9.5 COOLING WATER SYSTEMS - COMPONENT COOLING, SERVICE WATER, AND SALTWATER

9.5.1 DESIGN BASIS

The CC and SRW systems are designed to remove heat from the plant's various auxiliary systems. The Saltwater System provides the cooling medium for the CC and SRW heat exchangers, and the ECCS pump room air coolers. System components are rated for maximum duty requirements during normal and SDC, and are also capable of providing heat removal during a LOCA. The CC and SRW systems serve as an intermediate barrier between the various auxiliary systems and the saltwater system.

9.5.2 SYSTEM DESCRIPTIONS

9.5.2.1 Component Cooling System

Figures 9-6 (Unit 1) and 9-25 (Unit 2) shows the schematic diagram of the CC. The system for each unit consists of three motor-driven component cooling circulating pumps, two component cooling heat exchangers (Table 9-17), a head tank, associated valves, piping, instrumentation, and controls.

The component cooling heat exchangers are designed for a CC supply temperature of 95°F (a range of 70°F-95°F is acceptable during normal operating conditions), with a saltwater cooling supply temperature of 90°F, at normal operating conditions. Component cooling water may reach as high as 120°F during a LOCA and during plant cooldown and cold shutdowns.

The items cooled by CC include:

a. Letdown heat exchanger
b. Shutdown cooling heat exchangers
c. Miscellaneous waste processing heat exchanger (retired in place)
d. Waste gas compressor aftercoolers and jacket coolers
e. Control element drive mechanism (CEDM) coolers
f. RCP mechanical seals and lube oil coolers
g. LPSI pump seals and coolers
h. HPSI pump seals and coolers
i. Containment penetration cooling
j. Reactor support cooling
k. Steam generator lateral support cooling
l. Coolant waste evaporators (Retired in place)
m. Reactor coolant and miscellaneous waste sampling system
n. Degasifier vacuum pump cooler
o. Post-accident sample system
p. Reactor coolant drain tank heat exchanger

During normal plant operation, one of the pumps and one of the heat exchangers are required for cooling service.

During normal plant cooldowns from 300°F to ≤ 140°F, two CCW pumps and two CCW heat exchangers are required to provide maximum reactor decay heat removal. During post-LOCA long-term core cooling two CCW pumps and two CCW heat exchangers provide the necessary cooling capacity to remove the decay heat from the two shutdown cooling heat exchangers.

The CCW heat exchangers are designed such that, given any single failure, the CC heat exchangers can remove sufficient reactor decay heat to ensure that the containment pressure and temperatures remain within acceptable values during post-LOCA long-term core cooling. Because the two CCW system trains are cross- connected, there are certain failures scenarios where CCW flow may be directed through a CCW heat exchanger which is not removing heat (e.g., the CCW heat exchanger has lost saltwater cooling flow). In these cases CCW system heat removal performance is enhanced by isolating CCW flow to the non-heat removing CCW heat exchanger and directing all CCW flow through the in-service CCW heat exchanger. Depending on the failure, it may be required to isolate the non-functioning CCW heat exchangers to ensure that the post-LOCA containment pressures and temperatures remain within acceptable values.

The CC pump motors are supplied from two separate 480 Volt engineered safety feature (ESF) busses, with the third motor having two breakers, one from each bus. If a loss of offsite power occurs, the pumps can be supplied by the Emergency Diesel Generators (EDGs). During normal shutdown cooling, two pumps are running with the third pump on standby. Low discharge header pressure is annunciated in the Control Room where the operator can start the third pump.

A head tank allows for expansion of the system water and provides sufficient net positive suction head (NPSH) for the component cooling circulating pumps. Makeup can be added to the system to maintain head tank level. The source of makeup water is the plant demineralized water system. Additional makeup capacity may be provided from the condensate system.

A chemical additive tank connected to the system permits maintenance of the proper corrosion inhibitor concentration in the CC.

The operation of each system is controlled and monitored in the Control Room with the following instrumentation:

a. Temperature indicators and high temperature alarms from the component cooling heat exchangers and RCP CC outlets;
b. Temperature indicators on the shutdown cooling heat exchangers;
c. Pressure indicators and low pressure alarms for each discharge header;
d. Level indicators and high-low level alarms for the head tank;
e. Handswitches and indicating lights for the pumps and remotely-operated control valves;
f. Radiation indicators and high radiation level alarm from the discharge side to the suction side of the CC pumps; and,
g. Low component cooling flow alarm to RCPs.

9.5.2.2 Service Water System

The SRW System as shown in Figures 9-9 (Unit 1) and 9-27 (Unit 2) is a closed system and uses plant demineralized water with a corrosion inhibitor added. The system removes heat from turbine plant components, blowdown recovery heat exchangers, containment cooling units, SFPC heat exchangers, AFW Pump Room Emergency Cooling Fan Coil Units, and Fairbanks Morse Emergency Diesel Generator heat exchangers.

The system has been divided into two subsystems in the Auxiliary Building to meet single failure criteria. Each subsystem has a head tank to maintain the subsystem's pressure and to allow for thermal expansion. Demineralized water makeup to the head tank is automatically controlled by level controllers. Additional makeup capacity may be provided from the condensate system.

Operating instructions provide the operators with procedures for aligning alternate sources of SRW make-up during accident or abnormal operating conditions. A cross-connection (via temporary hose) between the Saltwater and SRW Systems could be established if all non-seismic make-up water sources (demineralized water, condensate, or fire system) are unavailable.

