135.6 m^3) for

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any one or both steam generators.

The auxiliary feedwater system is seismic Category I and Quality Group C up to the outermost motor-operated auxiliary feedwater isolation valve inlet piping and valves from the outermost motor-operated isolation valve to the feedwater system connection are Quality Group B. Under emergency conditions, the auxiliary feedwater pumps normally take suction from and have a recirculation line back to the condensate storage tanks, which are seismic Category I, Quality Group C (refer to Subsection 9.2.6). The auxiliary feedwater system can be supplied with demineralized water and/or raw water as a backup water source. These water sources are seismic Category III, Quality Group D, and are supplied through the condensate supply headers. 1

10.4.9.2 System Description

The auxiliary feedwater system consists of two subsystems. Each subsystem utilizes a motor-driven pump powered from the Class 1E switch gear which has been connected to one of the emergency onsite power systems supplied from an emergency diesel generator and a diesel-driven pump that is directly powered by a diesel engine through a gear increaser. Each of the two subsystems can deliver feedwater to both steam generators. The system has been designed to provide adequate feedwater to the intact steam generator in the event of a main feedwater or steam line rupture coupled with a single failure in the auxiliary feedwater system, as shown in Table 10.4-3. Equipment redundancy, flow paths, safety class and quality group boundaries, major line sizes, and system operation are illustrated on the system diagram (Figure 10.4-6). 1

The auxiliary feedwater system provides redundant and diverse means of supplying feedwater to the steam generators for cooling the reactor coolant system under emergency conditions. The auxiliary feedwater system can also perform its safety-related function assuming a postulated failure in the feedwater piping to one steam generator concurrent with a single active component

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failure in the auxiliary feedwater system. The minimum flow is delivered assuming the following failure modes:

a. Loss of normal feedwater.

b. Minor secondary system pipe breaks or valve failures with or without a concurrent loss of offsite power and the most limiting single failure in the auxiliary feedwater train.

c. Steam-generator tube rupture with or without a concurrent loss of offsite power and the most limiting single failure in the auxiliary feedwater train.

d. Major secondary-system pipe breaks with or without a concurrent loss of offsite power and the most limiting single failure in the auxiliary feedwater train.

e. Any incident that will result in loss of offsite power and normal onsite ac power.

f. Small LOCA with or without a concurrent loss-of-offsite power and the most limiting single failure in the auxiliary feedwater train.

During transient or accident conditions, the auxiliary feedwater system is designed to provide a required total flow as follows:

a. Without a secondary pipe rupture, the continuous flow delivered to any steam generator requiring auxiliary feedwater is equal to or greater than 550 gpm (2.08 m^3/min) at a steam-generator pressure of 1270 psia (89.3 kg/cm^2A) assuming the loss of offsite power and the most adverse single failure in the auxiliary feedwater system. If both steam generators require auxiliary feedwater, the total flow to

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both steam generators is equal to or greater than 550 gpm (2.08 m^3/min) at a steam-generator pressure of 1270 psia (89.3 kg/cm^2A) assuming the loss-of-offsite power and the most adverse single failure. The total flow delivered to one or both steam generators requiring auxiliary feedwater is less than or equal to 1550 gpm (5.87 m^3/min) at 1270 psia (89.3 kg/cm^2A).

b. With a secondary pipe rupture, the auxiliary feedwater flow rate is as follows:

Before isolation of the ruptured steam generator, the flow delivered to the intact steam generator is equal to or greater than 220 gpm (0.833 m^3/min) at a steam-generator pressure of 1270 psia (89.3 kg/cm^2A). This assumes that a loss-of-offsite power and the most adverse single failure in the auxiliary feedwater system have occurred. The total flow delivered to both the steam generators is less than or equal to 2300 gpm (8.71 m^3/min) at runout conditions in the auxiliary feedwater system (steam generators at atmospheric or containment pressure, depending on the rupture location).

After isolation of the ruptured steam generator, the auxiliary feedwater flow delivered to the intact steam generator is equal to or greater than 550 gpm (2.08 m^3/min) at a steam-generator pressure of 1270 psia (89.3 kg/cm^2A), assuming a loss-of-offsite power and the most adverse single failure in the auxiliary feedwater system. The flow delivered to the intact steam generator is less than or equal to 2300 gpm (8.71 m^3/min) at runout conditions, and 1550 gpm (5.87 m^3/min) at a steam generator pressure of 1270 psia (89.3 kg/cm^2A).

The auxiliary feedwater system starts automatically without operator action with an actuation signal following an accident. The auxiliary feedwater pumps

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automatic actuation is described in Sections 7.3 and 7.7. Manual actuation is also provided. The condensate storage tanks are normally aligned to provide feedwater to the auxiliary feedwater pumps.

The auxiliary feedwater system is continuously available to automatically deliver flow to the steam generator(s) within 45 seconds after receipt of an auxiliary feedwater actuation signal (AFAS), assuming loss-of-offsite ac power. The auxiliary feedwater system is designed to automatically discontinue flow to the affected steam generator(s) within 15 seconds following termination of the AFAS or identification of a ruptured steam generator.

Upon receipt of an AFAS flow is established along both the main and cross-tie flow paths. The auxiliary feedwater (AF) modulating valve to each steam generator is automatically placed into modulating operation. An open signal is automatically sent to the AF isolation/cross-tie isolation valves for each steam generator. Primary flow control is accomplished by modulation of the AF modulating valves, which receive a proportional signal based on the water level in the associated steam generator. When the steam generator level recovers, the AF cross-tie isolation valve is closed before a high level is reached in the associated steam generator. This modulation control continues until the end of the event.

During this modulating operation, if the AF modulating valve control becomes inoperable and/or if the steam generator level decreases, the cross-tie isolation valve open signal automatically reopens the AF cross-tie isolation valve, which was previously closed. If the AF modulating valve control is still inoperable and the steam generator level reaches the high level, the AF isolation/cross-tie isolation valves are closed. On-off control of these isolation valves continues until the end of the event.

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The AF modulating valves are normally open and fail open upon a loss of solenoid valve power. The valve actuators are normally supplied with air from the instrument air system. However, safety-related, seismic Category I backup nitrogen bottles with sufficient capacity for 16 hours of operation are also provided to enable valve modulation following loss of instrument air.

Heat is removed from the reactor by boiling the feedwater in the steam generators and venting steam to the atmosphere through the main steam atmospheric dump valves. If the main condenser is available, the steam may be discharged via the turbine bypass system to the condenser. When reactor coolant temperature and pressure drop to 350°F (177°C) and 410 psia (28.8 kg/cm^{2}A), cooldown is shifted to the shutdown cooling system.

The auxiliary feedwater system is not utilized for normal startup and shutdown of the unit. It is therefore classified as a moderate-energy system. The AFS can be used as an alternate means to the preferred method of using the startup feedwater pump for refilling the steam generators in the wet lay-up mode during operating Modes 5 and 6.

The auxiliary feedwater pumps are described as follows:

Number	Four per unit
Type	Horizontal, centrifugal two motor driven; two direct diesel-driven through a gear increaser
Delivered capacity (each)	353 gpm (1.34 m^3/min) including the minimum flow of 53 gpm (0.2 m^3/min)
Net developed head (approximate)	4100 feet (1250 meters)
Brake horsepower	719 hp (536.2 kW)

The direct-drive component cooling water (CCW) booster pump allows the diesel-driven auxiliary feedwater pumps to supply auxiliary feedwater even with complete loss of ac power for both trains of CCW pumps.

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10.4.9.3 Safety Evaluation

The auxiliary feedwater pumps are started by the auxiliary feedwater actuation signal (AFAS) described in Section 7.3. Two motor-driven pumps are supplied with emergency power from the Class 1E diesel generators. The motor-operated valves are supplied with emergency power from Class 1E ac or dc power sources. The other pumps are diesel-driven so that auxiliary feedwater can be supplied in the event that all onsite and offsite sources of ac power are lost.

The AFAS places the AF modulating valves into modulation mode and aligns the auxiliary feedwater isolation/cross-tie isolation valves to feed the intact steam generator(s). Once the steam generator level is restored, the pumps continue to operate, while the AF modulating valve or AF isolation/cross-tie isolation valves are closed. The same functional logic is also used to provide a close signal to the AF isolation/cross-tie isolation valves to a faulted steam generator to prevent flow to that steam generator. A failure modes and effects analysis is provided in Table 10.4-3.

A restricting flow orifice is provided in each steam-generator supply line so that the auxiliary feedwater flow to the steam generators remains within the minimum and maximum limitation and the auxiliary feedwater pumps can be protected from a runout flow condition caused by a depressurized steam generator.

Auxiliary feedwater is pumped to the downcomer nozzles of the steam generators. Therefore, steam generator downcomer feedwater piping is designed to prevent water hammer induced by the admission of unheated auxiliary feedwater to the steam generators.

Each direct diesel-driven auxiliary feedwater pump is equipped with an independent air start system and requires no supporting services to maintain flow of auxiliary feedwater to two steam generators during loss of onsite and

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offsite ac power. A seismic Category I, Quality Group C diesel fuel oil day tank in each designated room supplies fuel by gravity to its respective engine, via a seismic Category I, Quality Group C supply line.

A local alarm panel is provided for each direct diesel-driven pump to annunciate low lube oil pressure, high jacket water temperature, and low fuel oil day tank level. A trouble alarm in the main control room will annunciate when either of these conditions exists. The engine is automatically tripped in the event of overspeed, high jacket-water temperature and low diesel engine lube oil pressure.

An evaluation of the auxiliary feedwater system in accordance with action item II.E.1.1 of NUREG-0718 is provided in Appendix 10A.

10.4.9.4 Tests and Inspections

Each of the auxiliary feedwater pumps and auxiliary feedwater piping are hydrostatically tested in accordance with ASME Boiler and Pressure Vessel Code Section III, Class 2 for from the feedwater connection up to and including outermost AF isolation valves and Class 3 for the remaining piping and pumps. The diesel driver is given a quick start test, a performance test, and an overspeed trip test prior to shipment. The entire auxiliary feedwater system is functionally tested after assembly is completed. The system is capable of being tested periodically, while the plant is at power, in accordance with the frequency specified in ITS. During the testing period, the backup water sources are not permitted to contaminate the main feedwater system or the steam generators. 325

10.4.9.5 Instrumentation Application

The instrumentation and control for the auxiliary feedwater system are provided on the main control board and remote shutdown panel.

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Main control room instrumentation includes monitoring of auxiliary feedwater flow, temperature, pump suction pressure, pump discharge pressure, motor current for the motor-driven pumps, steam-generator level, control hand-switches with status indicating lights for all power-operated valves and auxiliary feedwater-pumps. The remote shutdown panel includes transfer switches in addition to the above control handswitches.

Alarm are provided for low pump suction pressure, low pump discharge pressure, AF supply high temperature, abnormal pump vibration, pump auto start fail, low air receiver pressure, and low N_2 gas supply header pressure on the main control board, and inoperable status of auxiliary feedwater system is indicated on the main control board.

Local controls are provided for the diesel driven auxiliary feedwater pumps via local push-button switch. The bearing temperature indication is monitored by the plant computer.

A detailed discussion of the auxiliary feedwater-system control functions is provided in Section 7.3. A list of control points and system parameters monitored at the remote shutdown panel is provided in Section 7.4.

A description of flow indication and automatic initiation of the auxiliary feedwater system in accordance with II.E.1.2 of NUREG-0718, Rev. 2, is provided in Section 7.3.

10.4.10 Chemical Feed and Handling System

The chemical feed and handling system injects hydrazine and pH agent into the condensate and feedwater systems to control dissolved oxygen and pH in the condensate, feedwater, and steam generators under all modes of operation and shutdown. 626

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10.4.10.1 Design Bases

The chemical feed and handling system is non-safety-related. The chemical feed and handling system supplies hydrazine continuously to the condensate in an amount required to scavenge dissolved oxygen of the condensate and feedwater systems in order to meet the steam-generator secondary water chemistry requirement as discussed in Subsection 10.3.5.

The chemical feed and handling system supplies pH agent continuously 626
to the condensate to control the pH of the condensate and feedwater system in order to meet the steam-generator secondary water chemistry requirements as discussed in Subsection 10.3.5.

In addition to continuous treatment for normal power operation, the chemical feed and handling system can supply hydrazine pH agent into the steam 626
generator recirculation loop of the steam-generator blowdown system during wet layup, the feedwater system line during startup, and the auxiliary feedwater system line during auxiliary feedwater pump operation.

10.4.10.2 System Description

The hydrazine feed system is supplied with concentrated hydrazine from hydrazine storage tank or drum. The pH agent feed system is supplied with concentrated pH agent from the bulk storage tank or drum to the day tank. 626
Dilution water for hydrazine and pH agent is taken from the condensate system and supplied to the day tanks.

The pH agent metering pumps for condensate system are automatically controlled 626
based on conductivity levels in the feedwater and condensate flow. The hydrazine metering pumps for condensate system are automatically controlled based on residual hydrazine levels in the feedwater and condensate flow.

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pH agent and hydrazine are both injected into a point in the main condensate flow downstream of the condensate polishing demineralizers. 626

pH agent and hydrazine are injected upstream of the recirculation pump of each steam generator when wet layup is required. pH agent and hydrazine may also be injected into the auxiliary feedwater-pump discharge header. 626

The diagram of chemical feed and handling system is shown in Figure 10.4-7.

10.4.10.3 Safety Evaluation

The chemical feed and handling system is a non-safety-related system and is not required for safe shutdown of the plant.

10.4.10.4 Test and Inspections

The chemical feed and handling system is operationally checked before plant startup to ensure proper functioning of the feed systems and chemical tank level sensors.

10.4.10.5 Instrumentation Application

Instrumentation is provided for manual and automatic control of the chemical injection system. The conductivity analyzers and hydrazine analyzers in the process sampling system provide indication of water quality and provide signal input to the automatic mode chemical injectors.

The automatically controlled pH agent metering pumps and hydrazine metering pumps supply pH agent and hydrazine into the condensate. The pump speed control signal is provided to the running pump only. The control signals for automatic operation are received from the process sampling system. 626

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Level switches are provided to stop the pumps when the chemicals in the day tanks drop below low and low-low level are annunciated on the local control panel. A system trouble alarm is provided in the main control room to alert any abnormal condition to the plant operator.

Local and remote alarms are provided to monitor the performance and to protect components of the system.

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TABLE 10.4-1

TURBINE GLAND SEAL SYSTEM

System Components	Design Data
Pressure in steam seal header	3 to 5 psig (0.21 to 0.35 kg/cm^2) 1
Vacuum in gland seal surface condenser	3 to 5 in. H_2O (76.2 to 127 mm H_2O)
Number of gland seal surface condensers	1
Number of blowers mounted on gland seal surface condenser	2

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TABLE 10.4-2

TURBINE-BUILDING DESIGN-BASIS FLOOD LEVEL

Parameter	Quantity
Maximum Inflow (6 CW pumps x 135,833 gpm/pump = 815,000 gpm)	815,000 gpm (185,087 m^3/hr)
Length of Drainage Weir (Permanently installed open louvre siding)	160 ft (48.8 meters)
Height of drainage weir	
Amount of weir blockage in louvre (%)	< 20
Bottom of louvred opening	El. 100 ft 6 in.
Top of louvred opening	El. 104 ft 6 in.
Height of flood over weir to remove 815,000 gpm*	< 3 ft 0 in. (0.9 meters)
Differential flood height required to drive water from turbine building to weir	< 1 ft (0.3 meters)
Height of turbine building flood above grade elevation (el. 100′-6")	< 4 ft 0 in. (1.2 meters)
Design-basis turbine building flood elevation	El. 104 ft 6 in. (31.4 meters)

* A flood height of 3′-0" over a 160′ weir is calculated to flow at 1,150,000 gpm.

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TABLE 10.4-3 (Sh. 1 of 2)

AUXILIARY FEEDWATER SYSTEM
FAILURE MODE AND EFFECT ANALYSIS

(Initiating accident: rupture of main feedwater line close to steam generator)

Component	Failure Mode	Effect
Auxiliary feedwater pump	Fails to start and/or run	Four pumps are provided. Safety-related function can be maintained with the remaining three pumps.
Auxiliary feedwater pump discharge check valve	Fails to open	NA (It may be exempted from single failure per ANSI/ANS 58.9)
	Fails to close (Feedwater back leakage to auxiliary feedwater line)	Redundant check valve and redundant temperature monitoring are available for each train.
Auxiliary feedwater modulating/isolation valves on line leading to steam generator	Fails closed	Redundant cross-tie flow path is available from the other train. The AF modulating valve is opened by fail-open air cylinder actuator. Also, the valves may be opened by a hand wheel.
	Fails open	Two isolation valves are provided on the line. Flow to the steam generator is isolated by at least one of the two redundant isolation valves.

