General Electric Advanced Technology Manual

Chapter 4.8

Service Water System Problems

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4.8 Service Water System Problems

Learning Objectives:

1. State three safety related functions performed by most service water systems.

2. List the most frequently observed cause of system degradation, other than system fouling.

3. List three fouling mechanisms that can lead to system degradation

4.8.1 Introduction

Because the characteristics of the service water system may be unique to each facility, the service water system is defined as the system or systems that transfer heat from the safety-related structures, systems, or components to the ultimate heat sink (UHS). Attached are selected service water systems of operating plants, to illustrate some of the differences found in the industry.

The service water system provides cooling water to selected safety equipment during a loss of offsite power. Failure of the service water system would quickly fail operating diesel generators and potentially fail the low pressure emergency core cooling pumps due to the loss of cooling pump or room coolers. The High Pressure Coolant Injection and Reactor Core Isolation Cooling pumps would fail upon loss of their room cooling.

There is an outstanding issue regarding the need for service water that involves the issue of the core spray and residual heat removal pumps requiring service water cooling. One utility (PECo) has stated that these pumps are designed to operate with working fluid temperatures approaching 1600F without pump cooling. However, because it is uncertain whether the suppression pool water temperature can be maintained below 1600F in some core damage PRA sequences the analyses still assume failure of the low pressure emergency core cooling pumps.

The NRC staff has been studying the problems associated with service water cooling systems for a number of years. At Arkansas Nuclear Plant, Unit 2, on September 3, 1980, the licensee shut down the plant when the resident inspector discovered that the service water flow rate through the containment cooling units did not meet the technical specification requirement. The licensee determined the cause to be extensive flow blockage by Asiatic clams (Corbicula species, a non-native fresh water bivalve mollusk). Prompted by this event and after determining that it represented a generic problem of safety significance, the NRC issued Bulletin No. 81-03, "Flow Blockage of Cooling Water to Safety System Components by Asiatic Clam."

After issuance of Bulletin No. 81-03, one event at San Onofre Unit 1 and two events at the Brunswick station indicated that conditions not explicitly discussed in the bulletin can occur and cause loss of heat transfer to the UHS. These conditions include:

- Flow blockage by debris from shellfish other than Asiatic clams and mussel.
- Flow blockage in heat exchanger causing high pressure drops that can deform baffles and allow flow to bypass heat exchanger tubes.
- A change in operating conditions, such as a change from power operation to a lengthy outage that permits a buildup of biofouling organisms.
- Degradation of cooling water systems due to icing.
- Injection of sealant into intake bays.

By March 1982, several reports of serious fouling events caused by mud, silt, corrosion products, or aquatic bivalve organisms in open-cycle service water systems had been received. These events led to plant shutdowns, reduced power operation for repairs and modifications, and degraded modes of operation. This situation forced the NRC to establish Generic Issue 51, "Improving the Reliability of Open-cycle Service Water Systems." To resolve this issue, the NRC initiated a research program to compare alternative surveillance and control programs to minimize the effects of fouling and increase plant safety.

June 12, 1996 the NRC issued Information Notice 96-36 to alert addressees to potential degradation of facility water intake systems due to icing conditions. This information notice was prompted by events at FitzPatrick (February 25, 1993), Wolf Creek (January 30, 1996), and Fermi (February 5, 1996). Frazil icing is a phenomenon that effects the operation of intake structures in regions that experience cold weather. The accumulation of frazil ice on intake trash rakes can completely block the flow of water in the bays. The process starts when the water flowing into the intake is supercooled (water below the freezing point).

Supercooling occurs with a loss of heat from a large surface area such as a lake with open water and clear nights. High winds contribute to the problem by providing mixing of the supercooled water to depths as great as 6 to 9 meters. The frazil ice, which is composed of very small crystals with little buoyancy, is carried along in the water and mixed all through the supercooled water.

