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November 2, 1981

Director, Office of Nuclear Reactor Regulation
Attention: D. M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Subject: Docket No. 50-206
SEP Topic IX-3
San Onofre Nuclear Generating Station
Unit 1

Enclosed is the draft assessment for SEP Topic IX-3, Station Service and Cooling Water Systems. If you have any questions on this draft topic assessment or require additional information, please let me know.

Very truly yours,

W C Moody

Enclosure

A035
S/1

Original
Diagram
To: BC

SEP REVIEW

OF

STATION SERVICE AND COOLING

WATER SYSTEMS

TOPIC IX-3

FOR THE

SAN ONOFRE NUCLEAR GENERATING STATION

UNIT 1

I. INTRODUCTION

The safety objective of Topic IX-3 is to assure that the cooling water systems have the capability, with adequate margin, to meet design objectives and, in particular, to assure that:

a. systems are provided with adequate physical separation such that there are no adverse interactions among those systems under any mode of operation;

b. sufficient cooling water inventory has been provided or that adequate provisions for makeup are available;

c. tank overflow cannot be released to the environment without monitoring and unless the level of radioactivity is within acceptable limits;

d. vital equipment necessary for achieving a controlled and safe shutdown is not flooded due to the failure of the main condenser circulating water system.

II. REVIEW CRITERIA

The current criteria and guidelines used to determine if the plant systems meet the topic safety objectives are those provided in General Design Criteria (GDC) 44, 45 and 46 and Standard Review Plan (SRP) Sections 9.2.1, "Station Service Water System", and 9.2.2, "Reactor Auxiliary Cooling Water Systems".

III. RELATED SAFETY TOPICS AND INTERFACES

The scope of review for this topic was limited to avoid duplication of effort since some aspects of the review were performed under related topics. The related topics and the subject matter are identified below. Each of the related topic reports contains the acceptance criteria and review guidelines for its subject matter.

II-2.A - Severe Weather Phenomena

II-3.B.1 - Capability of Operating Plants to Cope with Design Basis Flooding Conditions

VI-7.D - Long Term Cooling Passive Failures

III-3.C - Inservice Inspection of Water Control Structures

III-4.C - Internally Generated Missiles

III-5 A - Pipe Break Inside Containment

III-5 B - Pipe Break Outside Containment

VI-2.D - Mass and Energy Release for Pipe Breaks Inside Containment

III-6 - Seismic Design Considerations

VI-7.C.1 - Appendix K - EI&C Reviews

VII-3 - Systems Required for Safe Shutdown

VIII-2 - Onsite Emergency Power Systems - Diesel Generator

IX-1 - Fuel Storage

IV. REVIEW GUIDELINES

In addition to the guidelines of SRP Sections 9.2.1 and 9.2.2, (Reference 3), for determining which systems to evaluate under this topic, the definition of "systems important to safety" provided in Reference 1 was used. The definition states systems important to safety are those necessary to ensure (1) the integrity of the reactor coolant pressure boundary+ , (2) the capability to shut down the reactor and maintain it in a safe condition, or (3) the capability to prevent, or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR Part 100, "Reactor Site Criteria". This definition was used to determine which systems or portions of systems were "essential". Systems or portions of systems which perform functions important to safety were considered to be essential.

+ Reactor Coolant Pressure Boundary is defined in 10 CFR Part 50, Paragraph 50.2(v).

V. EVALUATION

The systems reviewed under this topic are the Component Cooling Water System and Salt Water Cooling System. The Spent Fuel Pool Cooling System is discussed in the SEP review of Topic IX-1, "Fuel Storage." Turbine plant cooling is provided by a separate system which is cooled by the circulating water pumps. It should be noted that this system also provides cooling for the instrument and service air compressors. However, since there is an emergency compressor which does not require cooling and a portable diesel driven air compressor, these compressors are not essential. Therefore the Turbine Plant Cooling Water System is not included in this evaluation. Service water for general plant washdown is by a separate system with no safety related function.