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TABLE 10.4-3 (Sh. 2 of 2)

Component	Failure Mode	Effect
Auxiliary feedwater isolation/cross-tie isolation valves on cross-tie line to the other steam generator	Fails closed	Redundant flow path leading to steam generator is available from the other train. The valves may be opened by a handwheel.
	Fails opened	Two isolation valves are provide on the line. Flow to the steam generator is isolated by at least one of the two redundant isolation valves.
Feedwater check valve, upstream of connection to the feedwater header	Fails to open	NA (It may be exempted from single failure per ANSI/ANS 58.9)
	Fails to close (Feedwater back leakage to auxiliary feedwater line)	Redundant check valve and redundant temperature monitoring are available for each train.

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CONDENSER VACUUM SYSTEM P&ID
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Figure 10.4-1

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Figure 10.4-1

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TURBINE GLAND SEALING SYSTEM
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Figure 10.4-2

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Figure 10.4-3

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Figure 10.4-3

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Figure 10.4-3

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Figure 10.4 3

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Figure 10.4-4

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Figure 10.4-4

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Figure 10.4-4

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Figure 10.4-4

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Figure 10.4-4

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CONDENSATE AND FEEDWATER SYSTEM P&ID
(Sheet 6 of 8)
Figure 10.4-4

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Figure 10.4-4

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CONDENSATE AND FEEDWATER SYSTEM
P&ID
(Sheet 8 of 8)

Figure 10.4-4

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STEAM GENERATOR BLOWDOWN SYSTEM
P&ID
(Sheet 1 of 3)

Figure 10.4-5

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STEAM GENERATOR BLOWDOWN SYSTEM
P&ID
(Sheet 2 of 3)

Figure 10.4-5

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STEAM GENERATOR BLOWDOWN SYSTEM P&ID
(Sheet 3 of 3)

Figure 10.4-5

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AUXILIARY FEEDWATER SYSTEM P&ID
(Sheet 1 of 3)

Figure 10.4-6

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AUXILIARY FEEDWATER SYSTEM P&ID
(Sheet 2 of 3)
Figure 10.4-6

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AUXILIARY FEEDWATER FYSTEM P&ID
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Figure 10.4-6

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CHEMICAL FEED AND HANDLING SYSTEM P&ID

Figure 10.4-7

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APPENDIX 10A

AUXILIARY FEEDWATER SYSTEM RELIABILITY STUDY

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APPENDIX 10A - AUXILIARY FEEDWATER SYSTEM RELABILITY STUDY

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APPENDIX 10A - AUXILIARY FEEDWATER SYSTEM RELABILITY STUDY

10A.1 INTRODUCTION

10A.1.1 Background

The results of many studies pertaining to the Three Mile Island Nuclear Power Plant accident concluded that a proper functioning Auxiliary Feedwater System (AFWS) is of prime importance in the mitigation of such accidents. The NRC letter dated March 10, 1980 (Reference 4) and NUREG-0718, Item II.E.1.1, require a reliability analysis of the AFWS to be performed for three transient conditions involving the loss of main feedwater in a manner similar to the analysis described in NUREG-0635 (Reference 1).

10A.1.2 Scope of Study

The primary objective of the analysis is to demonstrate that requirements of the NRC are met for the current design. The current design incorporates an upgrade to include safety-related air-operated valves with a safety-related backup nitrogen supply, and modification of the operational mode of the air-operated valves and AFW isolation/cross-tie isolation valves.

The other objective of the analysis is to compare the reliability of the two design cases. The reliability analysis of the YGN 3&4 AFWS was performed for the following transient events :

a. Loss of main feedwater and the subsequent tripping of the reactor.

b. Loss of main feedwater due to loss-of-offsite power and the subsequent tripping of the reactor.

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c. Loss of main feedwater due to loss-of-offsite power with loss of all onsite ac power sources (station ac blackout).

10A.1.3 Method of Analysis

The primary basis of this analysis consists of the construction and evaluation of fault trees. Minimal cut sets were determined from a fault tree that contained all active components and single-failure passive components.

Constants for common cause and human factors were also determined. Failure rates and the fault tree methodology were based on References 1, 2, and 5.

For each fault tree, common causes and human factors were studied. The minimal cut sets were determined using the NUPRA code (Reference 6).

10A.1.4 Criteria and Assumptions

The following analytical criteria, definitions, and assumptions were made:

a. Availability Criteria

Given that a postulated loss of feedwater (LOFW) flow event (with or without loss-of-offsite power) occurs, successful operation of the AFWS is defined to be the actuation of at least one pump and associated valves in that subtrain and the delivery of feedwater to either steam generator. Each train consists of two 50% capacity pumps. The 50% capacity is based on the minimum required flow of 550 gpm (2080 L/min) based on maintaining the steam-generator level. However, each pump is 100% capacity for decay heat removal to prevent core damage (Reference 8). For the postulated LOFW event given station blackout, successed operation is defined as startup of one of the two diesel-driven pumps and associated valves since power is not available to the motor-driven pumps. Unavailability of the motor-

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driven pumps is based on the unavailability of the safety-related 4.16-kV buses.

b. Mission Time

For all of the transient events, the success of AFWS function is assumed to be continuous operation until the shutdown cooling system is actuated or the plant is brought to a stable condition. The analysis assumed a mission time of 24 hours as a bounding case for determining component running failure rates.

c. Degraded Failures

A partially successful performance of any active or passive component was not credited. Each component and each operator action was assumed to be either completely successful or failed.

d. Auxiliary Feedwater Actuation Signal

For automatic operation during emergency shutdown conditions, the auxiliary feedwater actuation signal can be initiated on a low steam generator level by the ESF actuation system or the diverse protection system. The AFWS can also be actuated manually by the operator.

10A.2 SYSTEM DESCRIPTION

10A.2.1 Function and General Description of the AFWS

The auxiliary feedwater system is an engineered safety feature-grade secondary quality makeup water source to the steam generators in the event of a loss of the main feedwater supply.

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The AFWS supplies feedwater to the steam generators during hot standby conditions and reactor cooldown to the point where the shutdown cooling system starts operation, whenever the main feedwater system fails to supply feedwater following any postulated event.

A simplified flow diagram of the AFWS for YGN 3 is presented in Figure 10A-1. The AFWS for YGN 4 is of identical configuration. There are two redundant trains in each plant and one motor-driven pump and one diesel-driven pump in each train. Each train is capable of supplying either steam generator A or B. Crossovers with redundant valves between two trains permit either train of pumps to feed auxiliary feedwater to either steam generator via downcomer nozzle headers.

The primary source of auxiliary feedwater is from the condensate storage tanks. Backup supplies of water are also available from the demineralized water storage tank and/or raw water tank through the condensate supply headers.

Each diesel engine is provided with an independent air-start system. Fuel oil is supplied from an independent day tank located within a designated storage room adjacent to the diesel engine. A backup filling provision is available from the non-Class 1E diesel generator fuel oil transfer pump discharge header.

Component cooling water (CCW) is supplied to cool the diesel-driven pump room, the engine closed cooling water, and the gearbox lube oil.

When the CCW pumps are not in operation, the room cooling is accomplished by the shaft-driven CCW booster pump. Therefore, the AFW pump diesel operation is independent from the operability of the CCW pumps.

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10A.2.2 System Operation

The AFWS is not utilized for normal plant startup and shutdown of the unit. It is required as an engineered safety feature, and as such its function is to provide a sufficient water level in the steam generators to dissipate core residual heat from the reactor coolant system following an AFW actuation signal (AFAS) due to any one of the following :

a. Low water level in any intact steam generator
b. Manual actuation

When the AFAS is actuated, all four AFW pumps will be placed in operation and the cross-tie valves will be opened, supplying water to the steam generators through both the normal and cross-tie flow paths, and recirculating water to the condensate storage tanks through the normally open recirculation flow paths.

Flow control to the steam generators is accomplished by modulation of AFW modulating valves which receive a proportional signal from the associated steam-generator water level instrumentation.

When the steam generator level recovers, the AFW cross-tie isolation valve is closed before a high level is reached in the associated steam generator. At this time, six AFW isolation valves will not be operated because of different steam-generator level for operation of cross-tie isolation and other isolation valves. This modulation control by the air-operated valve continues until the end of the event.

During this modulating operation, if the AFW modulating control becomes inoperable and/or if the steam generator level decreases, the cross-tie isolation valve open signal automatically reopens the AFW cross-tie isolation valve which was previously closed. If the AFW modulating control is still

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inoperable and the steam generator level reaches the high level, the AFW isolation/cross-tie isolation valves are closed. On-off control of these isolation valves continues until the end of the event.

The AFAS places the AFW modulating valves into modulation mode and aligns the AFW isolation/cross-tie isolation valves to feed the intact steam generator(s). Once the steam generator level is restored, the pumps continue to operate, while the AFW modulating valves or AFW isolation/cross-tie isolation valves are closed. The same logic is also used to provide a close signal to the AFW isolation/cross-tie isolation valves to a faulted steam generator to prevent flow to that steam generator.

10A.2.3 Inspection and Testing

The AFW pumps are capable of being tested while the plant is in normal operation. A recirculation and flow test line to the condensate storage tank enables the pumps to be operationally tested. Control room discharge pressure and local flow indicators are provided to monitor pump performance.

10A.2.4 Instrumentation and Controls

The instrumentation and controls for the AFWS are provided on the main control board and remote shutdown panel. Main control room instrumentation includes monitoring of AFW flow, temperature, pump suction pressure, pump discharge pressure, motor current for the motor-driven pumps, steam-generator level, and control hand switch with status-indicating lights for all power-operated valves and AFW pumps. The AFW instrumentation meets the requirements of TMI action item II.E.1.2.

Local controls are provided for the diesel-driven AFW pumps via local pushbutton switches.

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10A.2.5 Power Sources and System Dependencies

The AFW system is dependent on the 4.16-kVac safety-related buses to supply power to the AFW motor-driven pumps and on 125-Vdc power to start and control the AFW pumps. In the event of loss-of-offsite power, the pumps receive power via the emergency buses from the diesel generators. The ac or dc motor-operated AFW isolation valves receive power from the 480-Vac motor control centers or 125-Vdc power sources, respectively.

The Class 1E 125-Vdc system consists of a battery, battery charger, 125-Vdc control center and a 125-volt distribution panel. Each dc control center receives power from its respective battery and/or battery charger, depending on plant conditions. The battery chargers of each subsystem are supplied with 480-Vac power.

The 120-Vac vital instrument power bus is required to supply power to the interposing logic system (ILS) logic cabinets that control the AFW pumps and valves. These ILS logic cabinets, however, receive back-up power from the 120-Vac distribution panels at the MCCs.

The AFW system depends on the engineered safety features actuation system (ESFAS) for the auxiliary feedwater actuation signal (AFAS).

The AFW system also depends on the essential chilled water system for cooling of the motor-driven pump room and CCW system integrity for cooling water suction supply to the CCW booster pump of the diesel-driven pump room.

The AFW system shares a common downcomer line with the feedwater system in order to supply water to the steam generators.

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10A.2.6 Technical Specifications and Test Frequency

The detailed descriptions of AFW system's Technical Specifications and Test Frequency are described in ITS 3.7.5.

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10A.3 RELIABILITY EVALUATION

10A.3.1 Analytical Approach

A master fault tree was constructed from P&IDs and logic diagrams and includes single and common cause failures of active and passive components, failures due to test and maintenance, and operator errors. The fault tree is shown in Failure 10A-3. Some of the failure rate data used for the quantification is given in Table 10A-14. The preferred source of data was NUREG-0635. In some cases, failure rates for such components as diesel generators were not given in NUREG-0635. In these cases, WASH-1400 data was used. There was no failure

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rate information available for the diesel-driven pumps from either of the above sources, so EPRI data were used. The median failure rates from NUREG-0635 and WASH-1400 were converted to mean values and the fault tree was quantified using the mean and median failure rates.

For consideration of common cause failures, the source for factors was EPRI data (Reference 5). The common cause parameters used are shown in Table 10A-15.

With the data above, dominant minimal cut sets were identified and quantified. Also, an importance analysis was performed.

10A.3.2 Results and Conclusions

The results of the analysis are presented in Table 10A-1. As shown in the table, the unreliability of the current AFWS satisfy the recommendated value in the NRC Standard Review Plan. In comparing the two design cases, the current design's reliability has improved by changing the design.

As shown in Table 10A-1, for the old design, the unavailability for LOOP is higher than for station blackout. This is because the ac motor-operated valves do not receive power in the event of a station blackout. Thus, failure of these valves during on/off cycling is not a contributor for station blackout. This problem was solved by modifying the design of the air-operated modulating valves. The dominant cut sets quantified by mean values are described for each transient event for the current design and shown in Table 10A-2 through 10A-7. Also, the results of the importance analysis are shown in Table 10A-8 through 10A-13.

The comparison of YGN 3&4 AFWS reliability to other AFWS designs in plants using Combustion Engineering nuclear steam supply systems is shown in Figure

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10A-2 (Reference 1 and 7). As shown in the figure, the reliability of the AFWS is very high.

10A.3.3 Interpretation of Results

In this subsection, minimal cut sets quantified by mean failure rate are described for three transient events with and without common cause failures (CCF).

10A.3.3.1 Loss of Main Feedwater and Subsequent Tripping of the Reactor

a. Case 1: With CCF

The absolute value for the top event unavailability for this case is 1.91E-05. The dominant cut sets fall into two basic failure categories. These cut sets are given in Table 10A-2.

1. The common cause failure of the 125-Vdc control center buses contributes 47.1% for the top event unavailability.

2. The common cause failure of the AFW pump suction pressure transmitters contributes 33.5% for the top event unavailability.

The above failure categories account for approximately 80.6% of the total top event failure probability.

The results of the Fussel-Vessely importance analysis for this case are as follows and also given in Table 10A-8.

1. The common cause failure of the 125-Vdc control center buses contributes 46.6% for the importance of the top event.

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2. The common cause failure of the AFW pump suction pressure transmitters contributes 46.6% for the importance of the top event.

3. The running failure of Train B diesel-driven pump contributes 9.0% for the importance of the top event.

4. The running failure of Train A diesel-driven pump contributes 9.0% for the importance of the top event.

5. The demand common cause failure of motor-driven pumps contributes 7.8% for the importance of the top event.

B. Case 2 : Without CCF

The absolute value for the top event unavailability for this case is 1.72E-06. The dominant cut sets fall into eight basic failure categories. These cut sets are given in Table 10A-3.

1. The combined unavailability of Train A AFW motor-driven pump due to test and maintenance, running failures of two diesel-driven pumps, and demand failure of Train B motor-driven pump contributes 2.1% for the top event unavailability.

2. The combined unavailability of Train B AFW motor-driven pump due to test and maintenance, running failures of two diesel-driven pumps, and demand failure of train A motor-driven pump contributes 2.1% for the top event unavailability.

3. The combined transfer failure of manual valve located on the return line to the Train A condensate storage tank, unavailability of Train B motor-driven pump due to test and maintenance, and

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running failure of train B diesel-driven pump contributes 2.1% for the top event unavailability.

4. The combined failure of check valve on the Train A suction line to open, unavailability of Train B motor-driven pump due to test and maintenance, and running failure of Train B diesel-driven pump contributes 2.1% for the top event unavailability.

5. The combined transfer failure of Train B condensate storage tank isolation valve, running failure of Train A diesel-driven pump, and unavailability of Train A motor-driven pump due to test and maintenance contributes 2.1% for the top event unavailability.

6. The combined failure of check valve on the Train B suction line to open, unavailability of Train A motor-driven pump due to test and maintenance, and running failure of train A diesel-driven pump contributes 2.1% for the top event unavailability.

7. The combined transfer failure of Train A condensate storage tank isolation valve, running failure of Train B diesel-driven pump, and unavailability of Train B motor-driven pump due to test and maintenance contributes 2.1% for the top event unavailability.

8. The combined transfer failure of manual valve located on the return line to the Train B condensate storage tank, unavailability of Train A motor-driven pump due to test and maintenance, and running failure of Train A diesel-driven pump contributes 2.1% for the top event unavailability.

The above failure categories account for approximately 16.8% of the total top event failure probability.

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The results the Fussel-Vessely importance analysis for this case are as follows and also given in Table 10A-9.

1. The running failure of each diesel-driven pump contributes 46.4% for the importance of the top event.

2. The unavailability of each motor-driven pump due to test and maintenance contributes 29.7% for the importance of the top event.

3. The demand failure of each diesel-driven pump contributes 17.5% for the importance of the top event.

4. The demand failure of each motor-driven pump contributes 13.1% for the importance of the top event.

5. The running failure each motor-driven pump contributes 10.2% for the importance of the top event.

10A.3.3.2 Loss of Main Feedwater due to Loss-of-Offsite Power and the Subsequent Tripping of the Reactor.

a. Case 1 : With CCF

The absolute value for the top event unavailability for this case is 1.29E-04. The dominant cut sets fall into five basic failure categories. These cut sets are given in Table 10A-4.

