NUCLEAR POWER PLANT SYSTEM SOURCEBOOK

ZION 1 & 2

50-295, 50-304

SAIC 89/1532

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50-295, 50-304

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RECORD OF REVISIONS

Revision	Issued	Comments
0	11/89	Original Sourcebook
1	10/90	Revisions to Auxiliar Feedwater System Figures, Service Water System Figures, Fire Water System Figures, and Table 4-1 "Definition of Zion 1 Building and Location Codes."
2	9/91	General reorganization of the Sourcebook and addition of the following new sections: (a) Westinghouse 4-Loop plant comparison, (b) containment and associated systems, (c) containment heat removal systems, (d) reactor core and reactivity control systems, and (e) residual heat removal system. Also expansion of existing sections on reactor coolant system, emergency core cooling systems and chemical and volume control system.

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CAUTION

The information in this Sourcebook has been developed over an extended period of time based on a site visit, the Final Safety Analysis Report, system and layout drawings, and other published information. To the best of our knowledge, it accurately reflects the plant configuration at the time the information was obtained, however, the information in this document has not been independently verified by the licensee or the NRC.

NOTICE

This Sourcebook will be periodically updated with new and/or replacement pages as appropriate to incorporate additional information on this reactor plant. Technical errors in this report should be brought to the attention of the following:

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Correction and other recommended changes should be submitted in the form of marked up copies of the affected text, tables or figures. Supporting documentation should be included if possible.

1. INTRODUCTION TO THE ZION 1 & 2 SYSTEM SOURCEBOOK

1.1 PURPOSE

This Sourcebook contains summary information on the Zion nuclear power plant, focusing on safety systems, system interfaces, and the basic layout of the plant. This Sourcebook is intended as a reference resource that should enable users to quickly become oriented to the safety features and safety systems at Zion. The summary information in this Sourcebook has been compiled from the Final Safety Analysis Report (FSAR) and other available resources as referenced in the text, however, the information has not been verified by means of a plant walk-down. For more definitive information on this nuclear power plant, users of this Sourcebook are encouraged to refer to a copy of the FSAR that is maintained current.

1.2 ORGANIZATION

The scope of systems covered in this Sourcebook and a brief listing of summary data on this plant are presented in Section 1. Similar nuclear power plants are identified and compared in Section 2. In Section 3, descriptions of selected systems at Zion 1 are provided in terms of general function, operation, system success criteria, major components, and support system requirements. The corresponding systems at Zion 2 are similar. The site and building layouts are illustrated in Section 4. A bibliography of reports that describe features of this plant or site is presented in Section 5. Symbols used in the system and layout drawings are defined in Appendix A. Terms used in data tables are defined in Appendix B.

1.3 SCOPE

The following systems are covered in the Nuclear Power Plant System Sourcebook for Zion 1 & 2:

- Reactor core and reactivity control systems
- Reactor coolant system
- Auxiliary feedwater system and secondary steam releif system
- Emergency core cooling system
- Chemical and volume control system
- Residual heat removal system
- Containment and associated systems
- Containment heat removal systems
- Instrumentation and control systems
- Electric power systems
- Component cooling water system
- Service water system
- Fire water system

A summary of major systems at Zion 1 & 2 is presented in Table 1-1. In the "Report Section" column of this table, a section reference (i.e. 3.1, 3.2, etc.) is provided for all systems that are described in this Sourcebook. An entry of "X" in this column means that the system is not covered in this Sourcebook. In the "FSAR Section Reference" column, a cross-reference is provided to the section of the Final or Updated Safety Analysis Report where additional information on each system can be found. References to other sources of information on this plant are included in the bibliography in Section 5 of this Sourcebook.

For each of the systems covered in this Sourcebook, the following information is provided:

- System Function:
  A brief statement defines the primary operational and safety function(s) of the system.

- System Definition:
  Brief statements identify the major elements of the system (i.e., number of trains, major components, etc.). Simplified system diagrams are provided for all systems, and for fluid systems, the major flow paths through the system are highlighted. Note that valve, damper, and circuit breaker positions shown in the system diagrams are the positions these components are in during normal power operation. While flow paths during various accident operating modes are shown, valve positions in these drawings have not been revised to correspond to the actual valve lineup during each accident operating mode. Additional figures are provided as appropriate to show features of major components or structures.

- System Operation:
  The state of the system during normal power operation is discussed along with the operation of the system in response to accidents.

- System Success Criteria:
  Criteria for system success relative to the intended system safety function are defined (i.e., x of y pumps, etc.).

- Component Information:
  Selected design and operating parameters are listed for major components in the system. Data tables list component power sources and and other information.

- Support Systems and Interfaces:
  Support systems for actuation and control, motive power, cooling water, and other important support functions are identified.

Each Sourcebook also includes simplified site and building layout drawings to provide a basic orientation to the plant arrangement.