A. COMPONENT COOLING WATER SYSTEM

The Component Cooling Water System (CCWS) is a closed loop system with three pumps, a surge tank, and two component cooling water heat exchangers which transfer heat to the salt water cooling system. SONGS 1's CCW system is designed and operated in accordance with Section 2.7 of Reference 4. The system removes heat from the following components:

1. Reactor coolant pump bearing oil coolers and thermal barrier coils (3)

2. Charging pump oil coolers (2)

3. Residual heat removal pumps (2), mechanical seal flush cooler, seal housing jacket, lube oil cooler, and motor driver

4. Reactor shield cooling coils (10)

5. Excess letdown heat exchanger (1)

6. Seal water heat exchanger (1)

7. Spent fuel pit heat exchanger (1)

8. Sample heat exchangers (4)

9. Residual heat removal exchangers (2)

10. Gas stripper condenser (1)

11. Recirculation heat exchanger (1)

During normal operation, one (of three) pumps and one (of two) CCW heat exchangers can accommodate heat removal requirements. Pump A is powered by 480V bus 1. Pump B is powered by 480V bus 2. Pump C can be switched to either bus but is normally aligned with bus 2. When the CCWS is placed in operation during a plant cooldown, three pumps and two heat exchangers are normally used; however, if one heat exchanger or two pumps were inoperable, cooldown could continue but at a slower rate. Major CCW equipment parameters are identified in Table 1. The component cooling water pumps, heat exchangers and surge tank are located in the same area, outside on the Auxiliary Building roof. The physical separation of the CCW components will be evaluated in SEP Topic III-4.C, Internally Generated Missiles.

The heat removal requirements of the CCW system during post-accident conditions were reviewed. The accidents considered were the Loss of Coolant Accident (LOCA) and the Main Steam Line Break (MSLB) inside containment because these two events result in the greatest potential heat loads on the CCWS. The MSLB case is considered representative of a normal cooldown case using the RHR.

Following a LOCA, some part of the energy released to containment is removed by the containment spray system to prevent exceeding the design pressure limit of the containment. The water from the LOCA and containment spray collects in the containment sphere sump. This water is pumped by two full capacity recirculation pumps through the recirculation heat exchanger where the heat is transferred to the CCWS. The sump water is returned to the suction of the charging pumps and refueling water pumps for recirculation to the reactor and containment spray.

The heat loads on the CCWS, following a LOCA, are given in Table 3. The charging pumps are essential for recirculation to the reactor. The recirculation heat exchanger is the only means for removing heat from the water recirculated from the containment sump after a LOCA and is therefore essential. Dual independent remote actuated valves are provided on the CCW supply to the recirculation heat exchanger.

The heat loads on the CCWS following an MSLB, are given in Table 4. The essential loads are the RHR pumps and heat exchangers. The RHR system is required to achieve cold shutdown after an MSLB. The recirculation heat exchanger is not used after an MSLB under normal circumstances.

The CCWS was analyzed to ensure adequate capacity following a LOCA or MSLB. In this analysis, the effects of various scenarios on the temperature of the CCW system were evaluated by steady state analyses using conservative assumptions (e.g., maximum RHR heat exchanger efficiency, minimum CCW heat exchanger efficiency, etc.). The analyses assumed that all heat loads on the system other than the RHR pump and heat exchanger load and the recirculation heat exchanger load are included in an assumed added value of 4×10^6 Btu/hr. Note that since the spent fuel pool is maintained at or below 120F, it will exert a cooling influence at the beginning of the more severe cases. However this cooling effect was conservatively not included in these analyses nor was a heat load from the spent fuel pool added in these analyses.

Four cases were determined to have the most significant effect on the CCWS. No operator action to realign the SWC system or to place one of the CCW pumps on the activated bus was assumed in any of these cases. The cases considered were:

A. Loss of offsite power with single failure of one diesel generator (MLSB)

B. Loss of offsite power with single failure of one SWC pump (MSLB)

C. Loss of offsite power with single failure of one diesel generator (LOCA)

D. Loss of offsite power with single failure of one SWC pump (LOCA)

The results of these analyses are shown in Table 5. These analyses indicate that the maximum CCW heat exchanger inlet temperature occurs for Case A. This temperature is higher than the design temperature for the CCW system (200F). All other cases have results less than or equal to 200F. Case A is based on full RHR flow through one heat exchanger when reactor coolant temperature reaches 350F. However, since RHR is manually aligned, the operator would take the necessary action to limit the cooldown rate based on the available system components or realign the SWCS and CCWS. Case A was reanalyzed (Case A^1) under the assumption that the operator realigns the SWC system by closing the manual cross-tie valve. It was also assumed that the swing bus activated CCW pump was placed in service. With these assumptions the maximum CCW inlet temperature was 184F.

No post-LOCA realignment of the CCW system is performed by the operator except for the opening of both CCW supply valves to the recirculation heat exchanger at the start of recirculation and the closing of the seal water return valves to provide isolation of the seal water supply to the seal water heat exchanger. Post-MSLB realignment of the CCW system is limited to closing the seal water return to the seal water heat exchanger and opening the CCW supply valves to the RHR heat exchangers to achieve cold shutdown.