The SRW additive tank is connected to both subsystems to allow chemical addition and control to prevent corrosion.

During normal operation, both subsystems are required and are independent to the degree necessary to assure the safe operation and shutdown of the plant-assuming a single failure. During the shutdown, operation of the SRW system is the same as normal operation, except that the heat loads are reduced.

During LOCA operation, each of the two subsystems for the two nuclear units will cool a maximum of two containment air coolers and one diesel generator. Although Unit 2 has identical heat loads and flow requirements for LOCA operations, Unit 1 subsystems do not have identical heat loads as Unit 1 has only one service water-cooled diesel generator. Service Water Subsystem 12 cools Diesel Generator 1B, and 1A is cooled from an independent cooling source located in the safety-related Diesel Generator Building. The original design heat removal capability of three of the four containment cooling units was to provide the same heat removal capability as the containment spray system. The analysis of these systems operating together post-LOCA in accordance with the Technical Specification requirements is presented in Section 14.20.

There are three SRW pumps in all. Each of two pumps is powered from a different ESFs 4 kV bus. The third pump is capable of being powered from either ESFs 4 kV bus. In the event that one bus is unavailable, a manual transfer capability to the operating bus is provided for this pump.

A low discharge header pressure will annunciate in the Control Room and the operator can then manually activate the standby pump.

The turbine plant components cooled by SRW include:

a. Generator isolated 3 phase bus duct coolers
b. Exciter air coolers
c. Generator hydrogen coolers
d. Stator liquid coolers (Unit 1 only)
e. Circ. Water System Priming Pump seal water coolers
f. Condenser vacuum pump seal water coolers
g. Feed pump turbine lube oil coolers
h. Condensate booster pump lube oil and seal water coolers
i. Instrument and plant air compressors and aftercoolers
j. Turbine lube oil cooler
k. Electro-hydraulic oil coolers

l. Turbine Building sample cooling system
m. Seal oil system coolers (Unit 2 only)
n. Auxiliary Feed Pump Room Air Cooler

Service water to the Turbine Building is not automatically isolated upon a seismic event. However, to ensure that this portion of the system will perform its pressure boundary function and provide continued cooling to the diesel generators during and after a seismic event, the entire Turbine Building SRW piping was walked down and evaluated for seismic adequacy. Consequently, a few small bore pipes and associated supports were modified to protect the non-safety-related portion of the system from potential seismically-induced spatial interaction with adjacent stationary structures and/or pipes and components.

Supply and return line redundancy is provided for containment cooling units, and diesel generators. Redundancy for SFPC is provided by cooling one SFP cooler from each unit.

Radiation monitors are installed in the SRW return header from the SFP coolers to detect possible in-leakage of radioactive liquids through the heat exchangers (Section 11.2.3.1).

9.5.2.3 Saltwater System

The Saltwater System has three pumps for each unit æ Nos. 11, 12, 13 in Unit 1, and Nos. 21, 22, 23 in Unit 2. The pumps provide the driving head to move saltwater from the intake structure, through the system and back to the circulating water discharge conduits (Figures 9-8 and 9-26). The system is designed such that each pump has sufficient head and capacity to provide cooling water for the SRW and CC Systems, as required by 10 CFR Part 50, Appendix A. The system also cools the ECCS pump room air coolers. The maximum recommended pump flow for each pump is 25,000 gpm. Although under most conditions this is not a limiting feature, when storm conditions consisting of the lowest expected tide of 4’0” below mean sea level and the lowest expected barometric pressure of 26.9” of mercury are considered, sufficient net positive suction head may not be available at flows above 25,000 gpm.

Power is supplied to Pumps No. 11 and 21 by 4 kV Busses No. 11 and 21, respectively, and Pumps No. 12 and 22 from 4kV Busses No. 14 and 24, respectively. Pumps No. 13 and 23 can receive power from either of the 4 kV busses in their respective units. (Figure 8-1) Pumps No. 11, 12, 21 and 22 start automatically on a SIAS or Shutdown Sequencer Signal. Pump No. 13(23) is aligned to back up Pump Nos. 11 or 12 (21 or 22). Pump No. 13(23) starts on a SIAS on shutdown sequencer signal when the backed up pump [Nos. 11 or 12 (21 or 22)] fails to start. A low discharge header pressure alarm will annunciate in the Control Room where the operator can manually activate the standby pump. The motors and controls for the saltwater pumps are located at or above Elevation +17’00” to protect them against flooding. The peak hypothetical tide and storm surge is 16.2’00” above mean low water. (Sections 7.3.2.2 and 7.3.2.3)

The Saltwater System consists of two subsystems in each unit. Each subsystem provides saltwater to two SRW heat exchanger, a CC heat exchanger and the ECCS pump room air cooler in order to transfer heat from those systems to the Chesapeake Bay. Seal water for the circulating water pumps is supplied by both subsystems. A self-cleaning strainer is installed upstream of each SRW heat exchanger.

During normal operation, both subsystems in each unit are in operation with one pump running on each header and a third pump in standby. If needed, the standby pumps can be lined-up to either supply header. Normally, the saltwater flow through the CC heat exchangers is throttled and the SRW heat exchanger saltwater valves are full open to provide sufficient cooling to the heat exchangers, while maintaining total subsystem flow below the maximum recommended value to prevent pump runout.

The operator has the option to reduce saltwater flow to the SRW heat exchangers by placing the SRW heat exchanger saltwater outlet valve flow controllers in automatic to maintain saltwater flow to each plate heat exchanger at a nominal value of 4550 gpm. At the design saltwater flow rates, the SRW heat exchangers can remove the accident heat load at saltwater inlet temperatures up to 90°F.