1. The combined running failures of two emergency diesel generators and two diesel-driven pumps and human error to provide alternate ac diesel generator to ESF Train B 4.16-kV bus contribute 7.4% for the top event unavailability.

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2. The common cause failure of the 125-Vdc control center buses contributes 7.0% for the top event unavailability.

3. The common cause failure of the AFW pump suction pressure transmitters contributes 5.0% for the top event unavailability.

4. The combined running failures of two emergency diesel generators, demand common cause failure of two diesel-driven pumps, and human error to provide alternate ac diesel generator to ESF Train B 4.16-kV bus contributes 4.5% for the top event unavailability.

5. The combined running failures of two emergency diesel generators and two diesel-driven pumps, and running failure of the alternate ac diesel generator contributes 4.3% for the top event unavailability.

The above failure categories account for approximately 28.2% of the total top event failure probability.

The results of the Fussel-Vessely importance analysis for this case are as follows and given in Table 10A-10.

1. The running failure of each emergency diesel generator contributes 53.1% for the importance of the top event.

2. The human error to provide the alternate ac diesel generator to ESF Train B 4.16-kV bus contributes 48.0% for the importance of the top event.

3. The running failure of each diesel-driven pump contributes 44.1% for the importance of the top event.

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4. The running failure of the alternate ac diesel generator contributes 27.6% for the importance of the top event.

5. The demand common cause failure of the diesel-driven pumps contributes 18.0% for the importance of the top event.

6. The demand failure of each diesel-driven pump contributes 16.6% for the importance of the top event.

7. The running common cause failure of the emergency diesel generators contributes 15.0% for the importance of the top event.

b. Case 2 : Without CCF

The absolute value for the top event unavailability for this case is 6.68E-05. The dominant cut sets fall into four basic failure categories. These cut sets are given in Table 10A-5.

1. The combined running failures of two emergency diesel generators and two diesel-driven pumps and human error to provide the alternate ac diesel generator to ESF Train B 4.16-kV bus contributes 14.3% for the top event unavailability.

2. The combined running failures of two emergency diesel generators and two diesel-driven pumps and running failure of the alternate ac diesel generator contributes 8.3% for the top event unavailability.

3. The combined running failures of two emergency diesel generators and Train B diesel-driven pump, demand failure of Train A diesel-driven pump, and human error to provide the alternate ac diesel generator to ESF Train B 4.16-kV bus contributes 5.6% for the top

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event unavailability.

4. The combined running failures of two emergency diesel generators and Train A diesel-driven pump, demand failure of Train B diesel-driven pump, and human error to provide alternate ac diesel generator to ESF Train B 4.16-kV bus contributes 5.6% for the top event unavailability.

The above failure categories account for approximately 33.8% of the total top event failure probability.

The results of the Fussel-Vessely importance analysis for this case are as follows and also given in Table 10A-11.

1. The running failure of the each emergency diesel generator contributes 74.2% for the importance of the top event.

2. The running failure of each diesel-driven pumps contributes 68.2% for the importance of the top event.

3. The human error to provide the alternate ac diesel generator to ESF Train B 4.16-kV bus contributes 55.3% for the importance of the top event.

4. The running failure of the alternate ac diesel generator contributes 31.9% for the importance of the top event.

5. The demand failure of each diesel-driven pump contributes 25.5% for the importance of the top event.

6. The demand failure of each emergency diesel generator contributes 13.6% for the importance of the top event.

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10A.3.3.3 Loss of Main Feedwater due to Loss-of-Offsite Power and Loss of Onsite AC Power Sources

a. Case 1 : With CCF

The absolute value for the top event unavailability for this case is 7.75E-03. The dominant cut sets fall into six basic failure categories. These cut sets are given in Table 10A-6.

1. The running failures of AFW diesel-driven pumps contributes 33.7% for the top event unavailability.

2. The demand common cause failure of AFW diesel-driven pumps contributes 20.4% for the top event unavailability.

3. The running failure of Train B AFW diesel-driven pump and the demand failure of Train A AFW diesel-driven contributes 13.2% for the top event unavailability.

4. The running failure of Train A AFW diesel-driven pump and the demand failure of Train B AFW diesel-driven contributes 13.2% for the top event unavailability.

5. The running common cause failure of AFW diesel-driven pumps contributes 6.6% for the top event unavailability.

6. The demand failures of AFW diesel-driven pumps contributes 5.2% for the top event unavailability.

The above failure categories account for approximately 92.3% of the total top event failure probability.

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The results of the Fussel-Vessely importance analysis for this case are as follows and also given in Table 10A-12.

1. The running failure of each diesel-driven pump contributes 49.5% for the importance of the top event.

2. The demand common cause failure of the diesel-driven pumps contributes 20.4% for the importance of the top event.

3. The demand failure of each diesel-driven pump contributes 19.4% for the importance of the top event.

b. Case 2 : Without CCF

The absolute value for the top event unavailability for this case is 5.64E-03. The dominant cut sets fall into four basic failure categories. These cut sets are given in Table 10A-7.

1. The running failures of AFW diesel-driven pumps contributes 46.3% for the top event unavailability.

2. The running failures of Train B AFW diesel-driven pump and the demand failure of Train A AFW diesel-driven pump contributes 18.1% for the top event unavailability.

3. The running failures of Train A AFW diesel-driven pump and the demand failure of Train B AFW diesel-driven pump contributes 18.1% for the top event unavailability.

4. The demand failures of AFW diesel-driven pumps contributes 7.1% percent for the top event unavailability.

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The above failure categories account for approximately 89.6% of the total top event failure probability.

The results of the Fussel-Vessely importance analysis for this case are as follows and given in Table 10A-13.

1. The running failure of each AFW diesel-driven pump contributes 68.0% for the importance of the top event.

2. The demand failure of each diesel-driven pump contributes 26.6% for the importance of the top event.

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10A.4 REFERENCES

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TABLE 10A-1

RESULTS OF AFWS RELIABILITY ANALYSIS

Transient Events[1]		Current Design		Old Design	
		Use Median Value	Use Mean Value	Use Median Value	Use Mean Value
Loss of Main Feedwater	CCF	1.06E-5	1.91E-5	9.48E-5	1.24E-4
(LMFW)	Ind	4.80E-7[2]	1.72E-6	4.71E-6	7.42E-6
Loss of Offsite Power	CCF	1.83E-5	1.29E-4	9.66E-3	3.77E-2
(LOOP)	Ind	3.24E-6	6.68E-5	6.62E-3	3.01E-2
Station Blackout	CCF	2.94E-3	7.75E-3	3.01E-3	8.04E-3
(SBO)	Ind	1.48E-3	5.64E-3	1.52E-3	5.90E-3

1) CCF : Common Cause Estimate
Ind : Statistical Independent Estimate

2) This value should be in the range of 10^{-4} to 10^{-5} according to SRP requirements.

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TABLE 10A-2 (Sh. 1 of 2)

MINIMAL CUT SETS FOR LMFW (MEAN VALUES WITH CCF)

Unavailability : 1.91E-05

1.	9.000E-06	EDBSK125DC		
2.	6.390E-06	AFPT0001K		
3.	5.170E-07	AFDP0002RA	AFMP0001W	AFDP0002RB
4.	3.128E-07	AFMP0001W	AFDP0002W	
5.	2.024E-07	AFDP0002SA	AFMP0001W	AFDP0002RB
6.	2.024E-07	AFDP0002RA	AFMP0001W	AFDP0002SB
7.	1.012E-07	AFMP0001W	AFDP0002K	
8.	7.920E-08	AFDP0002SA	AFMP0001W	AFDP0002SB
9.	5.170E-08	AFDP0002RA	AFMP0001K	AFDP0002RB
10.	3.610E-08	AFMP0001MA	AFDP0002RA	AFMP0001SB
		AFDP0002RB		
11.	3.610E-08	AFMP0001SA	AFDP0002RA	AFMP0001MB
		AFDP0002RB		
12.	3.532E-08	CDCV1178OA	AFMP0001MB	AFDP0002RB
13.	3.532E-08	CDVV1167TA	AFMP0001MB	AFDP0002RB
14.	3.532E-08	AFDP0002RB	AFMP0001MB	CDMV0459TA
15.	3.532E-08	AFMP0001MA	AFDP0002RA	CDVV1196TB
16.	3.532E-08	CDMV0460TB	AFDP0002RA	AFMP0001MA
17.	3.532E-08	AFMP0001MA	AFDP0002RA	CDCV1181OB
18.	3.128E-08	AFMP0001K	AFDP0002W	
19.	2.859E-08	AFMP0001MA	AFDP0002RA	AFMP0001RB
		AFDP0002RB		
20.	2.859E-08	AFMP0001RA	AFDP0002RA	AFMP0001MB
		AFDP0002RB		
21.	2.543E-08	EDBSY401EA	AFMP0001MB	AFDP0002RB
22.	2.543E-08	AFMP0001MA	AFDP0002RA	EDBSY401EB
23.	2.350E-08	AFDP0002RA	EKBSK416KV	AFDP0002RB
24.	2.184E-08	AFMP0001MA	AFMP0001SB	AFDP0002W
25.	2.184E-08	AFMP0001SA	AFMP0001MB	AFDP0002W
36.	2.024E-08	AFDP0002SA	AFMP0001K	AFDP0002RB
37.	2.024E-08	AFDP0002RA	AFMP0001K	AFDP0002SB
38.	1.805E-08	AFMDPCOOL-A	AFDP0002RA	AFMP0001MB
		AFDP0002RB		
39.	1.805E-08	AFMP0001MA	AFDP0002RA	AFMDPCOOL-B
		AFDP0002RB		
40.	1.730E-08	AFMP0001RA	AFMP0001MB	AFDP0002W
41.	1.730E-08	AFMP0001MA	AFMP0001RB	AFDP0002W
42.	1.632E-08	AFMP0001SA	AFDP0002RA	AFMP0001SB
		AFDP0002RB		
43.	1.597E-08	CDCV1178OA	AFMP0001SB	AFDP0002RB

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TABLE 10A-2 (Sh. 2 of 2)

Unavailability : 1.91E-05

44.	1.597E-08	CDVV1167TA	AFMP0001SB	AFDP0002RB
45.	1.597E-08	AFDP0002RB	AFMP0001SB	CDMV0459TA
46.	1.597E-08	AFMP0001SA	AFDP0002RA	CDVV1196TB
47.	1.597E-08	CDMV0460TB	AFDP0002RA	AFMP0001SA
48.	1.597E-08	AFMP0001SA	AFDP0002RA	CDCV1181OB
49.	1.563E-08	CDMV0460TB	CDCV1178OA	
50.	1.563E-08	CDVV1196TB	CDMV0459TA	
51.	1.563E-08	CDCV1178OA	CDVV1196TB	
52.	1.563E-08	CDMV0459TA	CDMV0460TB	
53.	1.563E-08	AFCV1048OA	AFCV1049OB	
54.	1.563E-08	CDCV1181OB	CDMV0459TA	
55.	1.563E-08	CDCV1178OA	CDCV1181OB	
56.	1.563E-08	CDMV0460TB	CDVV1167TA	
57.	1.563E-08	CDVV1167TA	CDCV1181OB	
58.	1.563E-08	CDVV1167TA	CDVV1196TB	
59.	1.508E-08	AFDP0002MA	AFMP0001W	AFDP0002RB
60.	1.508E-08	AFDP0002RA	AFMP0001W	AFDP0002MB
61.	1.422E-08	EKBSK416KV	AFDP0002W	
62.	1.413E-08	AFMP0001MA AFDP0002SB	AFDP0002RA	AFMP0001SB
63.	1.413E-08	AFMP0001MA AFDP0002RB	AFDP0002SA	AFMP0001SB
64.	1.413E-08	AFMP0001SA AFDP0002SB	AFDP0002RA	AFMP0001MB
65.	1.413E-08	AFMP0001SA AFDP0002RB	AFDP0002SA	AFMP0001MB
66.	1.383E-08	CDCV1178OA	AFMP0001MB	AFDP0002SB
67.	1.383E-08	CDVV1167TA	AFMP0001MB	AFDP0002SB
68.	1.383E-08	CDMV0460TB	AFDP0002SA	AFMP0001MA
69.	1.383E-08	AFDP0002SB	AFMP0001MB	CDMV0459TA
70.	1.383E-08	AFMP0001MA	AFDP0002SA	CDVV1196TB
71.	1.383E-08	AFMP0001MA	AFDP0002SA	CDCV1181OB
72.	1.293E-08	AFMP0001SA AFDP0002RB	AFDP0002RA	AFMP0001RB
73.	1.293E-08	AFMP0001RA AFDP0002RB	AFDP0002RA	AFMP0001SB
74.	1.265E-08	CDCV1178OA	AFMP0001RB	AFDP0002RB
75.	1.265E-08	CDVV1167TA	AFMP0001RB	AFDP0002RB
76.	1.265E-08	AFMP0001RA	AFDP0002RA	CDVV1196TB
77.	1.265E-08	CDMV0460TB	AFDP0002RA	AFMP0001RA
78.	1.265E-08	AFMP0001RA	AFDP0002RA	CDCV1181OB
79.	1.265E-08	AFDP0002RB	AFMP0001RB	CDMV0459TA

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TABLE 10A-3 (Sh. 1 of 3)

MINIMAL CUT SETS FOR LMFW (MEAN VALUES WITHOUT CCF)

Unavailability : 1.72E-06

1.	3.610E-08	AFMP0001MA AFDP0002RB	AFDP0002RA	AFMP0001SB
2.	3.610E-08	AFMP0001SA AFDP0002RB	AFDP0002RA	AFMP0001MB
3.	3.532E-08	CDVV1167TA	AFMP0001MB	AFDP0002RB
4.	3.532E-08	CDCV1178OA	AFMP0001MB	AFDP0002RB
5.	3.532E-08	CDMV0460TB	AFDP0002RA	AFMP0001MA
6.	3.532E-08	AFMP0001MA	AFDP0002RA	CDCV1181OB
7.	3.532E-08	AFDP0002RB	AFMP0001MB	CDMV0459TA
8.	3.532E-08	AFMP0001MA	AFDP0002RA	CDVV1196TB
9.	2.859E-08	AFMP0001MA AFDP0002RB	AFDP0002RA	AFMP0001RB
10.	2.859E-08	AFMP0001RA AFDP0002RB	AFDP0002RA	AFMP0001MB
11.	2.543E-08	AFMP0001MA	AFDP0002RA	EDBSY401EB
12.	2.543E-08	EDBSY401EA	AFMP0001MB	AFDP0002RB
13.	1.805E-08	AFMP0001MA AFDP0002RB	AFDP0002RA	AFMDPCOOL-B
14.	1.805E-08	AFMDPCOOL-A AFDP0002RB	AFDP0002RA	AFMP0001MB
15.	1.632E-08	AFMP0001SA AFDP0002RB	AFDP0002RA	AFMP0001SB
16.	1.597E-08	CDVV1167TA	AFMP0001SB	AFDP0002RB
17.	1.597E-08	CDCV1178OA	AFMP0001SB	AFDP0002RB
18.	1.597E-08	CDMV0460TB	AFDP0002RA	AFMP0001SA
19.	1.597E-08	AFMP0001SA	AFDP0002RA	CDCV1181OB
20.	1.597E-08	AFDP0002RB	AFMP0001SB	CDMV0459TA
21.	1.597E-08	AFMP0001SA	AFDP0002RA	CDVV1196TB
22.	1.563E-08	AFCV1048OA	AFCV1049OB	
23.	1.563E-08	CDMV0459TA	CDMV0460TB	
24.	1.563E-08	CDCV1181OB	CDMV0459TA	
25.	1.563E-08	CDMV0460TB	CDCV1178OA	
26.	1.563E-08	CDCV1178OA	CDCV1181OB	
27.	1.563E-08	CDMV0460TB	CDVV1167TA	
28.	1.563E-08	CDVV1167TA	CDCV1181OB	
29.	1.563E-08	CDVV1167TA	CDVV1196TB	
30.	1.563E-08	CDVV1196TB	CDMV0459TA	
31.	1.563E-08	CDCV1178OA	CDVV1196TB	
32.	1.413E-08	AFMP0001MA AFDP0002RB	AFDP0002SA	AFMP0001SB

TABLE 10A-3 (Sh. 2 of 3)