1.4 SUMMARY DATA ON PLANT

Basic information on the Zion nuclear plant is listed below:

- Docket number	50-295 (Unit 1) and 50-304 (Unit 2)
- Operator	Commonwealth Edison Company
- Location	Zion, Illinios
- Commercial operation date	10/73 (Unit 1), 11/74 (Unit 2)
- Reactor type	PWR
- NSSS vendor	Westinghouse
- Number of loops	4
- Power (MWt/MWe)	3250/1040
- Architect-engineer	Sargent & Lundy
- Containment type	Reinforced concrete cylinder with steel liner

Several cooling water systems are identified in Table 1-1. The functional relationships that exist among cooling water systems required for safe shutdown are shown in Figure 1-1. Details on the individual cooling water systems are provided in the Sourcebook sections identified in Table 1-1.

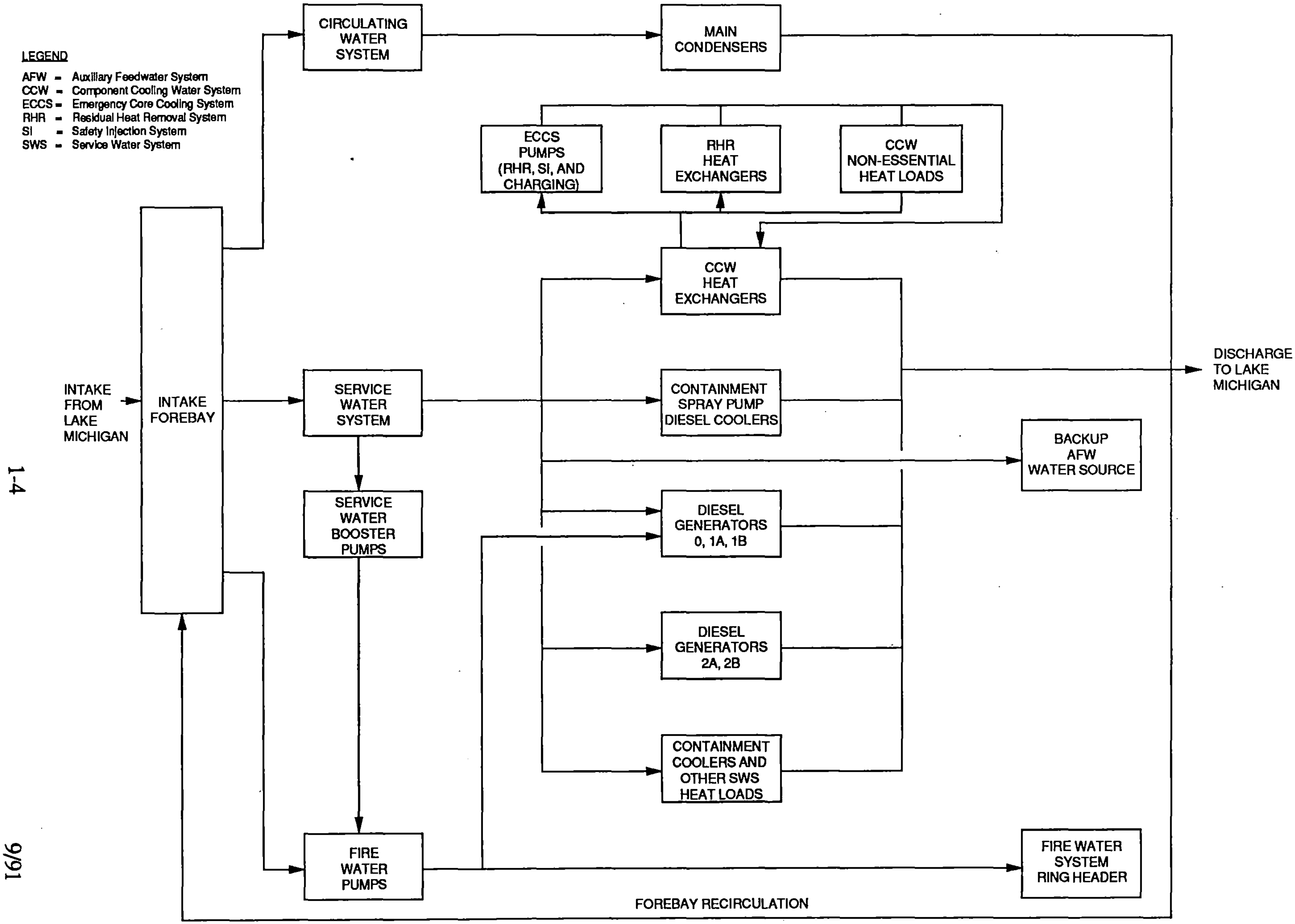


Figure 1-1. Cooling Water Systems Functional Diagram for Zion 1 and 2

Table 1-1. Summary of Zion 1 & 2 Systems Covered in this Report

Generic System Name	Plant-Specific System Name	Report Section	FSAR Section Reference
Reactor and Reactivity Control Systems			
- Reactor Core	Same	3.1	3
- Control Rod System	Same	3.1	7.3
- Boration Systems	Chemical and Volume Control System (CVCS)	3.1,3.5	9.2
Reactor Heat Removal Systems			
- Reactor Coolant System (RCS)	Same	3.2	4
- Auxiliary Feedwater (AFW) and Secondary Steam Relief (SSR) Systems	Same	3.3	6.7
- Emergency Core Cooling Systems (ECCS)	Same		
- High-Pressure Injection & Recirculation	High Pressure Safety Injection System	3.4	6.2
- Low-Pressure Injection & Recirculation	Low Pressure Safety Injection System	3.4	6.2
- Decay Heat Removal (DHR) System (Residual Heat Removal (RHR) System)	Residual Heat Removal System	3.6	9.4
- Main Steam and Power Conversion Systems	Steam Flow System,	X	10.3
	Condensate and Feedwater System,	X	10.4
	Circulating Water System	X	10.5
- Other Reactor Heat Removal Systems	None identified	-	-

Table 1-1. Summary of Zion 1 & 2 Systems Covered in this Report (Continued)

Generic System Name	Plant-Specific System Name	Report Section	FSAR Section Reference
Reactor Coolant Inventory Control Systems			
- Chemical and Volume Control System (CVCS) (Charging System)	Same	3.5	9.2
- ECCS	See ECCS, above	-	-
Containment Systems			
- Containment	Same	3.7	5, 6.6
- Containment Heat Removal Systems			
- Containment Spray System	Same	3.8	6.4
- Containment Fan Cooler System	Same	3.8	6.3
- Containment Fission Product Control Systems	Containment Spray System (see above),	-	-
	Containment Activated Charcoal Filter Unit System	3.7	9.10.6
- Containment Normal Ventilation Systems	Containment Fan Cooler System (see above),	-	-
	Control Rod Drive Mechanism Ventilation System,	3.8	9.10.6
	Reactor Cavity and Out-of-Core Instrumentation Ventilation System,	3.8	9.10.6