The saltwater pumps were originally designed for a nominal flow of 20,000 gpm with a minimum flow requirement of 10,000 gpm. To allow system operation in lower flow configurations, a saltwater bypass line exists around the SRW heat exchangers. The saltwater bypass valves are normally shut; however, they may be automatically throttled by a pressure controller to maintain saltwater header pressure within selected limits.

Operation following a LOCA has two phases æ before the RAS and after the RAS. One subsystem can satisfy the cooling requirements of both phases.

After a LOCA, but before an RAS, each subsystem will cool two SRW heat exchangers and an ECCS pump room air cooler. Any flow established to the CC heat exchanger prior to the accident will continue during this phase. The minimum required saltwater flow is 4,000 gpm to each SRW heat exchanger, and 400 gpm to each ECCS pump room air cooler at 90°F. There is no required flow to the CC heat exchangers. The SRW heat exchanger saltwater outlet valves will remain full open or, if the outlet valves are in automatic, the saltwater flow controllers will continue to maintain flow at the same setpoint used during normal operation.

When an RAS occurs, the minimum required flow to each SRW heat exchanger remains at 4,000 gpm, and each ECCS pump room air cooler remains at 400 gpm with saltwater temperatures at 90°F. Flow is initiated or increased to the CC heat exchangers at a minimum required flow of 5,500 gpm each. The operator will throttle saltwater flow through the CC heat exchangers to maintain CC temperature. If in use to meet saltwater pump minimum flow requirements, the SRW heat exchanger bypass control valve is automatically throttled by the pressure controller to maintain the saltwater header pressure within the selected limits.

Should a piping rupture or blockage occur downstream of the heat exchangers and air coolers, an alternate flow path may be employed so the function of the components will not be impaired.

In an accident situation, control air for the throttling valves is supplied by two 64 scfm (Unit 1)/64 scfm (Unit 2), Seismic Category I air compressors. These designated air compressors are used because the Instrument Air System compressors which normally supply control air to the valves are not designated safety-related, and are not required to be operational after an accident. The compressors are normally not running, but will start automatically on receipt of a SIAS, or may be manually started from the Control Room. Upon evacuation of the

Control Room, remote manual control may be shifted to local manual control, and SIAS input to the compressors is overridden.

The throttling system meets all applicable requirements of IEEE 279.

The Saltwater Chemical Addition System serves both the Unit 1 and Unit 2 Saltwater Systems to minimize the marine fouling of piping and heat exchanger surfaces. This system has the ability to inject approved chemicals into each saltwater header, as necessary.

9.5.3 TESTING AND INSPECTION

Each component was inspected and cleaned prior to installation into the system.

Instruments were calibrated during testing. Automatic controls were tested for actuation at the proper setpoints. Alarm functions and limits were checked for operability during preoperational testing. The safety valves were set and checked.

Figures 9-6, 9-8, 9-9, 9-25, 9-26, and 9-27 show the CC, saltwater cooling, and SRW systems.

The pre-operational testing verified the following:

a. Pumps produce proper capacity and discharge head with one, two or more pumps.
b. System components receive proper flow for all modes of operation (i.e., normal, shutdown and LOCA).
c. Instrumentation and controls are functioning or responding properly.
d. Motor-operated (MOV) and control valves function.

Data is taken periodically during normal plant operation to confirm heat transfer capabilities.

9.5.4 RATINGS AND CONSTRUCTION OF COMPONENTS

Components of the cooling water system are described in Table 9-17.

9.5.5 SINGLE FAILURE ANALYSIS

The results of a single failure analysis (Table 9-17A) show that no single active failure at any time nor any single passive failure after recirculation from the containment sump will prevent the safety feature systems from fulfilling their design function.

The Nuclear Regulatory Commission (NRC) approved the application of a revised methodology for the evaluation of passive failures in moderate energy systems (Reference 1). The revised methodology assumes the passive failure to be a through-wall leakage crack of dimensions equal to one-half the pipe diameter in length, and one-half the wall thickness in width. The passive failure is postulated to occur in the largest pipe in the area to be evaluated, at least 24 hours after the initiating event. This methodology was specifically evaluated for a passive failure of the Saltwater System piping in the SRW Pump Room, but may be adopted for other moderate energy systems if supported by a similar analysis to that performed on the Saltwater System to ensure the validity of the revised methodology for those systems/subsystems. Systems evaluated by the revised methodology are annotated as such.

9.5.6 REFERENCES

1. Letter from D. G. McDonald, Jr. (NRC) to R. E. Denton (BGE), dated February 24, 1995, Methodology for Postulating Passive Failure Pipe Breaks