Unavailability : 1.72E-06

33.	1.413E-08	AFMP0001MA	AFDP0002RA	AFMP0001SB
		AFDP0002SB		
34.	1.413E-08	AFMP0001SA	AFDP0002RA	AFMP0001MB
		AFDP0002SB		
35.	1.413E-08	AFMP0001SA	AFDP0002SA	AFMP0001MB
		AFDP0002RB		
36.	1.383E-08	CDMV0460TB	AFDP0002SA	AFMP0001MA
37.	1.383E-08	CDVV1167TA	AFMP0001MB	AFDP0002SB
38.	1.383E-08	CDCV1178OA	AFMP0001MB	AFDP0002SB
39.	1.383E-08	AFMP0001MA	AFDP0002SA	CDCV1181OB
40.	1.383E-08	AFDP0002SB	AFMP0001MB	CDMV0459TA
41.	1.383E-08	AFMP0001MA	AFDP0002SA	CDVV1196TB
42.	1.293E-08	AFMP0001SA	AFDP0002RA	AFMP0001RB
		AFDP0002RB		
43.	1.293E-08	AFMP0001RA	AFDP0002RA	AFMP0001SB
		AFDP0002RB		
44.	1.265E-08	AFMP0001RA	AFDP0002RA	CDVV1196TB
45.	1.265E-08	CDMV0460TB	AFDP0002RA	AFMP0001RA
46.	1.265E-08	AFMP0001RA	AFDP0002RA	CDCV1181OB
47.	1.265E-08	CDCV1178OA	AFMP0001RB	AFDP0002RB
48.	1.265E-08	CDVV1167TA	AFMP0001RB	AFDP0002RB
49.	1.265E-08	AFDP0002RB	AFMP0001RB	CDMV0459TA
50.	1.150E-08	AFMP0001SA	AFDP0002RA	EDBSY401EB
51.	1.150E-08	EDBSY401EA	AFMP0001SB	AFDP0002RB
52.	1.125E-08	EDBSY401EB	CDMV0459TA	
53.	1.125E-08	EDBSY401EA	CDVV1196TB	
54.	1.125E-08	CDMV0460TB	EDBSY401EA	
55.	1.125E-08	CDVV1167TA	EDBSY401EB	
56.	1.125E-08	CDCV1178OA	EDBSY401EB	
57.	1.125E-08	EDBSY401EA	CDCV1181OB	
58.	1.119E-08	AFMP0001MA	AFDP0002SA	AFMP0001RB
		AFDP0002RB		
59.	1.119E-08	AFMP0001RA	AFDP0002SA	AFMP0001MB
		AFDP0002RB		
60.	1.119E-08	AFMP0001MA	AFDP0002RA	AFMP0001RB
		AFDP0002SB		
61.	1.119E-08	AFMP0001RA	AFDP0002RA	AFMP0001MB
		AFDP0002SB		
62	1.024E-08	AFMP0001RA	AFDP0002RA	AFMP0001RB
		AFDP0002RB		
63.	9.954E-09	AFMP0001MA	AFDP0002SA	EDBSY401EB
64.	9.954E-09	EDBSY401EA	AFMP0001MB	AFDP0002SB

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Unavailability : 1.72E-06

65.	9.106E-09	AFMP0001RA	AFDP0002RA	EDBSY401EB
66.	9.106E-09	EDBSY401EA	AFMP0001RB	AFDP0002RB
67.	8.160E-09	AFMP0001SA	AFDP0002RA	AFMDPCOOL-B
		AFDP0002RB		
68.	8.160E-09	AFMDPCOOL-A	AFDP0002RA	AFMP0001SB
		AFDP0002RB		
69.	8.100E-09	EDBSY401EA	EDBSY401EB	
70.	7.984E-09	CDCV1178OA	AFMDPCOOL-B	AFDP0002RB
71.	7.984E-09	CDVV1167TA	AFMDPCOOL-B	AFDP0002RB

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TABLE 10A-4 (Sh. 1 of 3)

MINIMAL CUT SETS FOR LOOP (MEAN VALUES WITH CCF)

Unavailability : 1.29E-04

1.	9.526E-06	EGDGR01KA	AFDP0002RA	EAHBV01SB
		EGDGR01KB	AFDP0002RB	
2.	9.000E-06	EDBSK125DC		
3.	6.390E-06	AFPT0001K		
4.	5.764E-06	EGDGR01KA	EAHBV01SB	EGDGR01KB
		AFDP0002W		
5.	5.525E-06	AFDP0002RB	EGDGR01KB	EADGR01KS
		AFDP0002RA	EGDGR01KA	
6.	3.728E-06	EGDGR01KA	AFDP0002RA	EAHBV01SB
		EGDGR01KB	AFDP0002SB	
7.	3.728E-06	EGDGR01KA	AFDP0002SA	EAHBV01SB
		EGDGR01KB	AFDP0002RB	
8.	3.656E-06	AFDP0002RA	EAHBV01SB	EGDGK01KAB
		AFDP0002RB		
9.	3.343E-06	AFDP0002W	EGDGR01KB	EADGR01KS
		EGDGR01KA		
10.	2.212E-06	EAHBV01SB	EGDGK01KAB	AFDP0002W
11.	2.162E-06	AFDP0002SB	EGDGR01KB	EADGR01KS
		AFDP0002RA	EGDGR01KA	
12.	2.162E-06	AFDP0002RB	EGDGR01KB	EADGR01KS
		AFDP0002SA	EGDGR01KA	
13.	2.120E-06	AFDP0002RB	EGDGK01KAB	EADGR01KS
		AFDP0002RA		
14.	1.870E-06	EGDGS01KA	AFDP0002RA	EAHBV01SB
		EGDGR01KB	AFDP0002RB	
15.	1.870E-06	EGDGR01KA	AFDP0002RA	EAHBV01SB
		EGDGS01KB	AFDP0002RB	
16.	1.864E-06	EGDGR01KA	EAHBV01SB	EGDGR01KB
		AFDP0002K		
17.	1.459E-06	EGDGR01KA	AFDP0002SA	EAHBV01SB
		EGDGR01KB	AFDP0002SB	
18.	1.431E-06	AFDP0002RA	EAHBV01SB	EGDGK01KAB
		AFDP0002SB		
19.	1.431E-06	AFDP0002SA	EAHBV01SB	EGDGK01KAB
		AFDP0002RB		
20.	1.334E-06	AFDP0002RB	EGDGR01KB	EADGS01KS
		AFDP0002RA	EGDGR01KA	
21.	1.283E-06	AFDP0002W	EGDGK01KAB	EADGR01KS
22.	1.132E-06	EGDGS01KA	EAHBV01SB	EGDGR01KB
		AFDP0002W		

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Unavailability : 1.29E-04

23.	1.132E-06	EGDGR01KA AFDP0002W	EAHBV01SB	EGDGS01KB
24.	1.085E-06	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGS01KA	EADGR01KS
25.	1.085E-06	AFDP0002RB AFDP0002RA	EGDGS01KB EGDGR01KA	EADGR01KS
26.	1.081E-06	AFDP0002K EGDGR01KA	EGDGR01KB	EADGR01KS
27.	8.464E-07	AFDP0002SB AFDP0002SA	EGDGR01KB EGDGR01KA	EADGR01KS
28.	8.299E-07	AFDP0002RB AFDP0002SA	EGDGK01KAB	EADGR01KS
29.	8.299E-07	AFDP0002SB AFDP0002RA	EGDGK01KAB	EADGR01KS
30.	8.070E-07	AFDP0002W EGDGR01KA	EGDGR01KB	EADGS01KS
31.	7.320E-07	EGDGS01KA EGDGR01KB	AFDP0002RA AFDP0002SB	EAHBV01SB
32.	7.320E-07	EGDGS01KA EGDGR01KB	AFDP0002SA AFDP0002RB	EAHBV01SB
33.	7.320E-07	EGDGR01KA EGDGS01KB	AFDP0002SA AFDP0002RB	EAHBV01SB
34.	7.320E-07	EGDGR01KA EGDGS01KB	AFDP0002RA AFDP0002SB	EAHBV01SB
35.	7.154E-07	EAHBV01SB	EGDGK01KAB	AFDP0002K
36.	6.564E-07	AFDP0002W EGDGS01KA	EGDGR01KB	EADGR01KS
37.	6.564E-07	AFDP0002W EGDGR01KA	EGDGS01KB	EADGR01KS
38.	6.234E-07	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGM01KA	EAHBV01SB
39.	6.234E-07	AFDP0002RB AFDP0002RA	EGDGM01KB EGDGR01KA	EAHBV01SB
40.	5.716E-07	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGR01KA	EADGM01KS
41.	5.600E-07	AFDP0002SA AFDP0002SB	EAHBV01SB	EGDGK01KAB
42.	5.220E-07	AFDP0002SB AFDP0002RA	EGDGR01KB EGDGR01KA	EADGS01KS
43.	5.220E-07	AFDP0002RB AFDP0002SA	EGDGR01KB EGDGR01KA	EADGS01KS
44.	5.170E-07	AFDP0002RA	AFMP0001W	AFDP0002RB

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Unavailability : 1.29E-04

45.	5.118E-07	AFDP0002RB AFDP0002RA	EGDGK01KAB	EADGS01KS
46.	4.246E-07	AFDP0002RB AFDP0002SA	EGDGS01KB EGDGR01KA	EADGR01KS
47.	4.246E-07	AFDP0002SB AFDP0002RA	EGDGS01KB EGDGR01KA	EADGR01KS
48.	4.246E-07	AFDP0002SB AFDP0002RA	EGDGR01KB EGDGS01KA	EADGR01KS
49.	4.246E-07	AFDP0002RB AFDP0002SA	EGDGR01KB EGDGS01KA	EADGR01KS
50.	4.149E-07	AFDP0002K	EGDGK01KAB	EADGR01KS
51.	3.772E-07	AFDP0002W EGDGR01KA	EGDGM01KB	EAHBV01SB
52.	3.772E-07	AFDP0002W EGDGM01KA	EGDGR01KB	EAHBV01SB

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TABLE 10A-5 (Sh. 1 of 3)

MINIMAL CUT SETS FOR LOOP (MEAN VALUES WITHOUT CCF)

Unavailability : 6.68E-05

1.	9.526E-06	EGDGR01KA EGDGR01KB	AFDP0002RA AFDP0002RB	EAHBV01SB
2.	5.525E-06	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGR01KA	EADGR01KS
3.	3.728E-06	EGDGR01KA EGDGR01KB	AFDP0002SA AFDP0002RB	EAHBV01SB
4.	3.728E-06	EGDGR01KA EGDGR01KB	AFDP0002RA AFDP0002SB	EAHBV01SB
5.	2.162E-06	AFDP0002RB AFDP0002SA	EGDGR01KB EGDGR01KA	EADGR01KS
6.	2.162E-06	AFDP0002SB AFDP0002RA	EGDGR01KB EGDGR01KA	EADGR01KS
7.	1.870E-06	EGDGS01KA EGDGR01KB	AFDP0002RA AFDP0002RB	EAHBV01SB
8.	1.870E-06	EGDGR01KA EGDGS01KB	AFDP0002RA AFDP0002RB	EAHBV01SB
9.	1.459E-06	EGDGR01KA EGDGR01KB	AFDP0002SA AFDP0002SB	EAHBV01SB
10.	1.334E-06	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGR01KA	EADGS01KS
11.	1.085E-06	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGS01KA	EADGR01KS
12.	1.085E-06	AFDP0002RB AFDP0002RA	EGDGS01KB EGDGR01KA	EADGR01KS
13.	8.464E-07	AFDP0002SB AFDP0002SA	EGDGR01KB EGDGR01KA	EADGR01KS
14.	7.320E-07	EGDGR01KA EGDGS01KB	AFDP0002SA AFDP0002RB	EAHBV01SB
15.	7.320E-07	EGDGR01KA EGDGS01KB	AFDP0002RA AFDP0002SB	EAHBV01SB
16.	7.320E-07	EGDGS01KA EGDGR01KB	AFDP0002RA AFDP0002SB	EAHBV01SB
17.	7.320E-07	EGDGS01KA EGDGR01KB	AFDP0002SA AFDP0002RB	EAHBV01SB
18.	6.234E-07	AFDP0002RB AFDP0002RA	EGDGM01KB EGDGR01KA	EAHBV01SB
19.	6.234E-07	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGM01KA	EAHBV01SB
20.	5.716E-07	AFDP0002RB AFDP0002RA	EGDGR01KB EGDGR01KA	EADGM01KS

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Unavailability : 6.68E-05

21.	5.220E-07	AFDP0002RB	EGDGR01KB	EADGS01KS
		AFDP0002SA	EGDGR01KA	
22.	5.220E-07	AFDP0002SB	EGDGR01KB	EADGS01KS
		AFDP0002RA	EGDGR01KA	
23.	4.246E-07	AFDP0002RB	EGDGS01KB	EADGR01KS
		AFDP0002SA	EGDGR01KA	
24.	4.246E-07	AFDP0002SB	EGDGS01KB	EADGR01KS
		AFDP0002RA	EGDGR01KA	
25.	4.246E-07	AFDP0002SB	EGDGR01KB	EADGR01KS
		AFDP0002RA	EGDGS01KA	
26.	4.246E-07	AFDP0002RB	EGDGR01KB	EADGR01KS
		AFDP0002SA	EGDGS01KA	
27.	3.672E-07	EGDGS01KA	AFDP0002RA	EAHBV01SB
		EGDGS01KB	AFDP0002RB	
28.	3.616E-07	EGDGR01KA	AFDP0002RA	EADGR01KS
		EGDGM01KB	AFDP0002RB	
29.	3.616E-07	EGDGM01KA	AFDP0002RA	EADGR01KS
		EGDGR01KB	AFDP0002RB	
30.	2.865E-07	EGDGR01KA	AFDP0002SA	EAHBV01SB
		EGDGS01KB	AFDP0002SB	
31.	2.865E-07	EGDGS01KA	AFDP0002SA	EAHBV01SB
		EGDGR01KB	AFDP0002SB	
32.	2.778E-07	EGDGR01KA	AFDP0002RA	EAHBV01SB
		EGDGR01KB	AFDP0002MB	
33.	2.778E-07	EGDGR01KA	AFDP0002MA	EAHBV01SB
		EGDGR01KB	AFDP0002RB	
34.	2.758E-07	EAHBV01SB	EGDGR01KA	AFDP0002RA
		AFMP0001MB	AFDP0002RB	
35.	2.758E-07	AFMP0001MA	AFDP0002RA	EAHBV01SB
		EGDGR01KB	AFDP0002RB	
36.	2.618E-07	AFDP0002RB	EGDGR01KB	EADGS01KS
		AFDP0002RA	EGDGS01KA	
37.	2.618E-07	AFDP0002RB	EGDGS01KB	EADGS01KS
		AFDP0002RA	EGDGR01KA	
38.	2.440E-07	AFDP0002RB	EGDGM01KB	EAHBV01SB
		AFDP0002SA	EGDGR01KA	
39.	2.440E-07	AFDP0002SB	EGDGM01KB	EAHBV01SB
		AFDP0002RA	EGDGR01KA	
40.	2.440E-07	AFDP0002SB	EGDGR01KB	EAHBV01SB
		AFDP0002RA	EGDGM01KA	
41.	2.440E-07	AFDP0002RB	EGDGR01KB	EAHBV01SB
		AFDP0002SA	EGDGM01KA	

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Unavailability : 6.68E-05

42. 2.237E-07	AFDP0002RB	EGDGR01KB	EADGM01KS
	AFDP0002SA	EGDGR01KA	
43. 2.237E-07	AFDP0002SB	EGDGR01KB	EADGM01KS
	AFDP0002RA	EGDGR01KA	
44. 2.130E-07	AFDP0002RB	EGDGS01KB	EADGR01KS
	AFDP0002RA	EGDGS01KA	
45. 2.043E-07	AFDP0002SB	EGDGR01KB	EADGS01KS
	AFDP0002SA	EGDGR01KA	
46. 1.662E-07	AFDP0002SB	EGDGS01KB	EADGR01KS
	AFDP0002SA	EGDGR01KA	
47. 1.662E-07	AFDP0002SB	EGDGR01KB	EADGR01KS
	AFDP0002SA	EGDGS01KA	
48. 1.611E-07	AFDP0002RB	EGDGR01KB	EADGR01KS
	AFDP0002MA	EGDGR01KA	
49. 1.611E-07	AFDP0002MB	EGDGR01KB	EADGR01KS
	AFDP0002RA	EGDGR01KA	

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TABLE 10A-6 (Sh. 1 of 3)

MINIMAL CUT SETS FOR SBO (MEAN VALUES WITH CCF)