During normal operation single active failures which could affect CCWS operations are (1) failure of one CCW pump, (2) failure of one CCW heat exchanger discharge valve, (3) failure of temperature controlled valve on RHR heat exchanger discharge or (4) failure of remote manual control valve on discharge of RCP thermal barrier coil. Failure of the operating CCW pump will result in a low discharge pressure signal which automatically starts the other two pumps. Failure of the CCW heat exchanger discharge valve to the closed position while that heat exchanger is in service would result in a low flow alarm. The operator would then have to manually open the discharge valve of the other heat exchanger.

Failure of the temperature controlled valve to one RHR heat exchanger to the closed position would result in the loss of the ability to cool one RHR heat exchanger. This would require alignment of letdown to the other heat exchanger during normal letdown and would limit a plant cooldown to only one heat exchanger. It should be noted that if the CCW supply to an RHR heat exchanger is lost or reduced, while primary coolant at greater than 200F continues to circulate through the heat exchanger, the CCW side could be subjected to temperatures greater than the design value of 200F. To preclude this occurrence the temperature controlled valves on the heat exchanger discharge are fail-open valves. In addition, primary coolant can be stopped to either RHR heat exchanger by closing a remotely operated valve on the inlet side of the heat exchanger. It is estimated that a CCW flow of 1,600 gpm is required to ensure a CCW temperature of less than 200F with a primary coolant flow of 1,170 gpm and $350^{\circ}F$ through one heat exchanger.

Failure of the control valve on the discharge of an RCP thermal barrier coil would result in loss of cooling to the thermal barrier coil of that pump. This would result in a low flow alarm from that line. However, charging flow to the RCP seals would still be maintained to ensure seal integrity. Leakage from the pump will discharge through the relief valve on the cooling water outlet line from the reactor coolant pump. Flow through the relief valve will continue to spill to the sphere sump until the pressure in the Reactor Coolant system is reduced below the relief valve set point.

If a loss of the CCWS occurs during normal operation, SONGS 1 has an operating procedure that directs the operator to shutdown the reactor using the charging system test pump for RCP seal water and commence decay heat removal using the steam generators with natural circulation of the reactor coolant system. The effects of a loss of CCW during a cooldown of the plant with the RHR system operating were also considered. In this case, with the reactor vessel head installed, the operator would terminate RHR and return the plant to hot shutdown. Decay heat could be removed via the steam generators. For normal decay heat removal when the reactor vessel head is removed, adequate cooling can be established by starting containment sphere ventilation and filling the reactor cavity to normal refueling level.

During normal and post-accident operation, thermal expansion and contraction of the CCWS system liquid is accommodated by the CCW surge tank (1,000 gal.), and leakage into or out of the system can be detected by surge tank level changes. High and low surge tank levels are alarmed in the control room. The surge tank also maintains a positive suction head on the CCW pumps during normal and post-accident operation. Makeup water to the CCW system is supplied by the primary plant makeup water system via local manual valves. The makeup rate is sufficient to accommodate system leakage. Isolation of individual leaking components in the CCWS would be accomplished by local or remote manual valves.

In the event that water leaks into the CCWS from a high pressure source, an alarm, indicating a high water level in the component cooling surge tank, will be initiated in the control room. A radiation detector is located in the piping at the suction of the component cooling water pumps. High radiation is annunciated in the control room and automatically closes the surge tank vent valve to prevent radioactivity release to the atmosphere. Depending upon the leakage rate, the temperature and flow of the cooling water from the leaking component will increase. A relief valve protects the surge tank from overpressure by relieving to a radwaste holdup tank. The maximum inleakage rate is limited by the surge tank relief valve capacity of 50 gpm at a set pressure of 50 psig after the air space (1,000 gallons) has been filled. After the component containing the leak has been located, the component is isolated from the high pressure source and from the CCW system.

Based on the review of the CCW system, only the cooling of the RHR pumps, RHR heat exchangers, charging pump cooling, and recirculation heat exchanger are considered to be essential functions. The other functions can be performed by other systems or are not required.