Drawing the supercooled water and the suspended frazil ice crystals through an intake structure brings the frazil ice crystals in contact with the trash rake bars. These ice crystals easily adhere to any object with which they collide. Ice collects first on the upstream side of the trash rakes, then steadily grows until the space between the trash takes is bridged. The accumulation of ice can withstand high differential pressures, effectively damming the intake bay(s).

4.8.2 AEOD Case Study

The Office for Analysis and Evaluation of Operational Data (AEOD) initiated a systematic and comprehensive review and evaluation of service water system failures and degradation at light water reactors from 1980 to early 1987. The results of that AEOD case study was published in "Operating Experience Feedback Report - Service Water System Failures and Degradations," NUREG-1275, Volume 3.

Of 980 operational events involving the service water system reported during this period, 276 were deemed to have potential generic safety significance. Of the 276 events with safety significance 58 percent involved system fouling. The fouling mechanisms included corrosion and erosion (27%), biofouling (10%), foreign material and debris intrusion (10%), sediment deposition (9%), and pipe coating failure and calcium carbonate deposition (1%).

The second most frequently observed cause of service water system degradations and failures is personnel and procedural errors (17%), followed by seismic deficiencies (10%), single failures and other design deficiencies (6%), flooding and significant failures 4% each.

During the evaluation period 12 events involved a complete loss of the service water system.

Following the evaluation of service water events, several NRC requirements were originated:

- Conduct, on a regular basis, performance testing of all heat exchangers, which are cooled by the service water system and are needed to perform a safety function. The testing performed should verify heat exchanger heat transfer capability.
- Require licensees to verify that their service water systems are not vulnerable to a single failure of an active component.
- Inspect, on a regular basis, important portions of the service water piping for corrosion, erosion, and biofouling.
- Reduce human errors in the operation, repair, and maintenance of the service water system.

4.8.3 Summary

Due to the significance of the service water system's contribution to core damage frequency in the probability risk assessment studies and the systems' troubled operating experiences, the NRC determined that compliance with 10CFR50 Appendix A, General design Criteria (GDC) is in question. Table 4.8-1 lists the service water system's contribution to core damage frequency (CDF) in terms of an absolute value and a percentage for a collection of BWRs and PWRs. The contribution made by service water to the total CDF varies from <1% to 65%. The reasons for the large differences for the most part have to do with the degree of dependency a plant has on service water, the reliability of the systems themselves, and to some extent, the differences in the PRAs in terms of modeling assumptions

Generic Letter 89-13 was issued to require licensees to supply information about their respective service water systems to assure the NRC of such compliance and to confirm that the safety functions of their systems are being met.

Table 4.8-1 Service Water Contribution to Core Damage Frequency

Plant	Type	Total Internal CDF (mean)	SW CDF Contribution	SW % Contribution
Calvert Cliffs 1	PWR	$1.3x10^{-4}$	$1.4x10^{-5}$	11
Point Beach 1	PWR	$1.4x10^{-4}$	$2.6x10^{-5}$	19
Turkey Point 3	PWR	$7.1x10^{-5}$	$3.4x10^{-6}$	5
St. Lucie 1	PWR	$1.4x10^{-5}$	$1.8x10^{-6}$	13
ANO-1	PWR	$8.8x10^{-5}$	$1.1x10^{-5}$	12
Quad Cities 1	BWR	$9.9x10^{-5}$	$3.0x10^{-5}$	30
Cooper	BWR	$2.9x10^{-4}$	$1.9x10^{-4}$	65
Surry 1	PWR	$4.0x10^{-5}$	$1.5x10^{-8}$	<1
Sequoyah 1	PWR	$5.7x10^{-5}$	$2.4x10^{-7}$	<1
Peach Bottom 2	BWR	$4.5x10^{-6}$	$1.4x10^{-6}$	22
Grand Gulf	BWR	$4.1x10^{-6}$	$5.6x10^{-7}$	14