	Manipulator Crane Ventilation System,	X	9.10.6
	Pressure and Vacuum Relief System,	3.7	9.10.6
	Containment Purge System	3.7	9.10.6
- Combustible Gas Control Systems	None noted	3.7	-

Table 1-1. Summary of Zion 1 & 2 Systems Covered in this Report (Continued)

Generic System Name	Plant-Specific System Name	Report Section	FSAR Section Reference
Instrumentation & Control (I&C) Systems			
- Reactor Protection System (RPS)	Same	3.9	7.2
- Engineered Safety Feature Actuation System (ESFAS)	Engineered Safety Features Systems	3.9	7.5
- Remote Shutdown System	Operating Control Stations	3.9	7.7
- Other I&C Systems	Various systems	3.9	7.3, 7.4
Support Systems			
- Class 1E Electric Power System	Same	3.10	8.4
- Non-Class 1E Electric Power System	Same	3.10	8.2, 8.3
- Diesel Generator Auxiliary Systems	Same	3.10	8.4.3, 9.10.9
- Component Cooling Water (CCW) System	Component Cooling System	3.11	9.3
- Service Water System (SWS)	Same	3.12	9.6
- Other Cooling Water Systems	Spent Fuel Pit Cooling System	X	9.5
- Fire Protection Systems	Plant Fire Protection System	3.13	9.9
- Room Heating, Ventilating, and Air-Conditioning (HVAC) Systems	Control Room HVAC System	X	9.10.3
- Instrument and Service Air Systems	None noted	X	-
- Refueling and Spent Fuel Systems	Same	X	9.7

Table 1-1. Summary of Zion 1 & 2 Systems Covered in this Report (Continued)

Generic System Name	Plant-Specific System Name	Report Section	FSAR Section Reference
- Radioactive Waste Systems	Same	X	11.1
- Radiation Protection Systems	Same	X	11.2

2. COMPARISON OF WESTINGHOUSE 4-LOOP NUCLEAR POWER PLANTS

The operating status of Westinghouse 4-loop PWR plants in the United States is summarized below:

Plant	Date of Commercial Operations
- Braidwood 1 & 2	7/29/88 (Unit 1), 10/17/88 (Unit 2)
- Byron 1 & 2	9/16/85 (Unit 1), 8/21/87 (Unit 2)
- Callaway	12/19/84
- Catawba 1 & 2	6/29/85 (Unit 1), 8/19/86 (Unit 2)
- Comanche Peak 1 & 2	8/13/90 (Unit 1), '92 (Unit 2, Planned)
- D.C. Cook 1 & 2	8/28/75 (Unit 1), 7/1/78 (Unit 2)
- Diablo Canyon 1 & 2	5/7/85 (Unit 1), 3/13/86 (Unit 2)
- Haddam Neck	1/1/68
- Indian Point 2 & 3	8/1/74 (Unit 2), 8/30/76 (Unit 3)
- McGuire 1 & 2	12/1/81 (Unit 1), 3/1/84 (Unit 2)
- Millstone 3	4/23/86
- Salem 1 & 2	6/30/77 (Unit 1), 10/13/81 (Unit 2)
- Seabrook	5/90
- South Texas 1 & 2	8/25/88 (Unit 1), 6/19/89 (Unit 2)
- Trojan	5/20/76
- Vogtle 1 & 2	6/1/87 (Unit 1), 5/20/89 (Unit 2)
- Watts Bar 1	'92 (Unit 1, Planned)
- Watts Bar 2	Indefinitely postponed
- Yankee-Rowe	7/1/61
- Zion 1 & 2	12/31/73 (Unit 1), 9/17/74 (Unit 2)

All of these plants had full power operating licenses as of 3/91 except for Comanche Peak 2 and Watts Bar 1 and 2. A comparison of basic features of these plants is presented in this section.