B. SALT WATER COOLING SYSTEM

The Salt Water Cooling System (SWCS) is designed and operated in accordance with Section 3.1.7 of Reference 4. The SWCS circulates water from the intake structure to the CCW heat exchangers to remove the heat transferred to the CCWS. The intake structure screenwell (to the salt water cooling pumps) is a seismic Category A structure. The system has two salt water cooling pumps, one auxiliary salt water cooling pump, and two CCW heat exchangers. One salt water cooling pump and one component cooling heat exchanger are normally in service. During post-accident conditions, the pump not in service would be automatically started by the sequencer. During normal shutdown the pump is manually started. Each heat exchanger is supplied by an individual line from each salt water cooling pump. A normally closed valve is provided in a cross-tie between the lines. The auxiliary salt water cooling pump is connected to the discharge of one of the salt water cooling pumps upstream of the cross tie. It should be noted, however, that credit is not taken for the auxiliary salt water cooling pump in determining the operability of the SWCS in accordance with Reference 6. Two non-safety related screenwash pumps are also connected to the system through isolation valves. Major SWC system equipment parameters are identified in Table 2.

The system incorporates redundant salt water cooling pumps and the auxiliary salt water cooling pump as discussed above to protect against the potential loss of salt water cooling. It should be noted that the station has experienced loss of all three pumps. This event was initiated by failure (shaft break) of the operating SWC pump. The other pump automatically started, but the discharge valve failed to open due to contamination in the compressed air lines. The auxiliary SWC pump could not be used due to a failure to maintain prime at the pump. Ultimately, SWC flow was established, at a reduced but acceptable rate, with the non-safety related screen wash pumps. After a delay of approximately 45 minutes, the SWC pump discharge valve was opened and SWC flow was re-established. Additional information pertaining to this event is provided in References 5 through 14.

The two SWC pumps are located outside in the circulating water pump pit. The auxiliary SWC pump is also located outside at a location remote from the SWC pumps adjacent to the seawall. The physical separation of the SWC pumps will be evaluated in SEP Topic III-4.C, Internally Generated Missiles.

Power for the SWC Pumps is provided from bus 1 for Pump A and bus 2 for Pump B. The Auxiliary SWC pump can be powered off either bus. The SWC pumps are provided with bearing flush water. Loss of this water will not result in any short-term effect on the pumps.

During normal operation single active failures which could affect SWCS (and therefore CCWS) opertions are (1) failure of one SWC pump, (2) failure of an SWC pump discharge valve, 3) failure of the tsunami or stop gate.

Failure of one SWC pump will result in the automatic start of the other pump on low pump discharge pressure. Failure of the operating SWC pump discharge valve will result in the loss of all salt water cooling. This condition will be indicated in the control room by an alarm. With the loads that occur during normal operation, the CCWS will reach 200^{o}F from 90^{o}F in approximately 20 minutes from loss of all salt water cooling. This is sufficient time for the operator to take appropriate corrective action.

Failure of the tsunami or stop gates in the closed position will result in the SWC pump eventually losing its water supply when the inventory in the screen well is depleted. The time from when the SWC pump loses its supply to when the CCWS exceeds 200^{o}F is approximately 20 minutes. This is sufficient time for the operator to take appropriate corrective action.

Minimum SWCS cooling results from a loss of offsite power and the single failure of one of the two diesel generators. This was discussed in the previous section. Operator action is required if additional cooling is required.

Leak detection for the SWCS is provided by header pressure switches, which start the standby SWCS pump on low pressure. Both heat exchangers have manual isolation valves to permit a heat exchanger to be removed from the system without interrupting flow to the other heat exchanger.

The only essential function of the SWCS is to remove heat from the CCW System.

VI. CONCLUSION

Based on the review of the service and cooling water systems for SONGS 1, it is concluded that the essential systems and functions are:

Component Cooling Water System:

Charging Pump Cooling

RHR Pump Cooling

RHR Heat Exchanger

Recirculation Heat Exchanger

Salt Water Cooling System:

CCW Heat Exchanger

The design of the above systems is in conformance with current regulatory guidelines as identified in SRP Sections 9.2.1 and 9.2.2 and with GDC 44 regarding capability and redundancy of the essential functions of the systems with the exception of the requirement for physical separation of CCW and SWC system components.

The above systems also meet the requirements of GDC 45 and 46 regarding system design to permit periodic inspections and testing.