TABLE 9-16A

HEAT EXCHANGER CONTROL VALVE POSITION

		NORMAL	LOCA BEFORE RECIRCULATION	LOCA DURING RECIRCULATION	ALTERNATE MODE
Heat Exchanger Discharge Control Valve					
Component Cooling	CV-5206	Throttle(a)	Throttle	Throttle	Closed
	CV-5208	Throttle(a)	Throttle	Throttle	Closed
	CV-5163	Open	Open	Open	Closed
	CV-5165	Closed	Closed	Closed	Open
	CV-5166	Closed	Closed	Closed	Open
Service Water	CV-5209	Open(f)	Open(f)	Open(f)	Open(f)
	CV-5210	Open(f)	Open(f)	Open(f)	Open(f)
	CV-5211	Open(f)	Open(f)	Open(f)	Open(f)
	CV-5212	Open(f)	Open(f)	Open(f)	Open(f)
	CV-5153	Open	Open	Open	Closed
	CV-5155	Closed	Closed	Closed	Open
	CV-5156	Closed	Closed	Closed	Open
Emergency Core Cooling	CV-5171	Closed(b)	Closed(b)	Closed(b)	Closed
	CV-5174	Open	Open	Open	Closed
	CV-5175	Open	Open	Open	Closed
	CV-5177	Closed	Closed	Closed	Open
	CV-5178	Closed	Closed	Closed	Open
Heat Exchanger Inlet Control Valve					
Component Cooling	CV-5160	Open(a)	Open	Open	Closed
	CV-5162	Open(a)	Open	Open	Open
Emergency Core Cooling	CV-5170	Closed(b)(c)	Closed(b)(c)	Closed(b)(c)	Closed(c)
	CV-5173	Closed(b)	Closed(b)	Closed(b)	Closed(b)
Service Water	CV-5150	Open	Open	Open	Closed
	CV-5152	Open	Open	Open	Open
Heat Exchanger Bypass Control Valve					
Service Water	CV-5154	Closed(g)	Closed(g)	Closed(g)	Closed
	CV-5157	Closed(g)	Closed(g)	Closed(g)	Closed(g)
Saltwater Strainer Control Valve					
Diverter Valve	CV-5148	Open(d)	Open(d)	Open(d)	Open(d)
	CV-5151	Open(d)	Open(d)	Open(d)	Open(d)
	CV-5158	Open(d)	Open(d)	Open(d)	Open(d)
	CV-5159	Open(d)	Open(d)	Open(d)	Open(d)
Flushing Valve	CV-5148A	Closed(e)	Closed(e)	Closed(e)	Closed(e)
	CV-5151A	Closed(e)	Closed(e)	Closed(e)	Closed(e)
	CV-5158A	Closed(e)	Closed(e)	Closed(e)	Closed(e)
	CV-5159A	Closed(e)	Closed(e)	Closed(e)	Closed(e)

TABLE 9-16A

HEAT EXCHANGER CONTROL VALVE POSITION

(a) Routinely only one CC heat exchanger is required for heat removal during normal operations. Saltwater flow to the other CC heat exchanger may be secured.

(b) ECCS pump room air cooler saltwater valves are automatically opened in order to regulate the ECCS pump room ambient temperature.

(c) A bypass line has been installed around this valve to allow for fluid expansion back into the saltwater header.

(d) Diverter valve is normally open; closes during strainer flush.

(e) Flushing valve is normally closed; opens during strainer flush.

(f) The SRW plate heat exchanger outlet valves are normally full open. They may be throttled and controlled by an FIC if the operator needs to reduce saltwater flow.

(g) Bypass valve is normally shut. It may be placed in automatic to assist in satisfying pump minimum flow requirements.

TABLE 9-16B

SALTWATER SYSTEM AIR COMPRESSORS

Type	Oil-less, Reciprocating Duplex (each SWAC has two compressor units mounted on a common air receiver tank)
No. of Stages	One
Quantity	Two
Design Capacity (scfm)	64
Design Pressure (psig)	100
Motor	Electric Motors, 10 hp each, 460 Volt, 3 phase, 60 Hz (two motors per SWAC)
Accessories	Air Receiver, Air-cooled Aftercooler, Automatic Condensate Trap
Seismic Requirements	Category I
Codes	Receiver - ASME Section VIII, Motor - NEMA

TABLE 9-17

COOLING SYSTEM COMPONENT DESCRIPTION

Component Cooling Pumps

Type	Centrifugal, horizontal, double volute, with mechanical seal
Quantity	3
Capacity each (gpm)(c)	5000
Head (feet)(c)	100
Material	
Case	ASTM A216-59T-WCB
Impeller	ASTM B145, Gr 4A
	ASTM B584 C83600, C87500, or C87600
Shaft	ASTM A276, Type 410
	ASTM A276, Type 316 (ALT)
Motor	150 hp, 480 Volt, 60 Hz, 3 phase, 1750 RPM
Codes	Motor: NEMA
	Pump: Standards of the Hydraulic Institute, ASME VIII and IX

Component Cooling Heat Exchangers

Type	Horizontal, counterflow, straight tubes rolled into tubesheets
Quantity	2
Design duty each (Btu/hr)	10.4x10^6 (Normal)(a)
	122x10^6 (3.5 hrs after shutdown)(a)
	31.2x10^6 (27.5 hrs after shutdown) (a)
	43.5x10^6 (long term cooling following a LOCA) (a)
Heat transfer area, each (ft^2)	5860
Design pressure (psig)	Shell side: 150 Tube side: 50
Design temperature (°F)	Shell side: 200 Tube side: 200
Material	
Shell	Carbon steel ASTM A285, Gr C
Tubes	90-10 Cu-Ni ASTM B111
Tube Sheets	Aluminum bronze ASTM B171-67
Codes	ASME Section VIII, TEMA Class R

Head Tank

Type	Horizontal
Quantity	1
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Volume (gallons)	2550
Material	
Shell	ASTM A455A
Dished head	ASTM A455B
Code	ASME Section VIII

Additive Tank

Type	Vertical
Quantity	1
Design pressure (psig)	150
Design temperature (°F)	200
Volume (gallons)	75
Material	Carbon steel
Code	ASME Section VIII