Unavailability : 7.75E-03

1.	2.611E-03	AFDP0002RA	AFDP0002RB
2.	1.580E-03	AFDP0002W	
3.	1.022E-03	AFDP0002SA	AFDP0002RB
4.	1.022E-03	AFDP0002RA	AFDP0002SB
5.	5.110E-04	AFDP0002K	
6.	4.000E-04	AFDP0002SA	AFDP0002SB
7.	7.614E-05	AFDP0002MA	AFDP0002RB
8.	7.614E-05	AFDP0002RA	AFDP0002MB
9.	2.980E-05	AFDP0002MA	AFDP0002SB
10.	2.980E-05	AFDP0002SA	AFDP0002MB
11.	2.453E-05	AFVV1016UA	AFDP0002RB
12.	2.453E-05	AFVV1006UA	AFDP0002RB
13.	2.453E-05	AFDP0002RA	AFVV1006UB
14.	2.453E-05	AFDP0002RA	AFVV1016UB
15.	9.600E-06	AFDP0002SA	AFVV1006UB
16.	9.600E-06	AFDP0002SA	AFVV1016UB
17.	9.600E-06	AFVV1016UA	AFDP0002SB
18.	9.600E-06	AFVV1006UA	AFDP0002SB
19.	9.000E-06	EDBSK125DC	
20.	6.390E-06	AFPT0001K	
21.	6.388E-06	AFCV1014OA	AFDP0002RB
22.	6.388E-06	CDMV0459TA	AFDP0002RB
23.	6.388E-06	CDVV1167TA	AFDP0002RB
24.	6.388E-06	AFDP0002RA	AFCV1004OB
25.	6.388E-06	AFDP0002RA	AFVV1002TB
26.	6.388E-06	AFDP0002RA	CCVV1046TB
27.	6.388E-06	CCVV1214TB	AFDP0002RA
28.	6.388E-06	AFDP0002RA	CCCV1212OB
29.	6.388E-06	AFDP0002RA	AFCV1014OB
30.	6.388E-06	AFDP0002RA	CDVV1196TB
31.	6.388E-06	AFDP0002RA	CDCV1181OB
32.	6.388E-06	AFDP0002RA	CDMV0460TB
33.	6.388E-06	AFVV1006TB	AFDP0002RA
34.	6.388E-06	EDBYA401BB	AFDP0002RA
35.	6.388E-06	CCVV1045TA	AFDP0002RB
36.	6.388E-06	AFDP0002RB	EDBYA401BA
37.	6.388E-06	AFDP0002RB	AFVV1006TA
38.	6.388E-06	CDCV1178OA	AFDP0002RB
39.	6.388E-06	AFDP0002RB	CCVV1213TA
40.	6.388E-06	CCCV1211OA	AFDP0002RB
41.	6.388E-06	AFCV1004OA	AFDP0002RB

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Unavailability : 7.75E-03

42.	6.388E-06	AFVV1002TA	AFDP0002RB
43.	4.599E-06	EDBSY401EB	AFDP0002RA
44.	4.599E-06	AFDP0002RB	EDBSY401EA
45.	3.265E-06	AFDP0002RA	AFTP0008YB
46.	3.265E-06	AFTP0007YA	AFDP0002RB
47.	3.000E-06	EDBYW125DC	
48.	2.500E-06	AFCV1014OA	AFDP0002SB
49.	2.500E-06	CDMV0459TA	AFDP0002SB
50.	2.500E-06	AFDP0002SA	AFCV1004OB
51.	2.500E-06	AFDP0002SA	AFVV1002TB
52.	2.500E-06	CDVV1167TA	AFDP0002SB
53.	2.500E-06	AFDP0002SA	CCVV1046TB
54.	2.500E-06	CCVV1214TB	AFDP0002SA
55.	2.500E-06	AFDP0002SA	CCCV1212OB
56.	2.500E-06	AFDP0002SA	AFCV1014OB
57.	2.500E-06	AFDP0002SA	CDVV1196TB
58.	2.500E-06	AFDP0002SA	CDCV1181OB
59.	2.500E-06	AFDP0002SA	CDMV0460TB
60.	2.500E-06	AFVV1006TB	AFDP0002SA
61.	2.500E-06	EDBYA401BB	AFDP0002SA
62.	2.500E-06	CCVV1045TA	AFDP0002SB
63.	2.500E-06	AFDP0002SB	AFVV1006TA
64.	2.500E-06	AFDP0002SB	EDBYA401BA
65.	2.500E-06	CDCV1178OA	AFDP0002SB
66.	2.500E-06	AFDP0002SB	CCVV1213TA
67.	2.500E-06	CCCV1211OA	AFDP0002SB
68.	2.500E-06	AFCV1004OA	AFDP0002SB
69.	2.500E-06	AFVV1002TA	AFDP0002SB
70.	1.800E-06	EDBSY401EB	AFDP0002SA
71.	1.800E-06	AFDP0002SB	EDBSY401EA
72.	1.533E-06	AFDP0002RA	EDFSI401EB
73.	1.533E-06	EDFSI401EA	AFDP0002RB
74.	1.278E-06	AFDP0002SA	AFTP0008YB
75.	1.278E-06	AFTP0007YA	AFDP0002SB
76.	7.152E-07	AFDP0002MA	AFVV1006UB
77.	7.152E-07	AFDP0002MA	AFVV1016UB
78.	7.152E-07	AFVV1016UA	AFDP0002MB
79.	7.152E-07	AFVV1006UA	AFDP0002MB
80.	6.000E-07	AFDP0002SA	EDFSI401EB
81.	6.000E-07	EDFSI401EA	AFDP0002SB
82.	2.304E-07	AFVV1016UA	AFVV1006UB
83.	2.304E-07	AFVV1016UA	AFVV1016UB

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Unavailability : 7.75E-03

84.	2.304E-07	AFVV1006UA	AFVV1006UB
85.	2.304E-07	AFVV1006UA	AFVV1016UB
86.	1.863E-07	AFDP0002MA	AFCV1004OB
87.	1.863E-07	AFDP0002MA	AFVV1002TB
88.	1.863E-07	AFDP0002MA	CCVV1046TB
89.	1.863E-07	CCVV1214TB	AFDP0002MA
90.	1.863E-07	AFDP0002MA	CCCV1212OB
91.	1.863E-07	AFDP0002MA	AFCV1014OB
92.	1.863E-07	AFDP0002MA	CDVV1196TB
93.	1.863E-07	AFDP0002MA	CDCV1181OB
94.	1.863E-07	AFDP0002MA	CDMV0460TB
95.	1.863E-07	AFVV1006TB	AFDP0002MA
96.	1.863E-07	AFCV1014OA	AFDP0002MB
97.	1.863E-07	CDMV0459TA	AFDP0002MB
98.	1.863E-07	CDVV1167TA	AFDP0002MB

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TABLE 10A-7 (Sh. 1 of 3)

MINIMAL CUT SETS FOR SBO (MEAN VALUES WITHOUT CCF)

Unavailability : 5.64E-03

1.	2.611E-03	AFDP0002RA	AFDP0002RB
2.	1.022E-03	AFDP0002SA	AFDP0002RB
3.	1.022E-03	AFDP0002RA	AFDP0002SB
4.	4.000E-04	AFDP0002SA	AFDP0002SB
5.	7.614E-05	AFDP0002MA	AFDP0002RB
6.	7.614E-05	AFDP0002RA	AFDP0002MB
7.	2.980E-05	AFDP0002MA	AFDP0002SB
8.	2.980E-05	AFDP0002SA	AFDP0002MB
9.	2.453E-05	AFVV1006UA	AFDP0002RB
10.	2.453E-05	AFVV1016UA	AFDP0002RB
11.	2.453E-05	AFDP0002RA	AFVV1006UB
12.	2.453E-05	AFDP0002RA	AFVV1016UB
13.	9.600E-06	AFVV1006UA	AFDP0002SB
14.	9.600E-06	AFVV1016UA	AFDP0002SB
15.	9.600E-06	AFDP0002SA	AFVV1006UB
16.	9.600E-06	AFDP0002SA	AFVV1016UB
17.	6.388E-06	AFDP0002RB	AFVV1006TA
18.	6.388E-06	AFDP0002RB	CCVV1213TA
19.	6.388E-06	CCCV1211OA	AFDP0002RB
20.	6.388E-06	AFCV1014OA	AFDP0002RB
21.	6.388E-06	EDBYA401BA	AFDP0002RB
22.	6.388E-06	CDVV1167TA	AFDP0002RB
23.	6.388E-06	AFCV1004OA	AFDP0002RB
24.	6.388E-06	AFVV1002TA	AFDP0002RB
25.	6.388E-06	AFDP0002RA	EDBYA401BB
26.	6.388E-06	CDCV1178OA	AFDP0002RB
27.	6.388E-06	AFDP0002RA	AFCV1004OB
28.	6.388E-06	AFDP0002RA	AFVV1002TB
29.	6.388E-06	CDMV0459TA	AFDP0002RB
30.	6.388E-06	AFDP0002RA	CCVV1046TB
31.	6.388E-06	CCVV1214TB	AFDP0002RA
32.	6.388E-06	AFDP0002RA	CCCV1212OB
33.	6.388E-06	AFDP0002RA	AFCV1014OB
34.	6.388E-06	AFDP0002RA	CDVV1196TB
35.	6.388E-06	AFDP0002RA	CDCV1181OB
36.	6.388E-06	AFDP0002RA	CDMV0460TB
37.	6.388E-06	AFVV1006TB	AFDP0002RA
38.	6.388E-06	CCVV1045TA	AFDP0002RB
39.	4.599E-06	EDBSY401EB	AFDP0002RA
40.	4.599E-06	AFDP0002RB	EDBSY401EA
41.	3.265E-06	AFDP0002RA	AFTP0008YB

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Unavailability : 5.64E-03

42.	3.265E-06	AFTP0007YA	AFDP0002RB
43.	2.500E-06	AFDP0002SB	AFVV1006TA
44.	2.500E-06	AFDP0002SB	CCVV1213TA
45.	2.500E-06	CCCV1211OA	AFDP0002SB
46.	2.500E-06	AFCV1014OA	AFDP0002SB
47.	2.500E-06	EDBYA401BA	AFDP0002SB
48.	2.500E-06	CDVV1167TA	AFDP0002SB
49.	2.500E-06	AFDP0002SA	EDBYA401BB
50.	2.500E-06	AFCV1004OA	AFDP0002SB
51.	2.500E-06	AFVV1002TA	AFDP0002SB
52.	2.500E-06	CDCV1178OA	AFDP0002SB
53.	2.500E-06	AFDP0002SA	AFCV1004OB
54.	2.500E-06	AFDP0002SA	AFVV1002TB
55.	2.500E-06	AFDP0002SA	CCVV1046TB
56.	2.500E-06	CCVV1214TB	AFDP0002SA
57.	2.500E-06	AFDP0002SA	CCCV1212OB
58.	2.500E-06	AFDP0002SA	AFCV1014OB
59.	2.500E-06	AFDP0002SA	CDVV1196TB
60.	2.500E-06	AFDP0002SA	CDCV1181OB
61.	2.500E-06	AFDP0002SA	CDMV0460TB
62.	2.500E-06	AFVV1006TB	AFDP0002SA
63.	2.500E-06	CDMV0459TA	AFDP0002SB
64.	2.500E-06	CCVV1045TA	AFDP0002SB
65.	1.800E-06	EDBSY401EB	AFDP0002SA
66.	1.800E-06	AFDP0002SB	EDBSY401EA
67.	1.533E-06	AFDP0002RB	EDFSI401EA
68.	1.533E-06	EDFSI401EB	AFDP0002RA
69.	1.278E-06	AFDP0002SA	AFTP0008YB
70.	1.278E-06	AFTP0007YA	AFDP0002SB
71.	7.152E-07	AFVV1006UA	AFDP0002MB
72.	7.152E-07	AFVV1016UA	AFDP0002MB
73.	7.152E-07	AFDP0002MA	AFVV1006UB
74.	7.152E-07	AFDP0002MA	AFVV1016UB
75.	6.000E-07	AFDP0002SB	EDFSI401EA
76.	6.000E-07	EDFSI401EB	AFDP0002SA
77.	2.304E-07	AFVV1006UA	AFVV1006UB
78.	2.304E-07	AFVV1016UA	AFVV1006UB
79.	2.304E-07	AFVV1006UA	AFVV1016UB
80.	2.304E-07	AFVV1016UA	AFVV1016UB
81.	1.863E-07	AFDP0002MA	CDVV1196TB
82.	1.863E-07	AFDP0002MA	AFCV1004OB
83.	1.863E-07	AFDP0002MA	AFVV1002TB

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Unavailability : 5.64E-03

84.	1.863E-07	AFDP0002MA	CCVV1046TB
85.	1.863E-07	CCVV1214TB	AFDP0002MA
86.	1.863E-07	AFDP0002MA	CCCV1212OB
87.	1.863E-07	AFDP0002MA	AFCV1014OB
88.	1.863E-07	AFDP0002MA	CDCV1181OB
89.	1.863E-07	AFDP0002MA	CDMV0460TB
90.	1.863E-07	AFVV1006TB	AFDP0002MA
91.	1.863E-07	AFDP0002MB	AFVV1006TA
92.	1.863E-07	AFDP0002MB	CCVV1213TA
93.	1.863E-07	CCCV1211OA	AFDP0002MB
94.	1.863E-07	EDBYA401BA	AFDP0002MB
95.	1.863E-07	AFCV1014OA	AFDP0002MB
96.	1.863E-07	CDVV1167TA	AFDP0002MB
97.	1.863E-07	AFDP0002MA	EDBYA401BB

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TABLE 10A-8

IMPORTANCE RESULTS OF LMFW (MEAN VALUES WITH CCF)

Rank	EVENT NAME	POINT EST.	F-V IMPORT	RSK ACMT	RISK RED
1	EDBSK125DC	9.000E-006	4.661E-001	51785.55	1.873
2	AFPT0001K	6.390E-006	3.309E-001	51785.69	1.495
3	AFDP0002RB	5.110E-002	8.957E-002	2.66	1.098
4	AFDP0002RA	5.110E-002	8.957E-002	2.66	1.098
5	AFMP0001W	1.980E-004	7.793E-002	394.52	1.085
6	AFMP0001MB	5.530E-003	3.649E-002	7.56	1.038
7	AFMP0001MA	5.530E-003	3.649E-002	7.56	1.038
8	AFDP0002SA	2.000E-002	3.419E-002	2.68	1.035
9	AFDP0002SB	2.000E-002	3.419E-002	2.68	1.035
10	AFDP0002W	1.580E-003	3.174E-002	21.06	1.033
11	AFMP0001SB	2.500E-003	1.598E-002	7.38	1.016
12	AFMP0001SA	2.500E-003	1.598E-002	7.38	1.016
13	AFMP0001RA	1.980E-003	1.251E-002	7.31	1.013
14	AFMP0001RB	1.980E-003	1.251E-002	7.31	1.013
15	AFDP0002K	5.110E-004	9.912E-003	20.39	1.010
16	CDMV0460TB	1.250E-004	8.905E-003	72.23	1.009
17	CDCV1181OB	1.250E-004	8.905E-003	72.23	1.009
18	CDVV1196TB	1.250E-004	8.905E-003	72.23	1.009
19	CDVV1167TA	1.250E-004	8.905E-003	72.23	1.009
20	CDCV1178OA	1.250E-004	8.905E-003	72.23	1.009
21	CDMV0459TA	1.250E-004	8.905E-003	72.23	1.009
22	AFMDPCOOL-A	1.250E-003	7.792E-003	7.23	1.008
23	AFMDPCOOL-B	1.250E-003	7.792E-003	7.23	1.008
24	AFMP0001K	1.980E-005	7.624E-003	386.06	1.008
25	EDBSY401EB	9.000E-005	6.285E-003	70.83	1.006
26	EDBSY401EA	9.000E-005	6.285E-003	70.83	1.006
27	EKBSK416KV	9.000E-006	3.395E-003	378.18	1.003
28	AFVV1005UA	4.800E-004	3.238E-003	7.74	1.003
29	AFVV1015UA	4.800E-004	3.238E-003	7.74	1.003

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TABLE 10A-9

IMPORTANCE RESULTS OF LMFW (MEAN VALUES WITHOUT CCF)