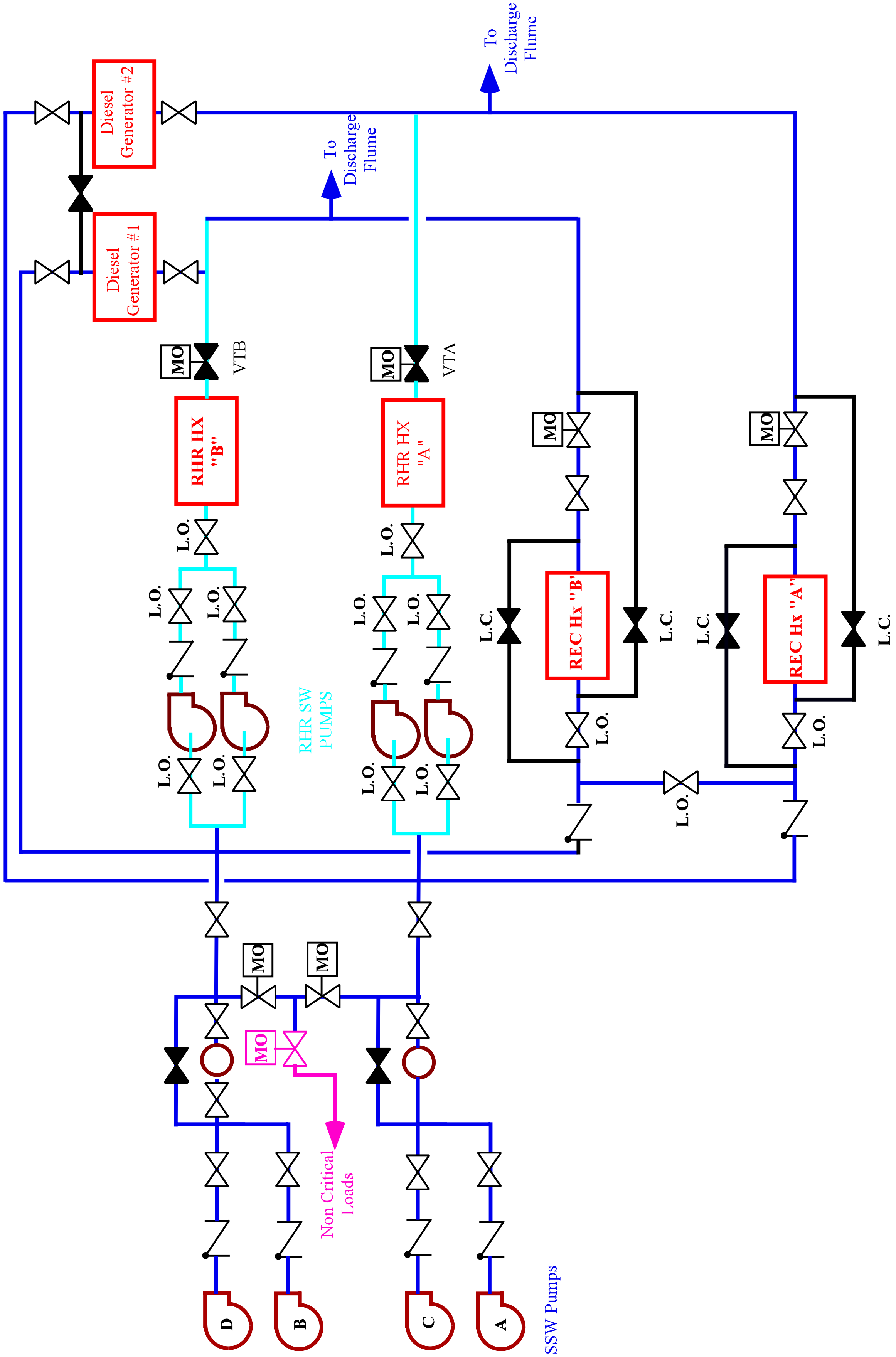

Figure 4.8-1 Cooper Station