TABLE 9-17

COOLING SYSTEM COMPONENT DESCRIPTION

Component Cooling Piping, Fittings, and Valves

Piping material	Carbon steel, seamless
Design pressure (psig)	150
Design temperature (°F)	180
Construction:	
2-1/2" and larger	
a. Gate and globe	Carbon steel, butt weld ends, ANSI 150 psi
b. Check and butterfly	Carbon steel, wafer type, ANSI 150 psi
2" and smaller	Carbon steel, socket weld ends, ANSI 600 psi
Codes	ANSI B31.1 except penetration piping. Penetration piping is designed and fabricated to ANSI B31.7, Class II

Service Water Heat Exchanger

Type	One pass plate and frame
Quantity	4
Capacity each (Btu/hr)	18x10^{6} (normal operation)(a) 137x10^{6} (LOCA operation)(a,b)
Heat Transfer Area each (ft^{2})	7704.4
Design Pressure (psig)	150
Design Temperature (°F)	300
Material	
Pressure Plates	Steel - SA516-70
Plates	Titanium - SB265 GR 1
Port Liners	Titanium - SB337 GR 2 (Saltwater) Stainless Steel - SA312-316 (SRW)
Gaskets	EPDM
Codes	ASME B&PV Code, Section VIII - Pressure Vessels, Section IX - Welding Qualifications, ASTM

Service Water Pumps

Type	Centrifugal, horizontal, double volute, with packed seal
Quantity	3
Capacity each (gpm)(c)	7,050
Head (ft)(c)	180
Material	
Case	ASTM A216, WCA
Impeller	ASTM B145-52, Gr-4A or B584 UNS # C83600 or B584 UNS # C87600
Shaft	ASTM A276, Type 410 or ASTM A276, Type 316
Motor	450 hp, 4000 Volt, 3 phase, 60 Hz 585 RPM
Codes	NEMA, Standards of the Hydraulic Institute, ASTM, ANSI B16.5

TABLE 9-17

COOLING SYSTEM COMPONENT DESCRIPTION

Service Water Head Tank

Type	Vertical
Quantity	2
Design Pressure (psig)	15
Design Temperature (°F)	150
Volume (gallons)	2,350
Material	ASTM A455, Gr A
Code	ASME Section VIII

Service Water Additive Tank

Type	Vertical
Quantity	1
Design Pressure (psig)	175
Design Temperature (°F)	200
Volume (gallons)	75
Material	ASTM A283, Gr C
Code	ASME Section VIII

Saltwater Pumps

Type	Vertical, dry pit
Quantity	3
Design Capacity each (gpm)[c]	15,500
Design Head (ft)[c]	82
Material	
Volute	2% Ni ASTM A48, C1.35 or A439 Type D3
Impeller	ASTM B148, Gr 9D or UNS # C95500
Shaft	AISI-C1141 or ASTM A322, Gr 4140
Motor	450 hp, 4000 Volt, 3 phase, 60 Hz, 600 RPM (nominal)
Codes	Motor: NEMA Pump: Standards of Hydraulic Institute, ASME B&PV Code, Section VIII, Pressure Vessels and IX, Welding

Saltwater Strainers

Type	Self-cleaning basket
Quantity	4
Design pressure (psig)	50
Design Temperature (°F)	100
Material	
Body	A416-60
Basket	A240 GR TP316
Code	ANSI B31.1

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[a] Per vendor rating sheet; actual heat duty will vary with flow and temperature.

[b] Per accident analysis, no rating sheet available for LOCA; actual heat duty will vary with flow and temperature.

[c] These numbers, together, represent a single point on the pumps' performance curve.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

ITEM	COMPONENT	NO. INSTALLED PER UNIT	NO. NEEDED FOR NORMAL OPERATION	MINIMUM NO. NEEDED FOR OPERATION FOLLOWING LOCA	DESIGN FUNCTION OF COMPONENT
Saltwater	Saltwater Pumps	3	2	1	Provide cooling water for SRW and component cooling heat exchangers and the ECCS pump room coolers.
Saltwater	Service Water Heat Exchangers	4	(a)	(b)	Provide cooling for turbine auxiliaries, SFP coolers, blowdown recovery system, containment coolers, and diesel generators.
Saltwater	Component Cooling Heat Exchangers	2	1	(b)	Provide cooling for reactor auxiliaries, HPSI pumps, LPSI pumps, and SDC heat exchangers.
Saltwater	ECCS Room Coolers	2	-	1	Maintain design temperature in ECCS rooms for long-term operation of the safety feature pumps.
Service Water	Service Water Pumps	3	2	1	Provides driving force for SRW system.
Service Water	Containment Coolers	4	(f)	(b)	Cools the containment.
Service Water	Diesel Generators	2(c)	-	1	Provides source of emergency on-site power.
Component Cooling	Component Cooling Water Pumps	3	(d)	1	Provides driving force for CC.
Component Cooling	Low Pressure Safety Injection Pumps	2	(d)	(e)	Provides safety injection water and SDC.
Component Cooling	High Pressure Safety Injection Pumps	3	-	1	Provides safety injection water.
Component Cooling	Shutdown Cooling Heat Exchanger	2	(d)	(b)	Provides cooling medium for spray water to remove heat from the containment following recirculation and SDC.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

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[a] Four SRW heat exchangers are needed.