2.1 REACTOR CORE AND FUEL ASSEMBLIES

The 4-loop Westinghouse plants can be grouped into the following categories based on core thermal output:

- 600 MWt	Yankee-Rowe
- 1825 MWt	Haddam Neck
- 2758 to 3817 MWt	All other 4-loop plants

The Yankee-Rowe core is comprised of 76 unique 9 x (6 x 6) fuel assemblies and uses cruciform control rods. The majority of the other 4-loop plants use 17 x 17 fuel assemblies, with a few still using 15 x 15 fuel assemblies. The Haddam Neck core has 157 fuel assemblies and all others have 193 fuel assemblies.

The average power densities of the earlier 4-loop plants (i.e., Yankee-Rowe, Haddam Neck, and Indian Point 2 and 3) are in the range from 82 to 93 kW/liter. All of the later plants using the 17 x 17 fuel assemblies have power densities in the range from 98 to 109 kW/liter.

2.2 REACTIVITY CONTROL SYSTEM

The control rods in all Westinghouse 4-loop PWRs except Yankee Rowe are multi-finger rod cluster control assemblies (RCCAs). Haddam Neck has 45 full-length RCCAs and no part-length RCCAs. Westinghouse 4-loop plants with 193 fuel assembly cores typically have 53 to 59 full-length RCCAs and 0 to 8 part-length RCCAs.

Yankee-Rowe is the only Westinghouse plant to use cruciform control rods. There are 24 cruciform control rods operated by magnetic jack CRDMs plus 8 cruciform fixed "shim" rods. The position of the shim rods can be changed only during refueling.

2.3 REACTOR COOLANT SYSTEM (RCS)

Each RCS loop consists of a U-tube steam generator, a single vertical, centrifugal reactor coolant pump, and connecting loop piping. The pressurizer is connected to one of the RCS hot legs. Most 4-loop plants have a reactor vessel with a 173 inch inside diameter. The only exceptions are the following:

- 109 inch vessel	Yankee-Rowe
- 154 inch vessel	Haddam Neck
- 167 inch vessel	Comanche Peak & 2

2.4 STEAM GENERATORS

All vintages of steam generators can be found among the 4-loop Westinghouse plants, as follows:

- 27-series	Yankee-Rowe
- 44-series	Indian Point 2 & 3
- 51-series	Most other 4-loop plants
- Model E	South Texas
- Model F	Seabrook, Wolf Creek, Callaway (late-model 4-loop plants)

2.5 SHUTDOWN COOLING SYSTEMS

In most of the 4-loop Westinghouse plants, shutdown cooling is accomplished by the Residual Heat Removal (RHR) system which also operates in the Low-Pressure Safety Injection (LPSI) mode as part of the Emergency Core Cooling System (ECCS). An exception is South Texas 1 & 2 which have separate RHR and LPSI pumps that share a common RHR heat exchanger in each loop.

2.6 EMERGENCY CORE COOLING SYSTEMS (ECCS)

A representative ECCS for a 4-loop Westinghouse PWR is comprised of the following subsystems:

- Two High-Pressure Safety Injection (HPSI) pump trains that can inject into the cold legs and hot legs, and two centrifugal charging pump trains that inject into the cold legs.
- Two RHR trains which perform the Low-Pressure Safety Injection (LPSI) function, each with a pump and heat exchanger
- Four safety injection accumulators, each connected to an RCS cold leg

Almost all 4-loop Westinghouse plants have two high-pressure ECCS subsystems; the high-pressure safety injection (HPSI) system and the centrifugal charging pumps which are part of the ECCS. In these plants, the shutoff head of the HPSI pumps typically is on the order of 1600 to 1700 psig. Each centrifugal charging pump pump can provide approximately 150 gpm makeup to the RCS at the PORV setpoint pressure.

The only exceptions to this high-pressure injection capability are the Yankee-Rowe and Indian Point 2 and 3 plants. These plants have an intermediate-pressure HPSI system and low-capacity positive displacement charging pumps which are not part of the ECCS. In the event of a small LOCA which leaves the RCS at high pressure, it is necessary to first depressurize the RCS before the HPSI pumps can provide makeup. Depressurization can be accomplished by heat transfer from the RCS to the steam generators or by opening the power-operated relief valves on the pressurizer.

South Texas 1 and 2 are unusual in that safety injection accumulators are provided for only three of the four primary loops, and separate RHR pumps (not the LPSI pumps) are used during shutdown cooling.