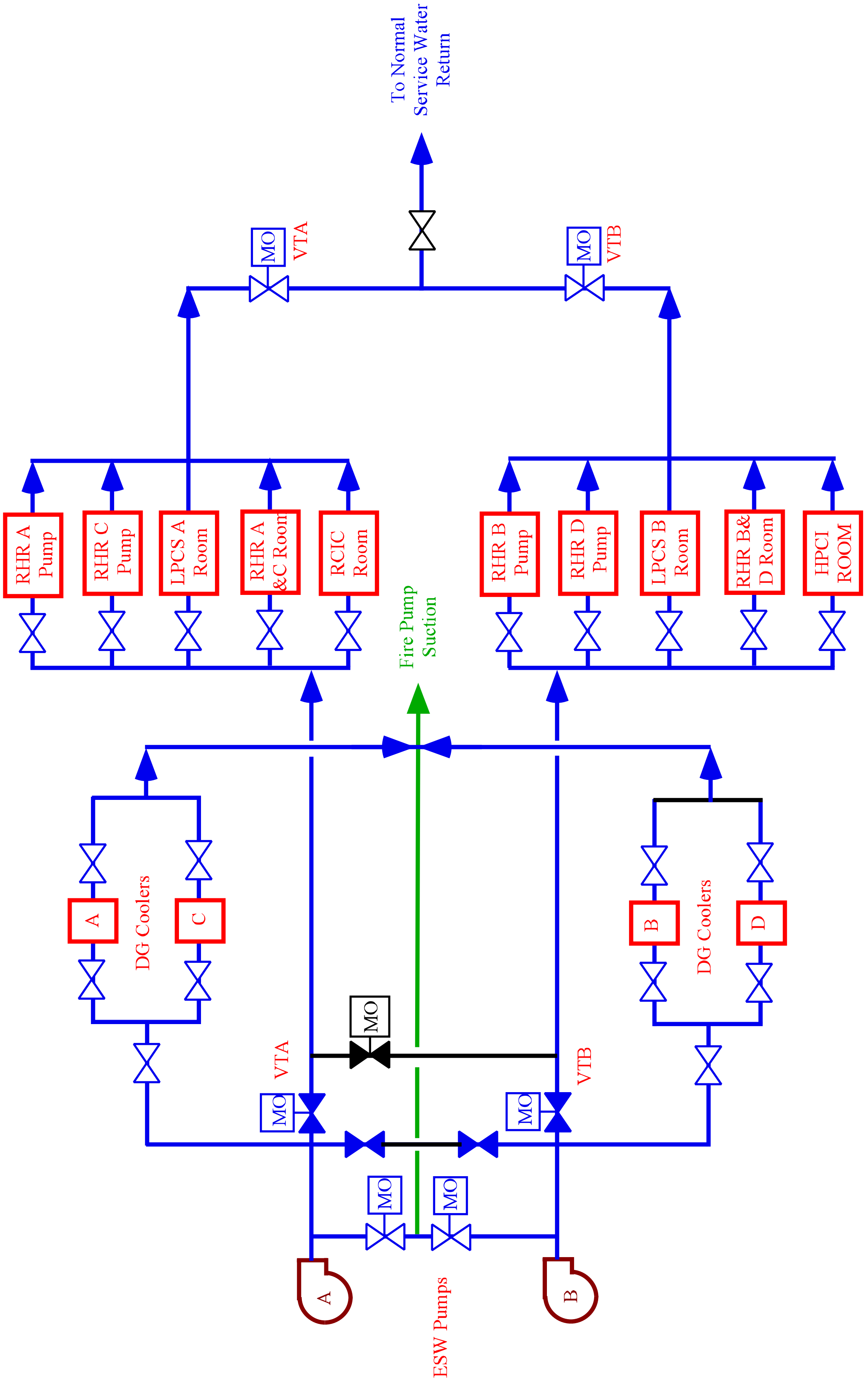

Figure 4.8-2 Fitzpatrick