VII. REFERENCES

1. Regulatory Guide 1.105, Systems Setpoints

2. SEP Review of Safe Shutdown Systems for the San Onofre Nuclear Generating Station (SEP Topics V-10.3, V-11.3, VII-3).

3. Standard Review Plan Sections 9.2.1 and 9.2.2.

4. SONGS 1 Final Safety Analysis.

5. Letter from H. L. Ottoson (SCE) to R. H. Engelken (NRC), dated March 24, 1980.

6. Letter from R. H. Engelken (NRC) to L. T. Papay (SCE), dated April 4, 1980.

7. Letter from H. L. Ottoson (SCE) to R. H. Engelken (NRC), dated April 9, 1980.

8. Letter from R. H. Engelken (NRC) to L. T. Papay (SCE), dated April 21, 1980.

9. Letter from L. T. Papay (SCE) to R. H. Engelken (NRC), dated May 13, 1980.

10. Letter from G. C. Lainas (NRC) to Robert Dietch (SCE), dated June 20, 1980.

11. Letter from J. G. Haynes (SCE) to D. M. Crutchfield (NRC), dated July 24, 1980.

12. Letter from J. G. Haynes (SCE) to D. M. Crutchfield (NRC), dated August 8, 1980.

13. Letter from G. C. Lainas (NRC) to Robert Dietch (SCE), dated August 29, 1980.

14. Letter from K. P. Baskin (SCE) to D. M. Crutchfield (NRC), dated October 8, 1980.

TABLE 1

Component Cooling Water System Equipment

Component Cooling Water Pumps

Design Head - 65 psi

Design Flow - 1850 gpm

Component Cooling Water Heat Exchanger

Design Duty - 45,400,000 BTU/hr

Component Cooling Water Surge Tank

Normal Volume - 1000 gallons

Maximum Volume - 2000 gallons

TABLE 2

Salt Water Cooling System Equipment

Salt Water Cooling Pumps

Design Head - 70 ft

Design Flow - 4620 gpm

Auxiliary Salt Water Cooling Pump

Design Flow - 4620 gpm

Design Head - 65 ft

TABLE 3

POST LOSS OF COOLANT ACCIDENT COMPONENT COOLING WATER SERVICES

	SERVICE	ITEM IN OPERATION (YES/NO)	HEAT LOAD (BTU/hr)	ITEM ESSENTIAL (YES/NO)	REMARKS
1.	RCP Bearings & Thermal Barrier	Yes	0.85×10^6 (est)/RCP	No	Primary system depressurization removes heat load; charging provided to RCP seals.
2.	Charging Pumps	Yes	1.0×10^6 (est)	Yes	
3.	RHR Pumps	No			RHR not used post-LOCA.
4.	Reactor Shield Cooling Coils	Yes	$.25 \times 10^6$ (est)	No	Required only during normal operation.
5.	Excess Letdown Heat Exch.	No			Not used post-LOCA.
6.	Seal Water Heat Exch.	No			Isolated following LOCA.
7.	Spent Fuel Heat Exch.	Yes	3×10^6	No	Time available before fuel becomes uncovered; other means available to provide water to spent fuel pool.
8.	Pressurizer and RC Sample Heat Exch.	No			
9.	RHR Heat Exch.	No			RHR not used post-LOCA.
10.	Gas Stripper Condenser	No			Not used post-LOCA.
11.	Recirculation Heat Exch.	Yes	(1)	Yes	