2.7 CONTAINMENT

Westinghouse 4-loop plants have either large, dry containments, a subatmospheric containment, or ice condenser containments of various designs, as described below. The ice condenser containment is unique to Westinghouse 4-loop PWRs.

2.7.1. Large, Dry Containment

Twenty-four of thirty-five 4-loop plants have large, dry containments. The types of construction used in these containments is summarized below.

Containment Construction	Applicable Plants
Bare steel sphere	Yankee-Rowe
Reinforced concrete cylinder with a steel liner	Comanche Peak 1 & 2 Diablo Canyon 1 & 2 Haddam Neck Indian Point 2 & 3 Salem 1 & 2
Reinforced concrete cylinder with a steel steel liner and secondary containment	Seabrook 1
Three-dimension post-tensioned concrete cylinder with a steel liner	Braidwood 1 & 2 Byron 1 & 2 Callaway South Texas 1 & 2 Trojan Vogtle 1 & 2 Wolf Creek Zion 1 & 2

2.7.2. Subatmospheric Containment

Millstone 3 is the only 4-loop Westinghouse PWR with a subatmospheric containment. Construction is of reinforced concrete cylinder with a steel liner and a secondary containment. All other subatmospheric containments in the U.S are found in Westinghouse 3-loop plants.

2.7.3. Ice Condenser (Pressure Suppression) Containment

Ice condenser containments are unique to 4-loop Westinghouse PWRs, and ten of the thirty-five 4-loop plants have this type of containments. The types of construction used in these containments is summarized below.

Containment Construction	Applicable Plants
Steel cylinder with concrete shield building	Catawba 1 & 2 Sequoyah 1 & 2 Watts Bar 1 & 2
Reinforced concrete cylinder with steel liner	D.C. Cook 1 & 2 McGuire 1 & 2

2.8 COOLING WATER SOURCE AND MAIN CONDENSER HEAT SINK

The normal cooling water sources and heat sinks for Westinghouse 4-loop plants are summarized below:

Plant	Water Source	Heat Sink
- Braidwood 1 & 2	Kanakee River	Braidwood Lake
- Byron 1 & 2	Rock River	Natural draft cooling towers
- Callaway	Missouri River	Natural draft cooling tower
- Catawba 1 & 2	Lake Wylie	Mechanical cooling towers
- Comanche Peak 1&2	Squaw Creek Reservoir	Same
- D.C. Cook 1 & 2	Lake Michigan	Same
- Diablo Canyon 1 & 2	Pacific Ocean	Same
- Haddam Neck	Conneticut River	Same
- Indian Point 2 & 3	Hudson River	Same
- McGuire 1 & 2	Lake Norman	Same
- Millstone 3	Long Island Sound	Niantic Bay
- Salem 1 & 2	Delaware River	Same
- Seabrook	Atlantic Ocean	Same
- South Texas 1 & 2	Colorado River	Cooling pond
- Trojan	Columbia River	Natural draft cooling tower
- Vogtle 1 & 2	Savannah River	Natural draft cooling towers
- Watts Bar 1 & 2	Chickamunga Lake	Natural draft cooling tower
- Yankee-Rowe	Sherman Pond	Same
- Zion 1 & 2	Lake Michigan	Same

2.9 SITE CHARACTERISTICS

Basic site characteristics in terms of Safe Shutdown Earthquake (SSE) horizontal and vertical g loads and design basis tornado wind speed for the Westinghouse 4-loop plant sites are summarized below:

Plant	SSE Horizontal Load (g's)	SSE Vertical Load (g's)	Tornado Wind Speed (mph)
- Braidwood 1 & 2	0.20	0.133	360
- Byron 1 & 2	0.20	0.133	360
- Callaway	0.20	0.133	360
- Catawba 1 & 2	0.15	0.10	360
- Comanche Peak 1 & 2	0.12	0.08	360
- D.C. Cook 1 & 2	0.20	0.133	360
- Diablo Canyon 1 & 2	0.75	0.50	200
- Haddam Neck	0.15	0.10	360
- Indian Point 2 & 3	0.15	0.10	300

-	McGuire 1 & 2	0.15	0.10	360
-	Millstone 3	0.17	0.113	300
-	Salem 1 & 2	0.20	0.133	360
-	Seabrook	0.20	0.133	360
-	South Texas 1 & 2	0.10	0.067	360
-	Trojan	0.25	0.167	200
-	Vogtle 1 & 2	0.20	0.133	360
-	Watts Bar 1 & 2	0.18	0.12	360
-	Yankee-Rowe	0.10	0.067	110
-	Zion 1 & 2	0.17	0.113	360

3. SYSTEM INFORMATION

3.1 REACTOR CORE AND REACTIVITY CONTROL SYSTEMS

3.1.1 System Function

The reactor core generates heat by means of nuclear fission and maintains an acceptable geometry for the transfer of core heat to the Reactor Coolant System (see Section 3.2) or the Emergency Core Cooling System (see Section 3.4). The fuel cladding constitutes the first physical barrier to a release of radioactive material from the fuel to the environment.