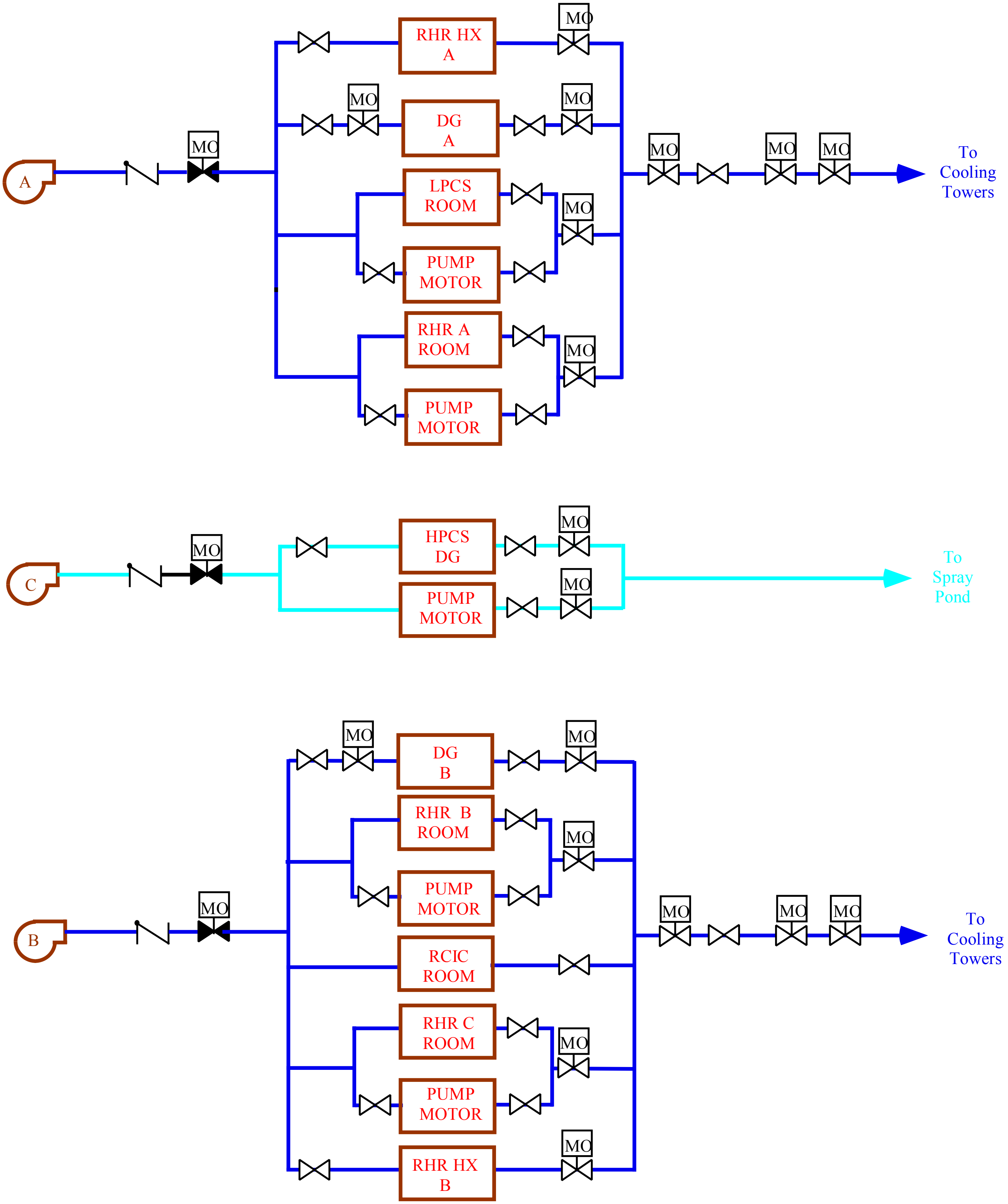

Figure 4.8-3 WNP-2