Rank	EVENT NAME	POINT EST.	F-V IMPORT	RSK ACMT	RISK RED
1	AFDP0002RA	5.110E-002	4.641E-001	9.62	1.866
2	AFDP0002RB	5.110E-002	4.641E-001	9.62	1.866
3	AFMP0001MB	5.530E-003	2.972E-001	54.44	1.423
4	AFMP0001MA	5.530E-003	2.972E-001	54.44	1.423
5	AFDP0002SB	2.000E-002	1.751E-001	9.58	1.212
6	AFDP0002SA	2.000E-002	1.751E-001	9.58	1.212
7	AFMP0001SA	2.500E-003	1.309E-001	53.22	1.151
8	AFMP0001SB	2.500E-003	1.309E-001	53.22	1.151
9	AFMP0001RA	1.980E-003	1.022E-001	52.49	1.114
10	AFMP0001RB	1.980E-003	1.022E-001	52.49	1.114
11	CDVV1196TB	1.250E-004	9.059E-002	725.61	1.100
12	CDMV0459TA	1.250E-004	9.059E-002	725.61	1.100
13	CDVV1167TA	1.250E-004	9.059E-002	725.61	1.100
14	CDCV1181OB	1.250E-004	9.059E-002	725.61	1.100
15	CDCV1178OA	1.250E-004	9.059E-002	725.61	1.100
16	CDMV0460TB	1.250E-004	9.059E-002	725.61	1.100
17	EDBSY401EA	9.000E-005	6.483E-002	721.23	1.069
18	EDBSY401EB	9.000E-005	6.483E-002	721.23	1.069
19	AFMDPCOOL-B	1.250E-003	6.381E-002	51.99	1.068
20	AFMDPCOOL-A	1.250E-003	6.381E-002	51.99	1.068
21	AFVV1015UB	4.800E-004	2.643E-002	56.03	1.027
22	AFVV1015UA	4.800E-004	2.643E-002	56.03	1.027
23	AFVV1005UA	4.800E-004	2.643E-002	56.03	1.027
24	AFVV1005UB	4.800E-004	2.643E-002	56.03	1.027
25	AFCV1048OA	1.250E-004	8.355E-003	67.83	1.008
26	AFCV1049OB	1.250E-004	8.355E-003	67.83	1.008
27	AFDP0002MB	1.490E-003	5.489E-003	4.68	1.006
28	AFDP0002MA	1.490E-003	5.489E-003	4.68	1.006
29	AFVV1006UA	4.800E-004	4.111E-003	9.56	1.004

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TABLE 10A-10

IMPORTANCE RESULTS OF LOOP (MEAN VALUES WITH CCF)

Rank	EVENT NAME	POINT EST.	F-V IMPORT	RSK ACMT	RISK RED
1	EGDGR01KA	1.910E-001	5.312E-001	3.25	2.133
2	EGDGR01KB	1.910E-001	5.312E-001	3.25	2.133
3	EAHBV01SB	1.000E-001	4.801E-001	5.32	1.924
4	AFDP0002RB	5.110E-002	4.405E-001	9.18	1.787
5	AFDP0002RA	5.110E-002	4.405E-001	9.18	1.787
6	EADGR01KS	5.800E-002	2.762E-001	5.49	1.382
7	AFDP0002W	1.580E-003	1.795E-001	114.44	1.219
8	AFDP0002SB	2.000E-002	1.657E-001	9.12	1.199
9	AFDP0002SA	2.000E-002	1.657E-001	9.12	1.199
10	EGDGK01KAB	1.400E-002	1.495E-001	11.53	1.176
11	EGDGS01KA	3.750E-002	9.809E-002	3.52	1.109
12	EGDGS01KB	3.750E-002	9.809E-002	3.52	1.109
13	EDBSK125DC	9.000E-006	6.998E-002	7776.28	1.075
14	EADGS01KS	1.400E-002	6.185E-002	5.36	1.066
15	AFDP0002K	5.110E-004	5.607E-002	110.66	1.059
16	AFPT0001K	6.390E-006	4.968E-002	7776.30	1.052
17	EGDGM01KB	1.250E-002	3.023E-002	3.39	1.031
18	EGDGM01KA	1.250E-002	3.023E-002	3.39	1.031
19	EADGM01KS	6.000E-003	2.455E-002	5.07	1.025
20	AFMP0001MA	5.530E-003	1.716E-002	4.09	1.017
21	AFMP0001MB	5.530E-003	1.716E-002	4.09	1.017
22	AFMP0001W	1.980E-004	1.145E-002	58.81	1.012
23	AFDP0002MA	1.490E-003	9.887E-003	7.63	1.010
24	AFDP0002MB	1.490E-003	9.887E-003	7.63	1.010
25	AFCLOSEDTM	5.000E-001	9.625E-003	1.01	1.010
26	EGDGW01KAB	7.500E-004	7.311E-003	10.74	1.007
27	AFMP0001SB	2.500E-003	6.392E-003	3.55	1.006
28	AFMP0001SA	2.500E-003	6.392E-003	3.55	1.006
29	AFMP0001RB	1.980E-003	4.841E-003	3.44	1.005

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TABLE 10A-11

IMPORTANCE RESULTS OF LOOP(MEAN VALUES WITHOUT CCF)

Rank	EVENT NAME	POINT EST.	F-V IMPORT	RSK ACMT	RISK RED
1	EGDGR01KA	1.910E-001	7.420E-001	4.14	3.876
2	EGDGR01KB	1.910E-001	7.420E-001	4.14	3.876
3	AFDP0002RA	5.110E-002	6.818E-001	13.66	3.143
4	AFDP0002RB	5.110E-002	6.818E-001	13.66	3.143
5	EAHBV01SB	1.000E-001	5.531E-001	5.98	2.238
6	EADGR01KS	5.800E-002	3.185E-001	6.17	1.467
7	AFDP0002SB	2.000E-002	2.553E-001	13.51	1.343
8	AFDP0002SA	2.000E-002	2.553E-001	13.51	1.343
9	EGDGS01KB	3.750E-002	1.362E-001	4.50	1.158
10	EGDGS01KA	3.750E-002	1.362E-001	4.50	1.158
11	EADGS01KS	1.400E-002	6.982E-002	5.92	1.075
12	EGDGM01KA	1.250E-002	4.175E-002	4.30	1.044
13	EGDGM01KB	1.250E-002	4.175E-002	4.30	1.044
14	EADGM01KS	6.000E-003	2.717E-002	5.50	1.028
15	AFMP0001MB	5.530E-003	2.435E-002	5.38	1.025
16	AFMP0001MA	5.530E-003	2.435E-002	5.38	1.025
17	AFDP0002MA	1.490E-003	1.503E-002	11.08	1.015
18	AFDP0002MB	1.490E-003	1.503E-002	11.08	1.015
19	AFCLOSEDTM	5.000E-001	1.284E-002	1.01	1.013
20	AFMP0001SA	2.500E-003	9.165E-003	4.66	1.009
21	AFMP0001SB	2.500E-003	9.165E-003	4.66	1.009
22	CDCV1178OA	1.250E-004	7.057E-003	57.45	1.007
23	CDMV0460TB	1.250E-004	7.057E-003	57.45	1.007
24	CDVV1196TB	1.250E-004	7.057E-003	57.45	1.007
25	CDCV1181OB	1.250E-004	7.057E-003	57.45	1.007
26	CDMV0459TA	1.250E-004	7.057E-003	57.45	1.007
27	CDVV1167TA	1.250E-004	7.057E-003	57.45	1.007
28	AFMP0001RA	1.980E-003	6.958E-003	4.51	1.007
29	AFMP0001RB	1.980E-003	6.958E-003	4.51	1.007

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TABLE 10A-12

IMPORTANCE RESULTS OF SBO(MEAN VALUES WITH CCF)

Rank	EVENT NAME	POINT EST.	F-V IMPORT	RSK ACMT	RISK RED
1	AFDP0002RA	5.110E-002	4.952E-001	10.20	1.981
2	AFDP0002RB	5.110E-002	4.952E-001	10.20	1.981
3	AFDP0002W	1.580E-003	2.038E-001	129.80	1.256
4	AFDP0002SB	2.000E-002	1.938E-001	10.50	1.240
5	AFDP0002SA	2.000E-002	1.938E-001	10.50	1.240
6	AFDP0002K	5.110E-004	6.592E-002	129.94	1.071
7	AFDP0002MB	1.490E-003	1.444E-002	10.68	1.015
8	AFDP0002MA	1.490E-003	1.444E-002	10.68	1.015
9	AFVV1006UB	4.800E-004	4.651E-003	10.69	1.005
10	AFVV1016UB	4.800E-004	4.651E-003	10.69	1.005
11	AFVV1006UA	4.800E-004	4.651E-003	10.69	1.005
12	AFVV1016UA	4.800E-004	4.651E-003	10.69	1.005
13	CCVV1045TA	1.250E-004	1.211E-003	10.69	1.001
14	EDBYA401BB	1.250E-004	1.211E-003	10.69	1.001
15	CDMV0460TB	1.250E-004	1.211E-003	10.69	1.001
16	AFVV1006TB	1.250E-004	1.211E-003	10.69	1.001
17	CDCV1181OB	1.250E-004	1.211E-003	10.69	1.001
18	AFVV1006TA	1.250E-004	1.211E-003	10.69	1.001
19	AFCV1004OA	1.250E-004	1.211E-003	10.69	1.001
20	AFVV1002TA	1.250E-004	1.211E-003	10.69	1.001
21	CCCV1211OA	1.250E-004	1.211E-003	10.69	1.001
22	CCVV1213TA	1.250E-004	1.211E-003	10.69	1.001
23	CDCV1178OA	1.250E-004	1.211E-003	10.69	1.001
24	EDBYA401BA	1.250E-004	1.211E-003	10.69	1.001
25	AFCV1004OB	1.250E-004	1.211E-003	10.69	1.001
26	AFVV1002TB	1.250E-004	1.211E-003	10.69	1.001
27	CDVV1167TA	1.250E-004	1.211E-003	10.69	1.001
28	AFCV1014OA	1.250E-004	1.211E-003	10.69	1.001
29	CDVV1196TB	1.250E-004	1.211E-003	10.69	1.001

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TABLE 10A-13

IMPORTANCE RESULTS OF SBO(MEAN VALUES WITHOUT CCF)

Rank	EVENT NAME	POINT EST.	F-V IMPORT	RSK ACMT	RISK RED
1	AFDP0002RB	5.110E-002	6.803E-001	13.63	3.128
2	AFDP0002RA	5.110E-002	6.803E-001	13.63	3.128
3	AFDP0002SB	2.000E-002	2.663E-001	14.05	1.363
4	AFDP0002SA	2.000E-002	2.663E-001	14.05	1.363
5	AFDP0002MB	1.490E-003	1.984E-002	14.29	1.020
6	AFDP0002MA	1.490E-003	1.984E-002	14.29	1.020
7	AFVV1006UB	4.800E-004	6.390E-003	14.31	1.006
8	AFVV1016UB	4.800E-004	6.390E-003	14.31	1.006
9	AFVV1016UA	4.800E-004	6.390E-003	14.31	1.006
10	AFVV1006UA	4.800E-004	6.390E-003	14.31	1.006
11	CCVV1214TB	1.250E-004	1.664E-003	14.31	1.002
12	CCVV1046TB	1.250E-004	1.664E-003	14.31	1.002
13	CDMV0459TA	1.250E-004	1.664E-003	14.31	1.002
14	AFVV1002TB	1.250E-004	1.664E-003	14.31	1.002
15	CDVV1196TB	1.250E-004	1.664E-003	14.31	1.002
16	AFVV1006TB	1.250E-004	1.664E-003	14.31	1.002
17	CCVV1045TA	1.250E-004	1.664E-003	14.31	1.002
18	CDMV0460TB	1.250E-004	1.664E-003	14.31	1.002
19	CDCV1181OB	1.250E-004	1.664E-003	14.31	1.002
20	AFCV1014OB	1.250E-004	1.664E-003	14.31	1.002
21	CCCV1212OB	1.250E-004	1.664E-003	14.31	1.002
22	CCCV1211OA	1.250E-004	1.664E-003	14.31	1.002
23	EDBYA401BA	1.250E-004	1.664E-003	14.31	1.002
24	CCVV1213TA	1.250E-004	1.664E-003	14.31	1.002
25	AFVV1006TA	1.250E-004	1.664E-003	14.31	1.002
26	AFCV1004OB	1.250E-004	1.664E-003	14.31	1.002
27	AFCV1014OA	1.250E-004	1.664E-003	14.31	1.002
28	AFVV1002TA	1.250E-004	1.664E-003	14.31	1.002
29	CDVV1167TA	1.250E-004	1.664E-003	14.31	1.002

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TABLE 10A-14 (Sh. 1 of 9)

FAILURE DATA(MEAN VALUE) USED IN QUATIFICATION

Event	Failure Probability		Description	Data Source *
	Mean	Median		
AFAS1A	1.25E-3	1.00E-3	AFAS-1 TRAIN A NOT ACTUATED AUTOMATICALLY	1
AFAS1B	1.25E-3	1.00E-3	AFAS-1 TRAIN B NOT ACTUATED AUTOMATICALLY	1
AFAS2A	1.25E-3	1.00E-3	AFAS-2 TRAIN A NOT ACTUATED AUTOMATICALLY	1
AFAS2B	1.25E-3	1.00E-3	AFAS-2 TRAIN B NOT ACTUATED AUTOMATICALLY	1
AFAV0045OA	3.75E-4	3.00E-4	TRAIN A FLOW CONTROL AOV V0045 FAILURE TO OPERATE	2
AFAV0045W	3.30E-5	2.64E-5	CCF OF AFW FLOW CONTROL AOVS	2
AFAV0046OB	3.75E-4	3.00E-4	TRAIN B AFW CONTROL AOV V0046 FAILS TO OPERATE	2
AFCCW-A	1.25E-3	1.00E-3	NO FLOW FROM CCW TRAIN A FOR TRAIN A AFW DDP	1
AFCCW-B	1.25E-3	1.00E-3	NO FLOW FROM CCW TRAIN B FOR TRAIN B AFW DDP	1
AFCLOSEDTM	5.00E-1	5.00E-1	TIME FRACTION THAT AFW ISOLATION MOV'S CLOSED	-
AFCV1003OA	1.25E-4	1.00E-4	MDP 01PA DISCHARGE LINE CV V1003A FAILS TO OPEN	2,3
AFCV1003OB	1.25E-4	1.00E-4	MDP 01PB DISCHARGE LINE V1003B FAILS TO OPEN	2,3
AFCV1004OA	1.25E-4	1.00E-4	DDP 02PA DISCHARGE LINE CV V1004A FAILS TO OPEN	2,3
AFCV1004OB	1.25E-4	1.00E-4	DDP 02PB DISCHARGE LINE V1004B FAILS TO OPEN	2,3
AFCV1008OA	1.25E-4	1.00E-4	AFW CORSS-TIE LINE CV V1008 FAILS TO OPEN	2,3
AFCV1008OB	1.25E-4	1.00E-4	AFW CROSS-TIE LINE CV V1008 FAILS TO OPEN	2,3
AFCV1012OA	1.25E-4	1.00E-4	AFW MDP 01PA MINI FLOW LINE V1012A FAILS TO OPEN	2,3
AFCV1012OB	1.25E-4	1.00E-4	AFW MDP 01PB MINI FLOW LINE V1012B FAILS TO OPEN	2,3
AFCV1014OA	1.25E-4	1.00E-4	AFW DDP 02PA MINI FLOW LINE V1014A FAILS TO OPEN	2,3
AFCV1014OB	1.25E-4	1.00E-4	AFW DDP 02PB MINI FLOW LINE V1014B FAILS TO OPEN	2,3
AFCV1048OA	1.25E-4	1.00E-4	CV V1048 ON FEEDWATER LINE A FAILS TO OPEN	2,3
AFCV1049OB	1.25E-4	1.00E-4	CV V1049 ON FEEDWATER LINE B FAILS TO OPEN	2,3
AFCVIADOA	1.25E-4	1.00E-4	CV ON IA LINE DOWN- STREAM FAILS TO OPEN	2,3
AFCVIADOB	1.25E-4	1.00E-4	CV ON IA LINE DOWN- STREAM FAILS TO OPEN	2,3
AFCVIAUOA	1.25E-4	1.00E-4	CV ON IA LINE UP-STREAM FAILS TO OPEN	2,3
AFCVIAUOB	1.25E-4	1.00E-4	CV ON IA LINE UP-STREAM FAILS TO OPEN	2,3
AFDP0002K	5.11E-4	1.92E-4	CCF(RUNNING) OF AFW DDP 02PA & 02PB	3
AFDP0002MA	1.49E-3	1.19E-3	AFW DDP 02PA UNAVAILABLE DUE TO TEST OR MAINTENANCE	1
AFDP0002MB	1.49E-3	1.19E-3	AFW DDP 02PB UNAVAILABLE DUE TO TEST OR MAINTENANCE	1
AFDP0002RA	5.11E-2	1.92E-2	AFW DDP 02PA FAILS TO RUN	3

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TABLE 10A-14 (Sh. 2 of 9)