The reactivity control systems use neutron-absorbing materials to control the rate of nuclear fission consistent with operational and safety requirements. The reactivity control function is accomplished by two independent systems; the Control Rod System and the Chemical and Volume Control System (CVCS).

3.1.2 System Definition

The reactor core is an approximately right circular array of 193 fuel assemblies surrounded by a reflector, thermal shield, core barrel, and other core internal structures that locate the core within the reactor vessel and establish the coolant flow paths in and out of the core. Fuel assemblies with three different enrichments, ranging from 2.25 to 3.30% U-235, typically comprise the core. The general arrangement of a typical Westinghouse 193-element core is shown in Figure 3.1-1.

Each fuel assembly consists of 204 helium-pressurized, zircaloy-clad fuel rods containing slightly enriched uranium dioxide fuel pellets in a 15 x 15 square lattice configuration as shown in Figure 3.1-2. Each fuel rod is plugged and seal welded at the ends to encapsulate the fuel pellets and establish the first barrier to a release of fission products from the fuel. All fuel rods in an assembly have the same enrichment. The center lattice position in each fuel assembly is reserved for in-core instrumentation. Guide thimbles occupy the remaining 20 lattice spaces in each fuel assembly. Depending on the position in the core, the guide thimbles provide locations for the rod cluster control assemblies (RCCAs) or other in-core components (i.e., burnable poison assemblies, neutron source assemblies, or thimble plug assemblies). Rod spacing in a fuel assembly is established by a series of grids and endcaps which are structurally connected by full-length guide thimbles.

The Control Rod System consists of 53 full-length RCCAs and their associated control rod drive mechanisms (CRDMs). Each RCCA consists of 20 neutron-absorbing control "fingers" or rods attached at the top by a "spider" assembly as shown in Figure 3.1-3. The RCCAs are divided into two groups; a control group of 29 RCCAs to compensate for reactivity changes due to power and temperature variations in the reactor core, and a shutdown group of 24 RCCAs that function with the control group to provide an adequate shutdown margin for the reactor.

The magnetic jack-type CRDMs are attached to the RCCA spider assemblies via a drive rod assembly and are used to insert and withdraw the RCCAs from the guide thimbles of the fuel assemblies. In addition to the drive rod assembly, each CRDM consists of a pressure housing that forms a part of the reactor coolant pressure boundary, a coil stack assembly, and a latch assembly. The coil stack assembly contains the following four magnetic coils outside the CRDM pressure housing: (a) the stationary gripper coil, (b) the movable gripper coil, (c) the lift coil, (d) the push-down coil and (e) the load-transfer coil. Details of a magnetic jack CRDM are shown in Figure 3.1-4 and the location of the CRDMs with respect to the reactor vessel and fuel assemblies is shown in Figure 3.1-5. The magnetic jack CRDMs are air-cooled.

The CVCS consists of several subsystems that perform the functions of maintaining RCS coolant inventory control, coolant chemistry and purity control, and reactivity control. Reactivity is adjusted by altering the concentration of soluble boron in the primary coolant. The various CVCS functions are accomplished by means of a continuous letdown of primary coolant for processing, and a corresponding makeup of purified coolant that has been chemically adjusted chemistry specifications and reactivity requirements. Details of the CVCS, focusing on the charging function, are discussed in Section 3.5.

3.1.3 System Operation

During normal power operation, the reactor is critical ($K_{eff} = 1$) at a power level dictated by steam demand from the main turbine. Reactivity control during normal operation is provided by two independent systems; the Control Rod System, which controls the movement of the RCCAs, and the Chemical and Volume Control System (CVCS), which controls the concentration of soluble boron in the primary coolant. The RCCAs provide reactivity control for the following:

- Shutdown
- Reactivity change due to reactor coolant temperature changes in the power range
- Reactivity changes associated with the power coefficient of reactivity
- Reactivity changes resulting from void formation

The boric acid concentration is varied to control long-term reactivity changes such as:

- Fuel depletion and fission product buildup
- Cold to hot zero power reactivity change
- Reactivity changes from intermediate-term fission products (i.e., xenon and samarium)
- Burnable poison depletion

A combination of burnable absorber assemblies with soluble boron is used to ensure a negative moderator temperature coefficient throughout the operating cycle.

The control rod system provides reactivity control by means of 53 multi-finger rod cluster control assemblies (RCCAs) that insert into guide thimbles in the fuel assemblies. The shutdown group consists of a total of 24 RCCAs that are withdrawn first during startup and are maintained in the fully withdrawn position during power operation. The control group consists of four banks (A, B, C, and D), with a total of 29 RCCAs that may be partially inserted into the core to control reactor power and axial power distribution. Each RCCA bank is operated and controlled as a unit.