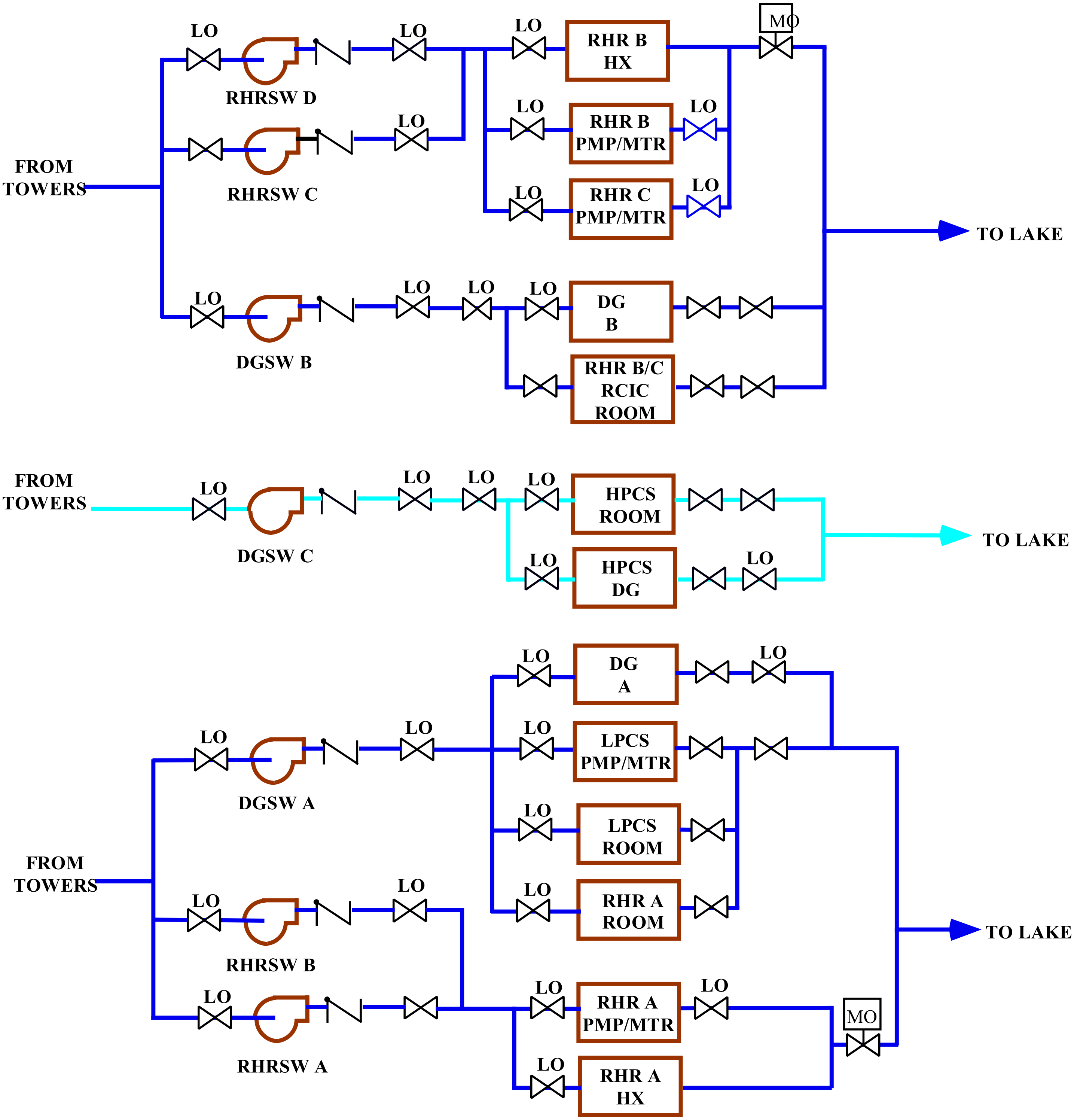

Figure 4.8-4 La Salle