If one saltwater subsystem is out for maintenance, the two subsystems of the SRW system may be cross-connected and the two remaining heat exchangers utilized to remove the heat load during normal operations. The two subsystems are physically separated during accident conditions; only the diesel generator connected to the operable SRW heat exchanger will be considered operable. Refer to Note (c).

[b] Each containment cooler was originally designed to remove 1/3 of the containment design heat load and each containment spray pump-shutdown heat exchanger was originally designed to remove 1/2 of the containment design heat load. The original design heat removal capability of three of the four cooling units was to provide the same heat removal capability as the containment spray system. The analysis of these systems operating together post-LOCA in accordance with the Technical Specification requirements is presented in Section 14.20. There are several combinations of equipment that could be utilized to remove heat from the containment. Each SIAS channel would actuate two containment coolers and one spray pump. For each shutdown cooling heat exchanger, one component cooling heat exchanger would be placed in service. If three containment coolers are utilized, at least three SRW heat exchangers need to be placed in service.

[c] Two diesel generators are installed per unit; however, only one diesel generator for Unit 1 and both diesel generators for Unit 2 are served by the SRW System.

[d] The LPSI pumps, the SDC heat exchangers and the CC System (i.e., CC heat exchangers and CC pumps) provide heat removal for a normal plant cooldown. One LPSI pump, one SDC heat exchanger, one CC pump, and one CC heat exchanger would provide cooldown at a slower rate. However, even at this slower rate, the plant is maintained in a safe condition (Sections 6.3.2.5, 9.5.2.1).

[e] One LPSI pump is required when suction is from the RWT and none is required when suction is switched to the containment sump during the recirculation mode of cooling.

[f] Three containment air coolers are normally in operation. Occasionally, during extended periods of high outside temperatures, all four coolers are used to limit average containment temperature to 120°F.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

ACTIVE FAILURES

SYSTEM	FIGURE	COMPONENT	TYPE OF FAILURE	CONSEQUENCES
Saltwater	9-8	Remotely actuated valves (CV-5150, 5152, 5153, 5155, 5156, 5160, 5162, 5163, 5165, 5166)	Fails to open or close, as applicable	These values are only operated to align the redundant discharge header. A failure of any valve would not impair the integrity of the system or prevent it from functioning.
Saltwater	9-8	Remotely actuated valves (CV-5209, 5210, 5211, 5212)	Fails open (fails to throttle)	Normally, these valves are full open. Should any one of these valves fail open while in automatic, saltwater flow to the associated PHE will be increased, improving the component's heat removal capability. The other PHE on the subsystem would continue to operate. Total system flow will increase or, if the saltwater bypass valve is in automatic, will be automatically adjusted by the bypass line CVs. The other saltwater subsystem would be unaffected by this failure and remain capable of removing the full design accident heat load.
Saltwater	9-8	Remotely actuated valves (CV-5154, 5157)	Fails closed (fails to throttle)	Normally, the saltwater bypass valves will be shut. However, should a bypass valve fail closed while in automatic, the PHE saltwater flow will increase or, if the FIC is in automatic, the outlet throttle CVs will maintain the flow through the PHEs at the setpoint. However, if only the SRW PHEs are in service, and the PHE saltwater outlet valves are in automatic, saltwater flow may drop below the minimum required flow for pump operation. The safety-related functions of the saltwater and SRW systems would not be immediately impacted. The operator can raise flow, if desired, by manually raising the FIC setpoint or remotely opening the PHE outlet valves, disabling the FIC. The other saltwater subsystem would be unaffected and capable of removing the full design accident heat load.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

ACTIVE FAILURES

SYSTEM	FIGURE	COMPONENT	TYPE OF FAILURE	CONSEQUENCES
Saltwater	9-8	Strainer	Basket clogs	The strainer is designed to flush automatically and on manual initiation. Should clogging occur, the affected strainer will eventually reach its dP limit and alarm setpoint. Heat exchanger saltwater flow will be maintained by the FIC, if in automatic, or will start to gradually decrease. Eventually the saltwater low flow alarm setpoint would be reached. A handhole allows quick inspection and manual cleaning. The affected strainer can be deenergized, allowing the unaffected strainer to resume automatic flushing. The other saltwater and SRW subsystems would be unaffected and capable of removing the full design accident heat load.
Saltwater	9-8	Strainer flushing valves (CV-5148A, 5151A, 5158A, 5159A)	Fails to cycle properly	If the valves fail to shut, the affected strainer would continue to flush and remain relatively clean. Condition would initiate system trouble alarm to alert operator. Without operator action, the interlock between the two subsystem strainers will prevent flushing of the unaffected strainer. As the strainer clogs, PHE saltwater flow will gradually decrease or, if in automatic, the FIC will compensate to maintain minimum flow to the heat exchanger. The operator can deenergize the failed strainer to allow the unaffected strainer to resume its automatic flushing sequence. Both PHEs will continue to remove their design basis heat load until the heat exchanger low flow setpoint is reached. If the valves fail to open, the operator will be alerted by the system trouble alarm. The affected strainer will gradually clog. Saltwater flow to the associated PHE will start to decrease. (Initially, the associated heat exchanger FIC will compensate, if in automatic.) The flushing circuit on the unaffected strainer would continue to function. Both PHEs will continue to remove their design basis heat load until the heat exchanger low flow setpoint is reached on the affected side.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