(1) $250^{\circ}F$ recirculation inlet temperature

TABLE 4

POST MAIN STEAM LINE BREAK COMPONENT COOLING WATER SERVICES

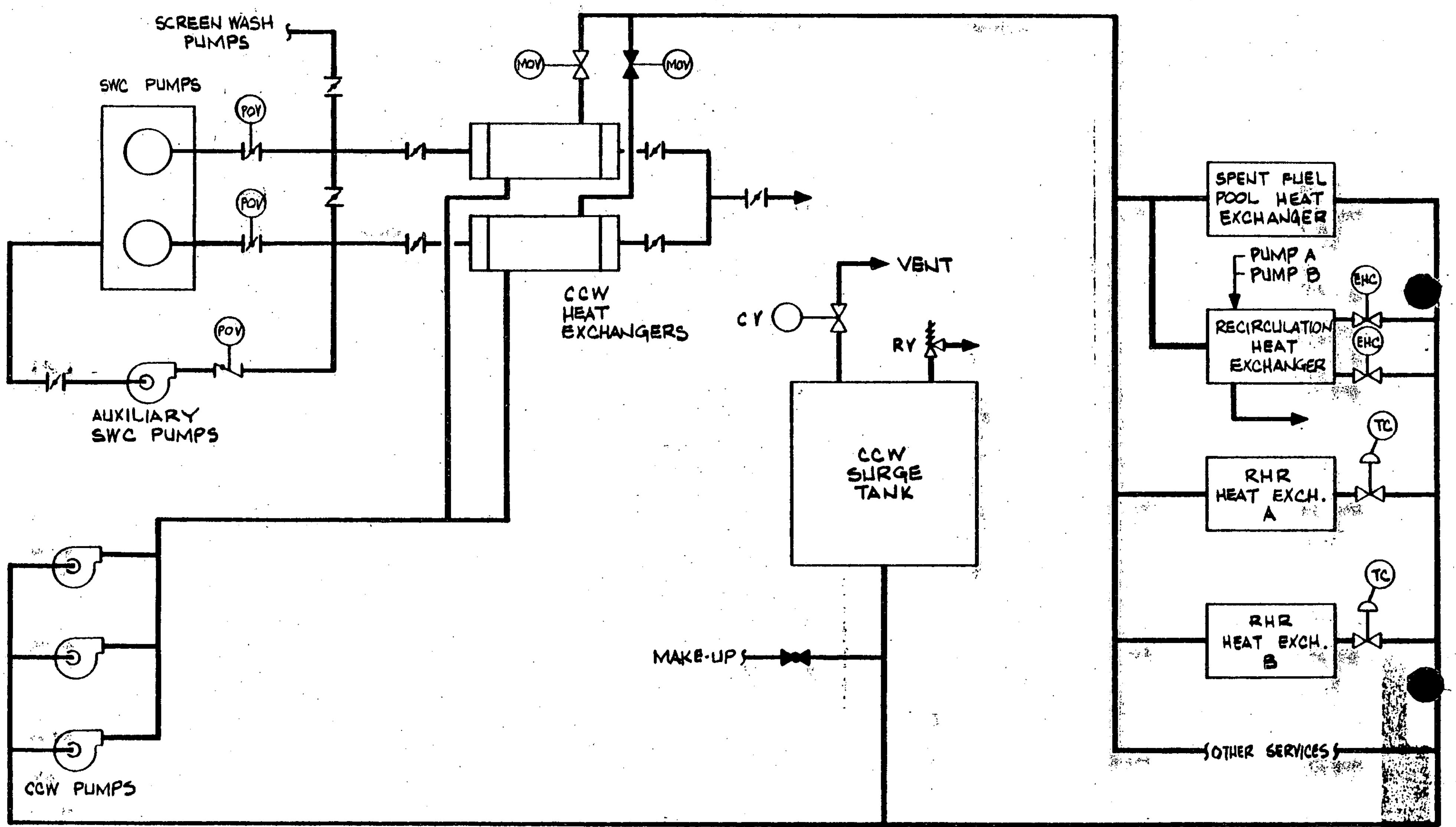
	SERVICE	ITEM IN OPERATION (YES/NO)	HEAT LOAD BTU/hr	ITEM ESSENTIAL (YES/NO)	REMARKS
1.	RCP Bearings & Thermal Barrier	Yes	$.85 \times 10^6$ (est)/RCP	No	Charging provided to RCP seals.
2.	Charging Pumps	Yes	1.0×10^6 (est)	Yes	
3.	RHR Pumps	Yes	1.0×10^6 (est)	Yes	
4.	Reactor Shield Cooling Coils	Yes	$.25 \times 10^6$ (est)	No	Required only during normal operation.
5.	Excess Letdown Heat Exch.	No			Not used post-MSLB.
6.	Seal Water Heat Exch.	No			Isolated following MSLB.
7.	Spent Fuel Heat Exch.	Yes	3×10^6	No	Time is available before fuel becomes uncovered; other means available to provide water to spent fuel pool.
8.	Pressurizer and RC Sample Heat Exch.	No			
9.	RHR Heat Exch.	Yes	(1)	Yes	
10.	Gas Stripper Condenser	No			Not used post-MSLB.
11.	Recirculation Heat Exch.	No			Not used post-MSLB.

(1) Initial inlet temperature of 350F

TABLE 5

CCW Heat Exchanger Inlet Temperature Results

Case	Event	Single Failure	CCW Heat Exchanger Inlet Temperature
A	MSLB+LOP	1 Diesel Generator	227F
A1	MSLB+LOP	1 Diesel Generator but operator realignment of system	184F
B	MSLB+LOP	1 SWC Pump	200F
C	LOCA+LOP	1 Diesel Generator	122F
D	LOCA+LOP	1 SWC Pump	95F



COMPONENT COOLING WATER (CCW) SYSTEM AND
SALT WATER COOLING (SWC) SYSTEM