Event	Failure Probabilty Mean	Failure Probabilty Median	Description	Data Source *
AFDP0002RB	5.11E-2	1.92E-2	AFW DDP 02PB FAILS TO RUN	3
AFDP0002SA	2.00E-2	1.60E-2	AFW DDP 02PA FAILS TO START	4
AFDP0002SB	2.00E-2	1.60E-2	AFW DDP 02PB FAILS TO START	4
AFDP0002W	1.58E-3	1.26E-3	CCF(DEMAND) OF AFW DDP 02PA & 02PB	4
AFMDPCOOL-A	1.25E-3	1.00E-3	AFW MDP 01PA ROOM COOLING FAILURE	1
AFMDPCOOL-B	1.25E-3	1.00E-3	AFW MDP 01PB ROOM COOLING FAILURE	1
AFMP0001K	1.98E-5	7.44E-6	CCF(RUNNING) OF AFW MDP 01PA & 01PB	3
AFMP0001MA	5.53E-3	4.44E-3	AFW MDP 01PA UNAVAILABLE DUE TO TEST OR MAINTENANCE	1
AFMP0001MB	5.53E-3	4.44E-3	AFW MDP 01PB UNAVAILABLE DUE TO TEST OR MAINTENANCE	1
AFMP0001RA	1.98E-3	7.44E-4	AFW MDP 01PA FAILS TO RUN	3
AFMP0001RB	1.98E-3	7.44E-4	AFW MDP 01PB FAILS TO RUN	3
AFMP0001SA	2.50E-3	2.00E-3	AFW MDP 01PA FAILS TO START	3
AFMP0001SB	2.50E-3	2.00E-3	AFW MDP 01PB FAILS TO START	3
AFMP0001W	1.98E-4	1.58E-4	CCF(DEMAND) OF AFW MDP 01PA & 01PB	3
AFMV0030W	2.13E-6	1.70E-6	CCF OF MOVS 0043 AND 0050	3
AFMV0034W	2.13E-6	1.70E-6	CCF OF MOVS 0043 AND 0044	3
AFMV0035OA	1.25E-3	1.00E-3	AFW ISOLATION MOV V0035 FAILS TO OPEN	3
AFMV0036OB	1.25E-3	1.00E-3	AFW ISOLATION MOV V0036 FAILS TO OPEN	3
AFMV0037OA	1.25E-3	1.00E-3	AFW X-TIE ISOL. MOV V0037 FAILS TO OPEN	3
AFMV0038OB	1.25E-3	1.00E-3	AFW X-TIE ISOL. MOV V0038 FAILS TO OPEN	3
AFMV0039W	2.13E-6	1.70E-6	CCF OF MOVS 0043 AND 0049	3
AFMV0040W	2.13E-6	1.70E-6	CCF OF MOVS 0044 AND 0050	3
AFMV0043OA	1.25E-3	1.00E-3	AFW ISOLATION MOV V0043 FAILS TO OPEN	3
AFMV0044OB	1.25E-3	1.00E-3	AFW ISOLATION MOV V0044 FAILS TO OPEN	3
AFMV0049CA	1.25E-3	1.00E-3	AFW X-TIE ISOLATION MOV, V0049 FAILS TO CLOSE	3
AFMV0049OA	1.25E-3	1.00E-3	AFW X-TIE ISOL. MOV V0049 FAILS TO OPEN	3
AFMV0049W	2.13E-6	1.70E-6	CCF OF MOVS 0044 AND 0049	3
AFMV0050CB	1.25E-3	1.00E-3	AFW X-TIE ISOLATION MOV, V0050 FAILS TO CLOSE	3
AFMV0050OB	1.25E-3	1.00E-3	AFW X-TIE ISOL. MOV V0050 FAILS TO OPEN	3
AFMV0056W	2.13E-6	1.70E-6	CCF OF MOVS 0035 AND 0036	3
AFMV0057W	2.13E-6	1.70E-6	CCF OF MOVS 0035 AND 0037	3
AFMV0058W	2.13E-6	1.70E-6	CCF OF MOVS 0035 AND 0038	3

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TABLE 10A-14 (Sh. 3 of 9)

Event	Failure Probability Mean	Failure Probability Median	Description	Data Source *
AFMV0067W	2.13E-6	1.70E-6	CCF OF MOVS 0036 AND 0037	3
AFMV0068W	2.13E-6	1.70E-6	CCF OF MOVS 0036 AND 0038	3
AFMV0078W	2.13E-6	1.70E-6	CCF OF MOVS 0037 AND 0038	3
AFMV0090W	2.13E-6	1.70E-6	CCF OF MOVS 0049 AND 0050	3
AFMV0340W	4.13E-6	3.30E-6	CCF OF MOVS 0043,0044 AND 0050	3
AFMV0349W	4.13E-6	3.30E-6	CCF OF MOVS 0043,0044 AND 0049	3
AFMV0390W	4.13E-6	3.30E-6	CCF OF MOVS 0043,0049 AND 0050	3
AFMV0490W	4.13E-6	3.30E-6	CCF OF MOVS 0044,0049 AND 0050	3
AFMV0567W	4.13E-6	3.30E-6	CCF OF MOVS 0035,0036 AND 0037	3
AFMV0568W	4.13E-6	3.30E-6	CCF OF MOVS 0035,0036 AND 0038	3
AFMV0578W	4.13E-6	3.30E-6	CCF OF MOVS 0035,0037 AND 0038	3
AFMV0678W	4.13E-6	3.30E-6	CCF OF MOVS 0036,0037 AND 0038	3
AFMV3490W	4.25E-5	3.40E-5	CCF OF 4 AFW ISOL. MOVS 0043,0044,0049 AND 0050	3
AFMV5678W	4.25E-5	3.40E-5	CCF OF 4 AFW ISOL. MOVS 0035,0036,0037 AND 0038	3
AFPT0001K	6.39E-6	2.40E-6	CCF OF PUMPS SUCTION PRESSURE TRANSMITTERS	3
AFPT0005YA	6.39E-5	2.40E-5	AFW MDP 01PA SUCTION PT-0005A OUTPUT FAILS LOW	3
AFPT0006YB	6.39E-5	2.40E-5	AFW MDP 02PB SUCTION PT-0006B OUTPUT FAILS LOW	3
AFSGLV-A	2.66E-4	1.00E-4	FAILURE OF S/G-1 LOW-LOW LEVEL SIGNAL	1
AFSGLV-B	2.66E-4	1.00E-4	FAILURE OF S/G-2 LOW-LOW LEVEL SIGNAL	1
AFTK0045BA	2.40E-6	9.00E-7	TRAIN A N2 RESERVOIR FAILURE	4
AFTK0046BB	2.40E-6	9.00E-7	TRAIN B N2 RESERVOIR FAILURE	4
AFTP0007YA	6.39E-5	2.40E-5	AFW DDP 02PA SUCTION PT-007A OUTPUT FAILS LOW	3
AFTP0008YB	6.39E-5	2.40E-5	AFW DDP 02PB SUCTION PT-008B OUTPUT FAILS LOW	3
AFVV1001TA	1.25E-4	1.00E-4	TRAIN A MDP 01PA SUCTION LINE V1001A FAILS CLOSED	2,3
AFVV1001TB	1.25E-4	1.00E-4	TRAIN B MDP 01PB SUCTION LINE V1001B FAILS CLOSED	2,3
AFVV1002TA	1.25E-4	1.00E-4	TRAIN A DDP 02PA SUCTION LINE V1002A FAILS CLOSED	2,3
AFVV1002TB	1.25E-4	1.00E-4	TRAIN B DDP 02PB SUCTION LINE V1002B FAILS CLOSED	2,3
AFVV1005TA	1.25E-4	1.00E-4	TRAIN A MDP 01PA DISCHARGE LINE V1005A FAILS CLOSED	2,3
AFVV1005TB	1.25E-4	1.00E-4	TRAIN B MDP 01PB DISCHARGE LINE V1005B FAILS CLOSED	2,3
AFVV1005UA	3.80E-4	3.04E-4	MDP 01PA DISCHARGE LINE V1005A NOT RESTORED AFTER T/M	5
AFVV1005UB	3.80E-4	3.04E-4	MDP 01PB DISCHARGE LINE V1005B NOT RESTORED AFTER T/M	5
AFVV1006TA	1.25E-4	1.00E-4	TRAIN A DDP 02PA DISCHARGE LINE V1006A FAILS CLOSED	2,3

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TABLE 10A-14 (Sh. 4 of 9)

Event	Failure Probability		Description	Data Source *
	Mean	Median		
AFVV1006TB	1.25E-4	1.00E-4	TRAIN B DDP 02PB DISCHARGE LINE V1006B FAILS CLOSED	2,3
AFVV1006UA	3.80E-4	3.04E-4	DDP 02PA DISCHARGE LINE V1006A NOT RESTORED AFTER T/M	5
AFVV1006UB	3.80E-4	3.04E-4	DDP 02PB DISCHARGE LINE V1006B NOT RESTORED AFTER T/M	5
AFVV1015UA	3.80E-4	3.04E-4	MINI FLOW ORIFICE BYPASS V1015A NOT RESTORED AFTER T/M	5
AFVV1015UB	3.80E-4	3.04E-4	MINI FLOW ORIFICE BYPASS V1015B NOT RESTORED AFTER T/M	5
AFVV1016UA	3.80E-4	3.04E-3	MINI FLOW ORIFICE BYPASS V1016A NOT RESTORED AFTER T/M	5
AFVV1016UB	3.80E-4	3.04E-3	MINI FLOW ORIFICE BYPASS V1016B NOT RESTORED AFTER T/M	5
AFVVN2TKTA	1.25E-4	1.00E-3	N2 SUPPLY LINE VALVE FAILS CLOSED	2,3
AFVVN2TKTB	1.25E-4	1.00E-3	N2 SUPPLY LINE VALVE FAILS CLOSED	2,3
AFXVFAILFA	1.25E-3	1.00E-4	TRAIN A N2 SUPPLY PRESSURE REGULATING VALVE FAILURE	1
AFXVFAILFB	1.25E-3	1.00E-4	TRAIN B N2 SUPPLY PRESSURE REGULATING VALVE FAILURE	1
CCCV1199OA	1.25E-4	1.00E-4	NORMAL AFW DDP 02PA COOLING DISCH. V1199 FAILS TO OPEN	2,3
CCCV1200OB	1.25E-4	1.00E-4	NORMAL AFW DDP 02PB COOLING DISCH. V1200 FAILS TO OPEN	2,3
CCCV1211OA	1.25E-4	1.00E-4	CCW BOOSTER PUMP A DISCHARGE LINE V1211 FAILS TO OPEN	2,3
CCCV1212OB	1.25E-4	1.00E-4	CCW BOOSTER PUMP B DISCHARGE LINE V1212 FAILS TO OPEN	2,3
CCVV1045TA	1.25E-4	1.00E-4	CCW INLET LINE V1045 FOR DDP 02PA FAILS CLOSED	2,3
CCVV1046TB	1.25E-4	1.00E-4	CCW INLET LINE V1046 FOR DDP 02PB FAILS CLOSED	2,3
CCVV1213TA	1.25E-4	1.00E-4	CCW BOOSTER PUMP A DISCHARGE V1213 FAILS CLOSED	2,3
CCVV1214TB	1.25E-4	1.00E-4	CCW BOOSTER PUMP B DISCHARGE V1214 FAILS CLOSED	2,3
CCVV1217TA	1.25E-4	1.00E-4	NORMAL AFW DDP 02PA COOLING DISCH. V1217 FAILS CLOSED	2,3
CCVV1218TB	1.25E-4	1.00E-4	NORMAL AFW DDP 02PB COOLING DISCH. V1218 FAILS CLOSED	2,3
[illegible]CV1178OA	1.25E-4	1.00E-4	CST A DISCHARGE LINE CV V1178 FAILS TO OPEN	2,3
[illegible]CV1181OB	1.25E-4	1.00E-4	CST B DISCHARGE LINE CV V1181 FAILS TO OPEN	2,3
[illegible]V0459TA	1.25E-4	1.00E-4	CST A DISCHARGE LINE MOV V0459 FAILS CLOSED	2,3
[illegible]V0460TB	1.25E-4	1.00E-4	CST B DISCHARGE LINE MOV V0460 FAILS CLOSED	2,3
[illegible]0001BA	2.40E-6	9.00E-7	CST A FAILS CATASTROPHICALLY	4
[illegible]0001BB	2.40E-6	9.00E-7	CST B FAILS CATASTROPHICALLY	4
[illegible]V1167TA	1.25E-4	1.00E-4	TRAIN A PUMPS MINI FLOW LINE V1167 FAILS CLOSED	2,3
[illegible]V1196TB	1.25E-4	1.00E-4	TRAIN B PUMPS MINI FLOW LINE V1196 FAILS CLOSED	2,3
[illegible]Y001ES	4.80E-6	3.84E-6	FAULT ON 1E 125V DC CONTROL CENTER AAC BUS 0-01ES	5
[illegible]S1416SS	4.80E-6	3.84E-6	FAULT ON 1E 4.16KV AAC SWITCH GEAR BUS 0-01SS	5
[illegible]Y[illegible]1SS	4.80E-6	3.84E-6	FAULT ON 1E 480V AAC LOAD CENTER BUS 001SS	5

TABLE 10A-14 (Sh. 5 of 9)

Event	Failure Probability		Description	Data Source *
	Mean	Median		
EABSYM01ES	4.80E-6	3.84E-6	FAULT ON 1E 480V AAC MCC BUS 001ES	5
EABYA001BS	1.20E-4	9.60E-5	1E AAC BAT. 0-01BS FAILS TO PROVIDE OUTPUT	5
EABYM001BS	1.00E-3	3.75E-4	1E AAC BAT.0-01BS UNAVAILABLE DUE TO MAINTENANCE	1
EADGK01KAB	9.28E-4	3.48E-4	1E D/G & 1E AAC D/G FAIL TO RUN (3D/G) (CCF)	1
EADGM01KS	6.00E-3	2.25E-3	1E AAC D/G 01KS UNAVAILABLE DUE TO TEST & MAINTENANCE	1
EADGR01KS	5.80E-2	2.18E-2	1E AAC D/G 01KS FAILS TO RUN	4
EADGS01KS	1.40E-2	5.26E-3	1E AAC D/G 01KS FAILS TO START	4
EADGW01KAB	2.10E-4	1.68E-4	1E D/G & 1E AAC D/G FAIL TO START(3D/G) (CCF)	4
EAHBCA1SA	3.00E-4	2.40E-4	1E AAC 4.16KV BUS LOAD BKR TO ESF BUS FAILS TO CLOSE	5
EAHBCA2SA	3.00E-4	2.40E-4	1E AAC 4.16KV BUS LOAD BKR TO ESF BUS FAILS TO CLOSE	5
EAHBCB1SB	3.00E-4	2.40E-4	1E AAC 4.16KV BUS LOAD BKR TO ESF BUS FAILS TO CLOSE	5
EAHBCB2SB	3.00E-4	2.40E-4	1E AAC 4.16KV BUS LOAD BKR TO ESF BUS FAILS TO CLOSE	5
EAHBC001XS	1.40E-5	1.12E-5	AAC LOAD CENTER XFMR 001XS FEED BKR OPENS SPURIOUSLY	5
EAHBV01SA	1.00E-1	1.00E-1	OPERATOR FAILS TO PROVIDE AAC D/G TO ESF 4.16KV BUS	1
EAHBV01SB	1.00E-1	1.00E-1	OPERATOR FAILS TO PROVIDE AAC D/G TO ESF 4.16KV BUS	1
EAHBW01SAB	3.00E-5	2.40E-5	1E AAC 4.16KV BUS LOAD BKR TO ESF BUS FAIL TO CLOSE	5
EAHBW02SAB	3.00E-5	2.40E-5	1E AAC 4.16KV BUS LOAD BKR TO ESF BUS FAIL TO CLOSE	5
EALBC001ES	1.20E-5	9.60E-6	C/B 01 FROM AAC BAT TO 125V DC AAC BUS SPURIOUS OPEN	5
EALBC002ES	1.20E-5	9.60E-6	C/B 02 FROM 125V DC AAC BUS TO AAC D/G SPURIOUS OPEN	5
EALBC003ES	1.20E-5	9.60E-6	C/B 03 FROM 125V DC AAC BUS TO C/B A1 SPURIOUS OPEN	5
EALBC004ES	1.20E-5	9.60E-6	C/B 04 FROM 125V DC AAC BUS TO C/B B1 SPURIOUS OPEN	5
EALBIL01SS	1.20E-5	9.60E-6	1E AAC LOAD CENTER BUS 001SS FEED BKR OPENS	5
EALBIM01ES	1.20E-5	9.60E-6	1E AAC MCC BUS 01ES FEED BKR AAC-X OPENS SPURIOUSLY	5
EAXMY001XS	1.70E-5	1.36E-5	1E AAC LOAD CENTER XFMR 001XS FAILS WHILE OPERATING	4
EDBCK125DC	9.00E-6	7.20E-6	BATTERY CHARGERS FAIL TO MAINTAIN OUTPUT (CCF)	3
EDBCM401NA	1.25E-4	1.00E-4	BATTERY CHARGER 4-01NA UNAVAILABLE DUE TO MAINTENANCE	1
EDBCM401NB	1.25E-4	1.00E-4	BATTERY CHARGER 4-01NB UNAVAILABLE DUE TO MAINTENANCE	1
EDBCY401NA	9.00E-5	7.20E-5	BATTERY CHARGER 01NA FAILS TO MAINTAIN OUTPUT	3
EDBCY401NB	9.00E-5	7.20E-5	BATTERY CHARGER 01NB FAILS TO MAINTAIN OUTPUT	3
EDBCY401NC	9.00E-5	7.20E-5	BATTERY CHARGER 01NC FAILS TO MAINTAIN OUTPUT	3
EDBCY401ND	9.00E-5	7.20E-5	BATTERY CHARGER 01ND FAILS TO MAINTAIN OUTPUT	3
EDBSK125DC	9.00E-6	7.20E-6	FAULTS ON 125V DC CONTROL CNTR BUSES (CCF)	3