ACTIVE FAILURES

SYSTEM	FIGURE	COMPONENT	TYPE OF FAILURE	CONSEQUENCES
				The other saltwater and SRW subsystems would be unaffected and capable of removing the full design accident heat load.
Saltwater	9-8	Strainer diverter valves (CV-5148, 5151, 5158, 5159)	Fails to cycle properly	If the valve fails to shut during regeneration, the saltwater trouble alarm will be activated. This failure would lead to less effective flushes, probably resulting in an increased number of automatically-initiated flushes. This would eventually have the same effect as a flushing valve failing closed. If the valve fails to open during the flush cycle, the saltwater trouble alarm will be activated. The number of automatic strainer flushes would increase. Eventually this would have the same affect as a flushing valve failing closed. The other saltwater and SRW subsystems would be unaffected and capable of removing the full design accident heat load.
Service Water	9-9B	Valves No. 1, 3, 9, or 11	Fails to close on SIAS	Valves No. 2, 4, 10, and 12 are actuated by a redundant channel and would shut, isolating SRW as required.
Service Water	9-9B	Valves No. 5, 7	Fails to close on CSAS	Valves No. 6 and 8 are actuated by a redundant channel and would shut, isolating SRW as required.
Service Water	9-9B	Valve 27(28)	Fails to close on CSAS	Failure of valve 27(28) could render subsystem 11(21) inoperable. However, subsystem 12(22) would continue to provide the necessary cooling for Unit 1 (Unit 2).
Service Water	9-9B	Check Valves No. 17, 18, 19, 20, 21 or 22	Fails to close under reverse flow	Since in all cases two check valves are provided in series, the second valve would close providing isolation.

NOTE: As shown above, sufficient numbers of all other active components are supplied to provide sufficient redundancy for all modes of operation.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

PASSIVE FAILURE DURING CONTAINMENT SUMP RECIRCULATION

SYSTEM	FIGURE	LOCATION OF RUPTURE	CONSEQUENCES
Saltwater	9-8	Anywhere	Water is lost from one of the two subsystems. Either subsystem can provide all necessary cooling water. Double valves are provided whenever subsystems are tied together. Both of these valves are normally closed. Hence, a rupture of any one valve will not cause failure of both subsystems.
Service Water	9-9B	Valves No. 23, 24, 25, or 26	One subsystem from each unit would be drained and rendered inoperable. However, one subsystem in each unit would continue to operate. This is adequate to provide the necessary cooling for each unit. No single rupture in any location could cause the loss of both subsystems of a unit as two normally closed valves are provided where two subsystems are tied together.
Component Cooling	9-6	Anywhere	The entire system would be lost. The unit can still be maintained in a safe condition since the containment coolers would be utilized in lieu of the spray pumps/shutdown heat exchangers to cool the containment and one of the air cooled spray pumps would be manually aligned from outside the ECCS rooms for safety injection. The HPSI pumps can operate for a minimum of two hrs without cooling water and this is considered sufficient to realign the valves. Flow of one spray pump is sufficient to keep the core covered during the recirculation of the containment sump.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

FLOODING DUE TO A PASSIVE FAILURE

STRUCTURE FLOODED	INDICATION IN CONTROL ROOM	SYSTEM RUPTURED	CONSEQUENCES
Intake Structure	High level alarm/Circulating Water Pumps Trip	Saltwater	The bottom of the Intake Structure is at Elevation 3'. The operator enters the Intake Structure from the Turbine Building at Elevation 12' and the saltwater pump motors are at Elevation 17'. It would take approximately 82 minutes for the water level to reach the motors and approximately 53 minutes to reach the entrance from the Turbine Building. This is sufficient time to allow shutting down one saltwater pump at a time until the leakage stops as visually determined by an operator in the Intake Structure.
Intake Structure	High level alarm/Circulating Pump Trip	Circulating Water	Before the saltwater pump motors would be flooded, the circulating water pump motors would flood and trip, eliminating the source of flooding. In addition, high level switches would trip the circulating water pump motors, eliminating the source of flooding.
Service Water Room	High level alarm in the room with normal service water head tank level	Saltwater[(a)]	Operators would have sufficient time to identify and isolate the break in the Saltwater System before safety-related equipment required to function would be affected by the break. For a saltwater line break that is limited to a single train, approximately 30 minutes is available to identify the affected train and isolate it. For a saltwater line break in the common portion of the SRW heat exchanger discharge piping, approximately 80 minutes is available to shift to overboard discharge after isolating the break.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

FLOODING DUE TO A PASSIVE FAILURE

STRUCTURE FLOODED	INDICATION IN CONTROL ROOM	SYSTEM RUPTURED	CONSEQUENCES
Service Water Room	High level alarm in room and low level from either SRW level tank	Service Water	One subsystem would be drained. However, the other subsystem would continue to operate and is sufficient to provide all necessary SRW. The entire contents of one SRW subsystem would not flood out the SRW pumps and motors.
Component Cooling Room	High level alarm in room with normal head tank level	Saltwater	Since this room is open to the entire Elevation 5', flooding is not considered credible. A 6" curb is provided at the doorway to provide a room level indication. Flooding would be terminated by closing the remote manual valves.
Containment	Low level alarm from either SRW head tank	Service Water	In the event of a line break associated with any one containment air cooler after the LOCA, it is assumed, as an upper limit, that one subsystem of SRW leaks into containment. The leak volume from one subsystem is approximately 16,000 gallons. Boron dilution, therefore, would be negligible, because the total volume of borated water in the containment structure is in excess of 400,000 gallons.
Component Cooling Room	High level alarm in room with low head tank level	Component Cooling	Since this room is open to the entire Elevation 5', flooding is not considered credible. A 6" curb is provided at the doorway to provide a room level indication.
ECCS Room	High level alarm in room	Safety injection containment spray, containment cooling, or salt water	ECCS room is isolated. Each room is watertight and fully redundant to the other. Remote manual valves would be closed to prevent further flooding.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