The magnetic jack CRDMs provide rod motion in small steps. The CRDM coil stack assembly contains the following four magnetic coils outside the CRDM pressure housing: (a) the stationary gripper coil, (b) the movable gripper coil, (c) the lift coil, (d) the push-down coil, and (e) the load-transfer coil. The jack assembly contains solenoid-operated plungers and "gripper latches" inside the pressure housing which engage the grooved drive rod assembly to hold, insert, or withdraw the RCCA. The action of the CRDMs is programmed so that stationary and movable grippers are alternately engaged with the grooved drive shaft by the magnetic jack coils. The stationary gripper holds the drive shaft while the movable gripper is moving to its new position to raise or lower the RCCA through steps of about 3/8 inch. The Rod Control System can command single steps or continuous stepping to meet the demand of the Reactor Control System. Even at the fully withdrawn position, each finger of an RCCA is partially inserted into the guide thimbles of the respective fuel assembly to ensure proper RCCA / fuel assembly alignment. The CRDM coils are designed so that, upon loss of electrical power, the RCCA is released and falls by gravity into the core. The auxiliary rod holdout device coil is designed to hold the RCCA out of the core to expedite refueling operations.

The Reactor Protection System (RPS) initiates an automatic reactor trip when monitored plant conditions reach specified safety system setpoints. The RPS causes a reactor trip by opening the circuit breakers supplying power to the Rod Control System. As a result, all CRDMs are deenergized, allowing all control rods to fall into the reactor core. The impact energy of the RCCAs is dissipated by coil springs inside the spider body and a dashpot region at the bottom of the guide thimbles.

The CVCS continuously adjusts boron concentration in the primary coolant to compensate for long-term reactivity changes during normal operation. The CVCS integrates the process of adjusting the primary coolant boron concentration with the RCS coolant inventory control function. The principal CVCS flow paths and interfaces are discussed Section 3.5. The CVCS can take the reactor subcritical without use of control rods by significantly increasing the boron concentration in the primary coolant.

3.1.4 System Success Criteria

For the reactor core integrity function to be successful, the integrity of the fuel cladding and core geometry must be maintained during both normal and accident conditions. The accident conditions considered for the reactor core are (Ref. 1):

- Loss of external electrical load
- Startup of an inactive RCS loop
- Loss of coolant flow
- Loss of normal feedwater
- Loss of offsite power

Adequate cold shutdown margin can be provided by the following combinations (Ref. 1):

- All RCCAs in the fully inserted position.
- The CVCS supplying the minimum boric acid inventory and all RCCAs inserted except for the highest reactivity worth RCCA which is assumed stuck in a fully withdrawn position.
- The CVCS supplying the required boric acid inventory.

An adequate hot shutdown margin can be provided solely by the CVCS supplying the minimum boric acid inventory. The minimum number of RCCAs required to provide an adequate hot shutdown margin was not stated in the FSAR (Ref. 1).

3.1.5 Component Information

A. Core thermal and hydraulic parameters:
1. Core heat output: 3,250 MWt (11,090 x 10^6 Btu/hr)
2. Average power density: unknown
3. Effective coolant flow rate: 128.9 x 10^6 lbm/hr (total)
4. Coolant temperature: 530.2 °F (nominal inlet)
5. Coolant temperature rise in core: 66.8°F

B. Active core
1. Fuel: Sintered UO_2
2. Core equivalent diameter: 132.7 inches
3. Active fuel height: 143.4 inches
4. Total cross-sectional area: 96.06 ft^2
5. Fuel weight as UO_2: 216,600 lbs
6. Enrichment: 2.25 to 3.30% U-235 in 3 non-uniform regions
7. Average discharge burnup: 33,000 MWD/MTU

C. Fuel assemblies (193)
 1. Lattice configuration: 15 x 15
 2. Lattice dimensions: 8.426 in. x 8.426 in.
 3. Fuel rods per assembly: 204
 4. Guide thimbles per assembly: 20
 5. Fuel rod cladding: Zircaloy-4

D. Rod cluster control assemblies (53, all full-length assemblies)
 1. Control rods per assembly: 20
 2. Neutron absorber material: Hafnium
 3. RCCA cladding: Type 304 stainless steel

E. Burnable poison rod assemblies (1,436)
 1. Poison rods per assembly: 8 to 20 (varies)
 2. Burnable poison material: Borosilicate glass
 3. Burnable poison rod cladding: Type 304 stainless steel

F. CVCS boron concentration
 1. Refueling, Keff = 0.83: 2000 ppm
 2. Shutdown, Keff = 0.99, RCCA's out, no xenon, cold: 1408 ppm
 3. Hot, full power, Keff = 1, RCCAs out, no xenon: 1,168 ppm
 4. Hot, full power, Keff = 1, RCCAs out, equilibrium xenon: 880 ppm
 5. Boron reduction with fuel burnup: unknown

3.1.6 <u>Support Systems and Interfaces</u>

A. Control Signals
 1. Automatic
  a. The Reactor Control System enables the plant to follow load changes automatically at power levels above 15%. This system automatically regulates the positions of the control banks to maintain coolant average temperature (T_{avg}) in the prescribed band. Typically Westinghouse plants operate with a constant cold leg temperature (T_{cold}), resulting in T_{avg} rising as a function of power.
  b. The Rod Control System receives rod speed and direction signals from the Reactor Control System (see section 7.3).
  c. The Reactor Control System imposes rod withdrawal interlocks and inhibits main turbine load changes when specified limits are reached.
  d. The Reactor Protection System automatically initiates a reactor scram which releases all RCCAs when specified parameters exceed their trip setpoints or on loss of power to the RPS (see Section 3.9).
 2. Remote Manual
  a. Rod position can be controlled manually.
  b. A reactor scram can be initiated by remote manual means from the control room, the remote shutdown panel, and at the RPS breakers.