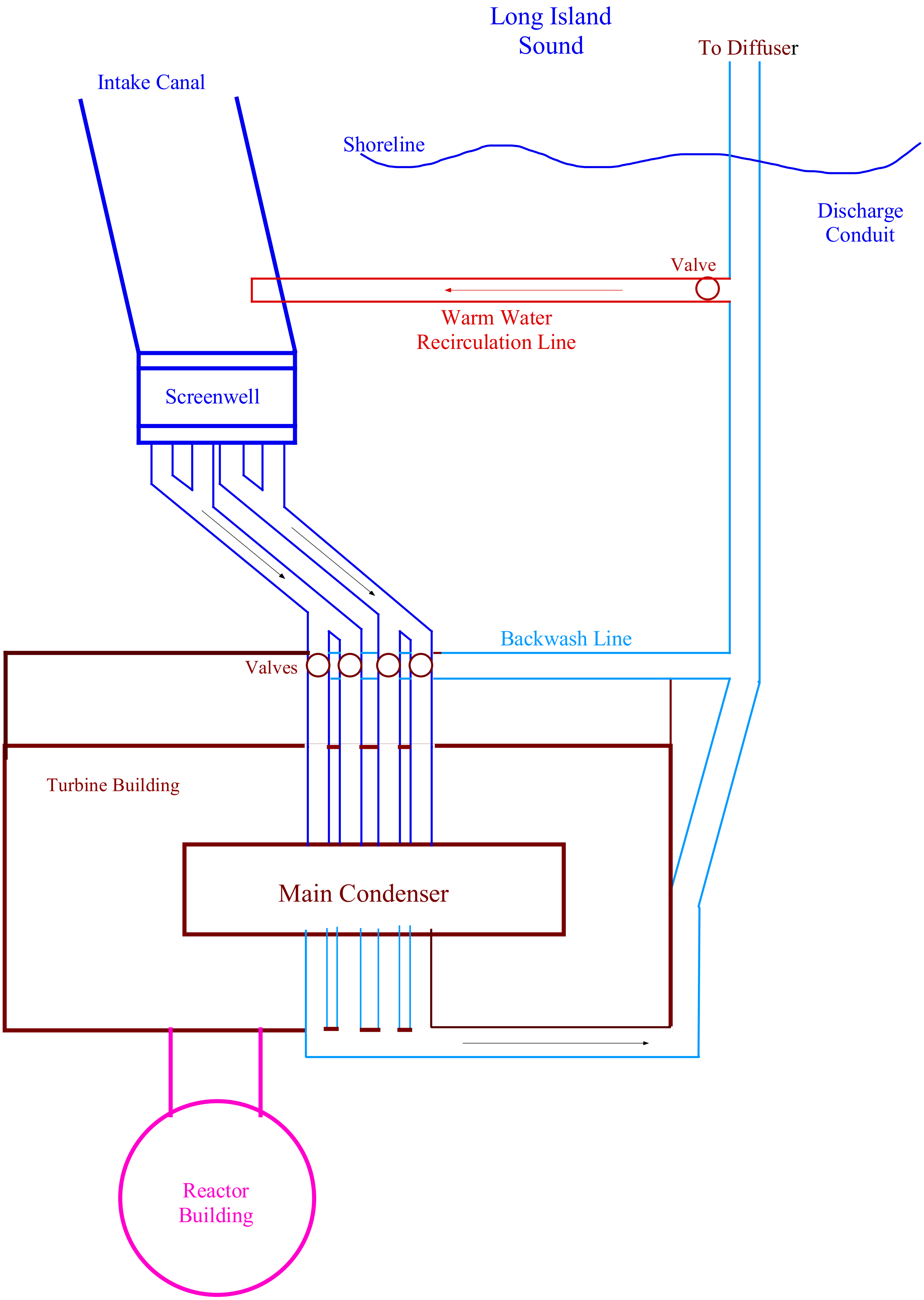

Figure 4.8-5 Circulation Water System Overview