FLOODING DUE TO A PASSIVE FAILURE

STRUCTURE FLOODED	INDICATION IN CONTROL ROOM	SYSTEM RUPTURED	CONSEQUENCES
Condenser Pit	High level alarm in Condenser Pit	Circulating Water Expansion Joint	The maximum flood height from an expansion joint rupture in the Turbine Building is the 15'-8" elevation, if the circulating water flow path was not stopped by operator action. The condenser pit would flood and overflow into the Turbine Building. The AFW pumps with local control, SRW pumps and intake structure are protected by watertight doors. The turbine-driven AFW pumps are also protected by drain isolation valves. It would take approximately 45 minutes to reach the watertight doors at elevation 12'-6" and greater than 60 minutes to impact the turbine-driven AFW pumps at an elevation of 13'-3". A Turbine Building flood event requires 37 minutes to reach a height of less than 12'-3". This allows sufficient time for operator action to stop the event.

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[a] The passive failure is evaluated using the methodology approved by the NRC in the Safety Evaluation Report dated February 24, 1995. The passive failure is assumed to be a through wall leakage crack of dimensions equal to one-half the pipe diameter in length, and one-half the pipe wall thickness in width. The passive failure is assumed to occur in the largest pipe in the area to be evaluated, at least 24 hours after the initiating event.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

FLOODING DUE TO A PASSIVE FAILURE

NOTE: Power cables to the saltwater pump motors could be submerged by the flooding under certain conditions. The following precautions have been taken to prevent this flooding from causing a failure of the saltwater pump motor cables:

1. These 5 kV Kerite HT and HV insulation type cables are suitable for submerged operation.
   a. The Kerite Company states that saltwater in contact with their 5 kV NS jacketed cables would cause no deleterious effects whatsoever.
   b. The Kerite Company has made numerous documented tests to prove the reliability of their Kerite HT and HV insulation cables in submerged applications. The reliability of this type of cable has also been proven through experience. The Kerite Company has been making cables with Kerite type insulation for over 100 years and has supplied many miles of this type cable for continuously submerged use.
   c. Baltimore Gas and Electric Company has used more than 100,000' of three-phase Kerite medium voltage (2.4 kV, 4 kV and 13 kV) cable for hundreds of circuits at 16 generating units. These cables have been installed for up to 31 years and over half of them are intermittently flooded by fresh or brackish water. This experience totaling nearly 1-1/2 million foot-years resulted in only one failure which was attributed to seven years of exposure to a concentrated caustic chemical powder. This 1951 cable had an asbestos fabric jacket instead of the neoprene type used since 1952.
2. To insure that the cables would not be damaged during the pulling operation, the maximum required pulling tension was calculated in 1970. These calculations showed that the maximum required tension would be less than one-third of the maximum allowable tension. Kerite engineers reviewed and concurred with these calculations. Calculations also indicated that the use of an approved pulling compound would reduce the maximum required pulling tension to less than one-sixth of the maximum allowable. Dynamometer checks during the actual cable pull measured the pulling tension at approximately one-seventh of the maximum allowable.
3. During cable installation visual spot checks were made to ascertain whether any damage was done during the cable pull. Cable was inspected after it was pulled into the Intake Structure pull box. No damage of any kind was detected.
4. To increase cable reliability, no cable splices were allowed in any of the cable runs.
5. The extensive experience which the Kerite Company and Baltimore Gas and Electric Company have had with this type cable indicates that there will be no deleterious effects due to aging during the life of the power plant.
6. The Kerite Company recommends the megger test for locating trouble without causing additional cable damage; also, the megohm readings will indicate trends toward insulation deterioration. In view of this recommendation, these saltwater pump motor feeders will be tested annually by a 2,500 Volt megger as a means of detecting any cable degradation.

TABLE 9-17A

SINGLE FAILURE ANALYSIS

DESCRIPTION OF LEVEL SWITCHES USED IN TABLE 9-17A

INTAKE STRUCTURE

Four level switches per unit are used. The Unit 1 side of the Intake Structure is separated from the Unit 2 side by a wall three feet high. Level switches on the Unit 1 side trip the Unit 1 circulating water pumps, and level switches on the Unit 2 side trip the Unit 2 circulating water pumps. Level switches are located at a height of 3" above floor, are Seismic Category I, are manufactured to special quality control requirements, are waterproof, and are testable. Level switches feed a two-out-of-four logic system located in the service building, which is testable when the plant is shut down. The logic system provides two outputs, either of which will trip all of the affected unit's individual pump circuit breakers. The system provides redundancy but not separation of components for tripping the pumps. The system also actuates an alarm in the Control Room for each unit.

CONDENSER PIT

Two level switches per location are used. Level switches are waterproof, testable, and are designed to function under seismic acceleration. The level switches feed a one-out-of-two logic system located in the Cable Spreading Room. The logic system is Seismic Category I, is testable, and actuates an alarm in the Control Room.

COMPONENT COOLING ROOM, ECCS ROOM AND SERVICE WATER ROOM

Two level switches per location are used. Level switches are waterproof, testable, and Seismic Category I. The level switches feed a one-out-of-two logic system located in the Cable Spreading Room. The logic system is Seismic Category I, is testable and actuates an alarm in the Control Room.