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TABLE 10A-14 (Sh. 6 of 9)

Event	Failure Probability		Description	Data Source *
	Mean	Median		
EDBSY401EA	9.00E-5	7.20E-5	FAULT ON 125V DC CONTROL CENTER BUS 4-01EA	3
EDBSY401EB	9.00E-5	7.20E-5	FAULT ON 125V DC CONTROL CENTER BUS 4-01EB	3
EDBSY401EC	9.00E-5	7.20E-5	FAULT ON 125V DC CONTROL CENTER BUS 4-01EC	3
EDBSY401ED	9.00E-5	7.20E-5	FAULT ON 125V DC CONTROL CENTER BUS 4-01ED	3
EDBYA401BA	1.25E-4	1.00E-4	BATTERY 01BA FAILS TO PROVIDE OUTPUT	5
EDBYA401BB	1.25E-4	1.00E-4	BATTERY 01BB FAILS TO PROVIDE OUTPUT	5
EDBYA401BC	1.25E-4	1.00E-4	BATTERY 01BC FAILS TO PROVIDE OUTPUT	5
EDBYA401BD	1.25E-4	1.00E-4	BATTERY 01BD FAILS TO PROVIDE OUTPUT	5
EDBYM401BA	1.25E-4	1.00E-4	BATTERY 01BA UNAVAILABLE DUE TO MAINTENANCE	1
EDBYM401BB	1.25E-4	1.00E-4	BATTERY 01BB UNAVAILABLE DUE TO MAINTENANCE	1
EDBYW125DC	3.00E-6	2.40E-6	BATTERIES FAIL TO PROVIDE OUTPUT (CCF)	3
EDFSI401EA	3.00E-5	2.40E-5	BATTERY 01BA LOAD FUSE TO BUS 4-01EA OPENS SPURIOUSLY	3
EDFSI401EB	3.00E-5	2.40E-5	BATTERY 01BB LOAD FUSE TO BUS 4-01EB OPENS SPURIOUSLY	3
EDFSI401EC	3.00E-5	2.40E-5	BATTERY 01BC LOAD FUSE TO BUS 4-01EC OPENS SPURIOUSLY	3
EDFSI401ED	3.00E-5	2.40E-5	BATTERY 01BD LOAD FUSE TO BUS 4-01ED OPENS SPURIOUSLY	3
EDFSI401NA	3.00E-5	2.40E-5	BATT CHGR 01NA LOAD FUSE TO BUS 4-01EA OPENS SPURIOUSLY	3
EDFSI401NB	3.00E-5	2.40E-5	BATT CHGR 01NB LOAD FUSE TO BUS 4-01EB OPENS SPURIOUSLY	3
EDFSI401NC	3.00E-5	2.40E-5	BATT CHGR 01NC LOAD FUSE TO BUS 4-01EC OPENS SPURIOUSLY	3
EDFSI401ND	3.00E-5	2.40E-5	BATT CHGR 01ND LOAD FUSE TO BUS 4-01ED OPENS SPURIOUSLY	3
EDLBIA2OA	1.20E-5	9.60E-6	1E 125V DC CNTL CTR LOAD C/B TO C/B A2 SPURIOUS OPEN	5
EDLBIB2OB	1.20E-5	9.60E-6	1E 125V DC CNTL CTR LOAD C/B TO C/B B2 SPURIOUS OPEN	5
EGDCCA	1.25E-3	1.00E-3	LOSS OF CCW FLOW TO TRAIN A D/G	1
EGDCCB	1.25E-3	1.00E-3	LOSS OF CCW FLOW TO TRAIN B D/G	1
EGDGK01KAB	1.40E-2	5.26E-3	DIESEL GENERATORS FAIL TO RUN (CCF)	3
EGDGM01KA	1.25E-2	1.00E-2	DIESEL GENERATOR 01KA UNAVAILABLE DUE TO MAINTENANCE	1
EGDGM01KB	1.25E-2	1.00E-2	DIESEL GENERATOR 01KB UNAVAILABLE DUE TO MAINTENANCE	1
EGDGR01KA	1.91E-1	7.20E-2	DIESEL GENERATOR 01KA FAILS TO RUN	3
EGDGR01KB	1.91E-1	7.20E-2	DIESEL GENERATOR 01KB FAILS TO RUN	3
EGDGS01KA	3.75E-2	3.00E-2	DIESEL GENERATOR 01KA FAILS TO START	3
EGDGS01KB	3.75E-2	3.00E-2	DIESEL GENERATOR 01KB FAILS TO START	3
EGDGW01KAB	7.50E-4	6.00E-4	DIESEL GENERATORS FAIL TO START (CCF)	3
EGDRMCOOLA	1.25E-3	1.00E-3	LOSS OF D/G 01KA ROOM COOLING	1

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TABLE 10A-14 (Sh. 7 of 9)

Event	Failure Probability Mean	Failure Probability Median	Description	Data Source *
EGDRMCOOLB	1.25E-3	1.00E-3	LOSS OF D/G 01KB ROOM COOLING	1
EKBSK416KV	9.00E-6	7.20E-6	FAULTS ON 4.16KV SWITCH GEAR BUSES (CCF)	3
EKBSY416SA	9.00E-5	7.20E-5	FAULT ON 4.16KV SWITCH GEAR BUS 2-01SA	3
EKBSY416SB	9.00E-5	7.20E-5	FAULT ON 4.16KV SWITCH GEAR BUS 2-01SB	3
EKHBC03XN	3.00E-5	2.40E-5	START-UP XFMR 03XN LOAD BKR TO BUS FAILS TO CLOSE	3
EKHBC04XN	3.00E-5	2.40E-5	START-UP XFMR 04XN LOAD BKR TO BUS FAILS TO CLOSE	3
EKHBI03XN	3.00E-5	2.40E-5	START-UP XFMR 03XN LOAD BKR TO BUS OPENS SPURIOUSLY	3
EKHBI04XN	3.00E-5	2.40E-5	START-UP XFMR 04XN LOAD BKR TO BUS OPENS SPURIOUSLY	3
EKHBI211XA	3.00E-5	2.40E-5	LOAD CENTER XFMR 11XA FEED BREAKER OPENS SPURIOUSLY	3
EKHBI211XB	3.00E-5	2.40E-5	LOAD CENTER XFMR 11XB FEED BREAKER OPENS SPURIOUSLY	3
EKHBI212XA	3.00E-5	2.40E-5	LOAD CENTER XFMR 12XA FEED BREAKER OPENS SPURIOUSLY	3
EKHBI212XB	3.00E-5	2.40E-5	LOAD CENTER XFMR 12XB FEED BREAKER OPENS SPURIOUSLY	3
EKHBV03XN	1.25E-2	1.00E-2	OPERATOR FAILS TO CLOSE S/U XFMR 03XN LOAD BKR TO BUS	1
EKHBV04XN	1.25E-2	1.00E-2	OPERATOR FAILS TO CLOSE S/U XFMR 04XN LOAD BKR TO BUS	1
EKXMILCXFR	3.00E-6	2.40E-6	L/C XFMRS FAIL WHILE OPERATING (CCF)	3
EKXMI211XA	3.00E-5	2.40E-5	LOAD CENTER XFMR 11XA FAILS WHILE OPERATING	3
EKXMI211XB	3.00E-5	2.40E-5	LOAD CENTER XFMR 11XB FAILS WHILE OPERATING	3
EKXMI212XA	3.00E-5	2.40E-5	LOAD CENTER XFMR 12XA FAILS WHILE OPERATING	3
EKXMI212XB	3.00E-5	2.40E-5	LOAD CENTER XFMR 12XB FAILS WHILE OPERATING	3
ELBSI480LC	9.00E-6	7.20E-6	FAULTS ON 480V LOAD CENTER BUSES (CCF)	3
ELBSY211SA	9.00E-5	7.20E-5	FAULT ON 480V LOAD CENTER BUS 2-11SA	3
ELBSY211SB	9.00E-5	7.20E-5	FAULT ON 480V LOAD CENTER BUS 2-11SB	3
ELBSY212SA	9.00E-5	7.20E-5	FAULT ON 480V LOAD CENTER BUS 2-12SA	3
ELBSY212SB	9.00E-5	7.20E-5	FAULT ON 480V LOAD CENTER BUS 2-12SB	3
ELBSY213SA	9.00E-5	7.20E-5	FAULT ON 480V LOAD CENTER BUS 2-13SA	3
ELLBC213SA	3.00E-5	2.40E-5	L/C BUS 2-12SB LOAD BKR TO BUS FAILS TO CLOSE	3
ELLBI201EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-01EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI201EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-01EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI202EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-02EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI202EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-02EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI203EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-03EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI203EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-03EB FEED BRKR OPENS SPURIOUSLY	3

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Event	Failure Probability		Description	Data Source *
	Mean	Median		
ELLBI204EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-04EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI204EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-04EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI205EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-05EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI205EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-05EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI206EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-06EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI206EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-06EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI207EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-07EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI207EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-07EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI208EA	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-08EA FEED BRKR OPENS SPURIOUSLY	3
ELLBI208EB	3.00E-5	2.40E-5	MOTOR CNTL CNTR BUS 2-08EB FEED BRKR OPENS SPURIOUSLY	3
ELLBI211SA	3.00E-5	2.40E-5	LOAD CENTER BUS 2-11SA FEED BREAKER OPENS SPURIOUSLY	3
ELLBI211SB	3.00E-5	2.40E-5	LOAD CENTER BUS 2-11SB FEED BREAKER OPENS SPURIOUSLY	3
ELLBI212SA	3.00E-5	2.40E-5	LOAD CENTER BUS 2-12SA FEED BREAKER OPENS SPURIOUSLY	3
ELLBI212SB	3.00E-5	2.40E-5	LOAD CENTER BUS 2-12SB FEED BREAKER OPENS SPURIOUSLY	3
ELLBI213SA	3.00E-5	2.40E-5	L/C BUS 2-12SA LOAD BKR TO BUS OPENS SPURIOUSLY	3
ELLBI401NA	3.00E-5	2.40E-5	BATTERY CHARGER 01NA FEED BREAKER OPENS SPURIOUSLY	3
ELLBI401NB	3.00E-5	2.40E-5	BATTERY CHARGER 01NB FEED BREAKER OPENS SPURIOUSLY	3
ELLBI401NC	3.00E-5	2.40E-5	BATTERY CHARGER 01NC FEED BREAKER OPENS SPURIOUSLY	3
ELLBI401ND	3.00E-5	2.40E-5	BATTERY CHARGER 01ND FEED BREAKER OPENS SPURIOUSLY	3
ELLBV212SB	1.25E-2	1.00E-2	OPERATOR FAILS TO CLOSE L/C BUS 12SB LOAD BKR TO BUS	1
EMBSK480MC	9.00E-6	7.20E-6	FAULTS ON 480V MCC BUSES (CCF)	3
EMBSY201EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-01EA	3
EMBSY201EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-01EB	3
EMBSY202EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-02EA	3
EMBSY202EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-02EB	3
EMBSY203EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-03EA	3
EMBSY203EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-03EB	3
EMBSY204EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-04EA	3
EMBSY204EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-04EB	3
EMBSY205EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-05EA	3
EMBSY205EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-05EB	3
EMBSY206EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-06EA	3

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Event	Failure Probability		Description	Data Source *
	Mean	Median		
EMBSY206EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-06EB	3
EMBSY207EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-07EA	3
EMBSY207EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-07EB	3
EMBSY208EA	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-08EA	3
EMBSY208EB	9.00E-5	7.20E-5	FAULT ON 480V MOTOR CONTROL CNTR. BUS 2-08EB	3
EOXHKSTUP	3.00E-6	2.40E-6	START-UP XFMRS FAIL WHILE OPERATING (CCF)	3
EOXHM03XN	1.25E-3	1.00E-3	START-UP XFMR 03XN UNAVAILABLE DUE TO MAINTENANCE	1
EOXHM04XN	1.25E-3	1.00E-3	START-UP XFMR 04XN UNAVAILABLE DUE TO MAINTENANCE	1
EOXHY03XN	3.00E-5	2.40E-5	START-UP XFMR 03XN FAILS WHILE OPERATING	3
EOXHY04XN	3.00E-5	2.40E-5	START-UP XFMR 04XN FAILS WHILE OPERATING	3
HDABZ: RUN	4.00E-4	3.20E-4	AAC D/G ROOM AHU FANS FAIL TO RUN	1
HDABZ: SRT	1.20E-3	4.50E-4	AAC D/G ROOM AHU FANS FAIL TO START	1
IA-FAIL	1.25E-3	1.00E-3	FAILURE OF INSTRUMENT AIR SUPPLY	1

* Data Sources

1. Assumed Conservatively
2. NUREG-0635 : Generic Evaluation of Feedwater Transient and Small Break Loss of Coolant Accident in Combustion Engineering Designed Operating Plants
3. WASH-1400 : Reator Safety Study
4. EPRI ALWR URD, Volume II, Chapter 1, Appendix A
5. CE-NPSD-742 : Final Level I Probabilistic Risk Assessment for Yonggwang Units 3 and 4

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TABLE 10A-15

COMMON CAUSE PARAMETERS FOR AFWS RELIABILITY ANALYSIS

Component	Size of CCF Group	Failure Mode	CCF parameter
AFW pumps	two(same driver) pumps	fail to start fail to run	β=7.9E-2 β=1.0E-2[1])
Motor-Operated Valves	four valves	fail to operate	β=4.9E-2 γ=9.0E-1 δ=7.8E-1
Air-Operated Valves	two valves	fail to operate	β=8.8E-2
Diesel-Generators	two generators	fail to start fail to run	β=2.0E-2 β=7.3E-2
Pressure Transmitters	two transmitters	fail to provide output	β=0.1[1])

1) There are no CCF parameters for these failure mode and component in EPRI data. Therefore these parameters were judged conservatively.

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SIMPLIFIED FLOW DIAGRAM OF AFWS

Figure 10A-1

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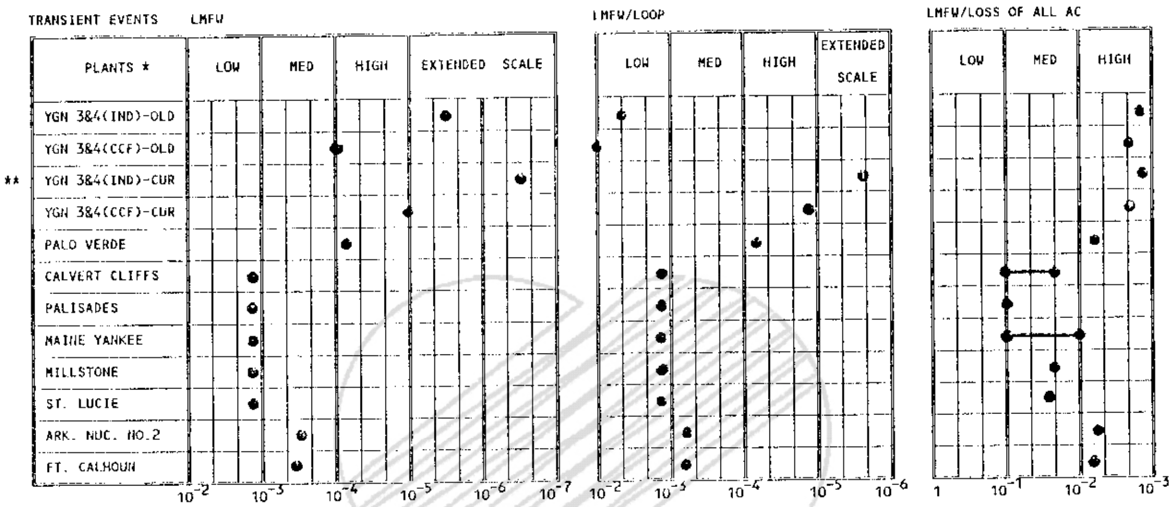

* OLD : Old Design
CUR : Current Design
IND : Statistical Independent Estimate
CCF : Common Cause Estimate
** These Values are for Comparison.

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COMPARISON OF YGN 3&4 AFWS RELIABILITY TO OTHER AFWS DESIGNS IN PLANTS USING THE CE NSSS

Figure 10A-2

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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FAULT TREE OF YONGGWANG 3&4
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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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Figure 10A-3

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Figure 10A-3