B. Motive Power
 1. The CRDMs are powered from non-Class 1E motor-generator sets.
 2. The Reactor Control System and the Rod Control System are powered from non-Class 1E sources.
 3. The CVCS motor-driven pumps and motor-operated valves are Class 1E AC loads that can be supplied from the standby diesel generators as described in Section 3.7.

C. Other

The CRDM magnetic jack coils are air-cooled by the CRDM Ventilation Subsystem (see Section 3.8).

3.1.7 Section 3.1 References

1. Zion 1 & 2 Final Safety Analysis Report, Sections 3.1, 3.2, 4.1, and 9.2.

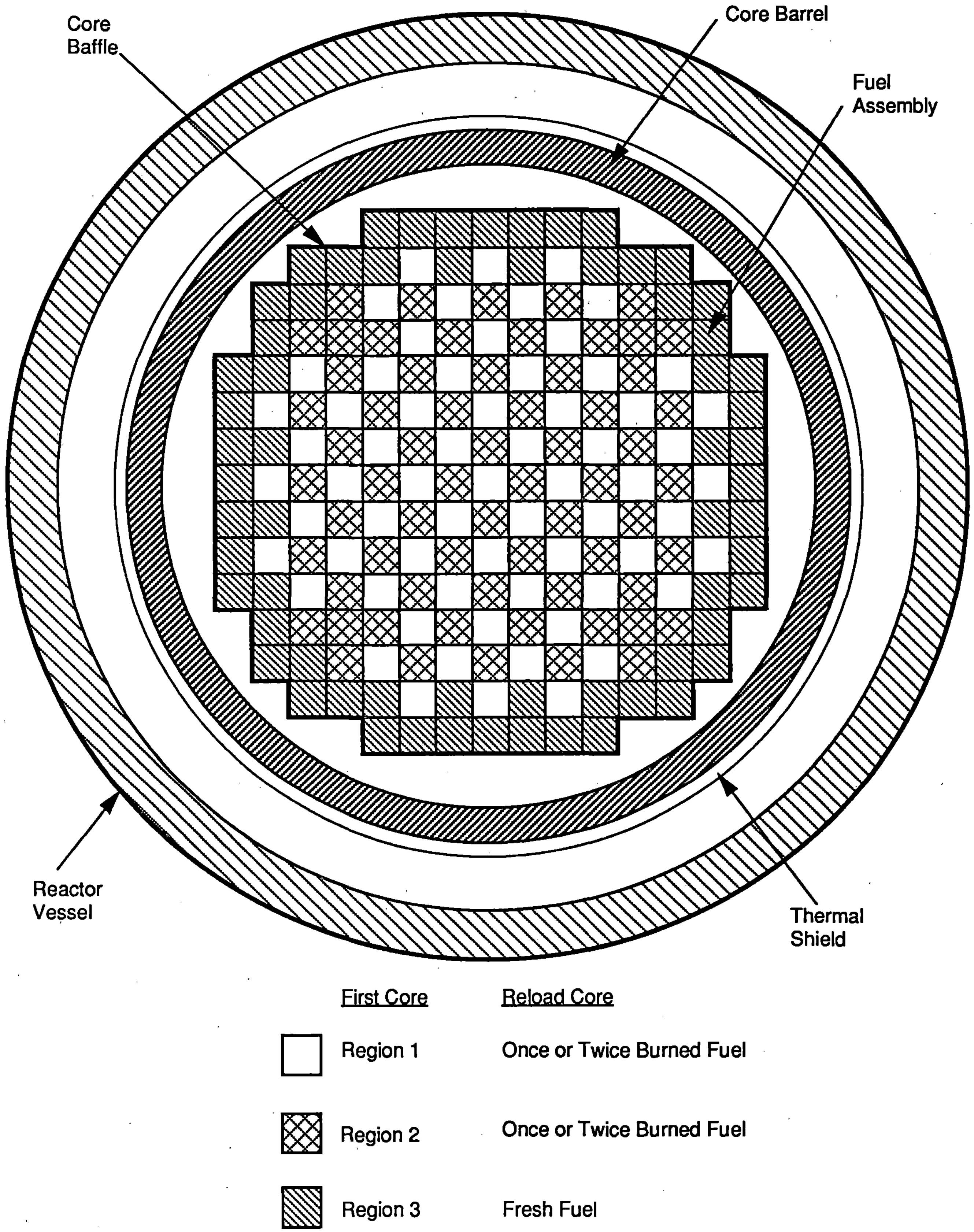


Figure 3.1-1. General Arrangement of a Westinghouse 193 Fuel Assembly Core

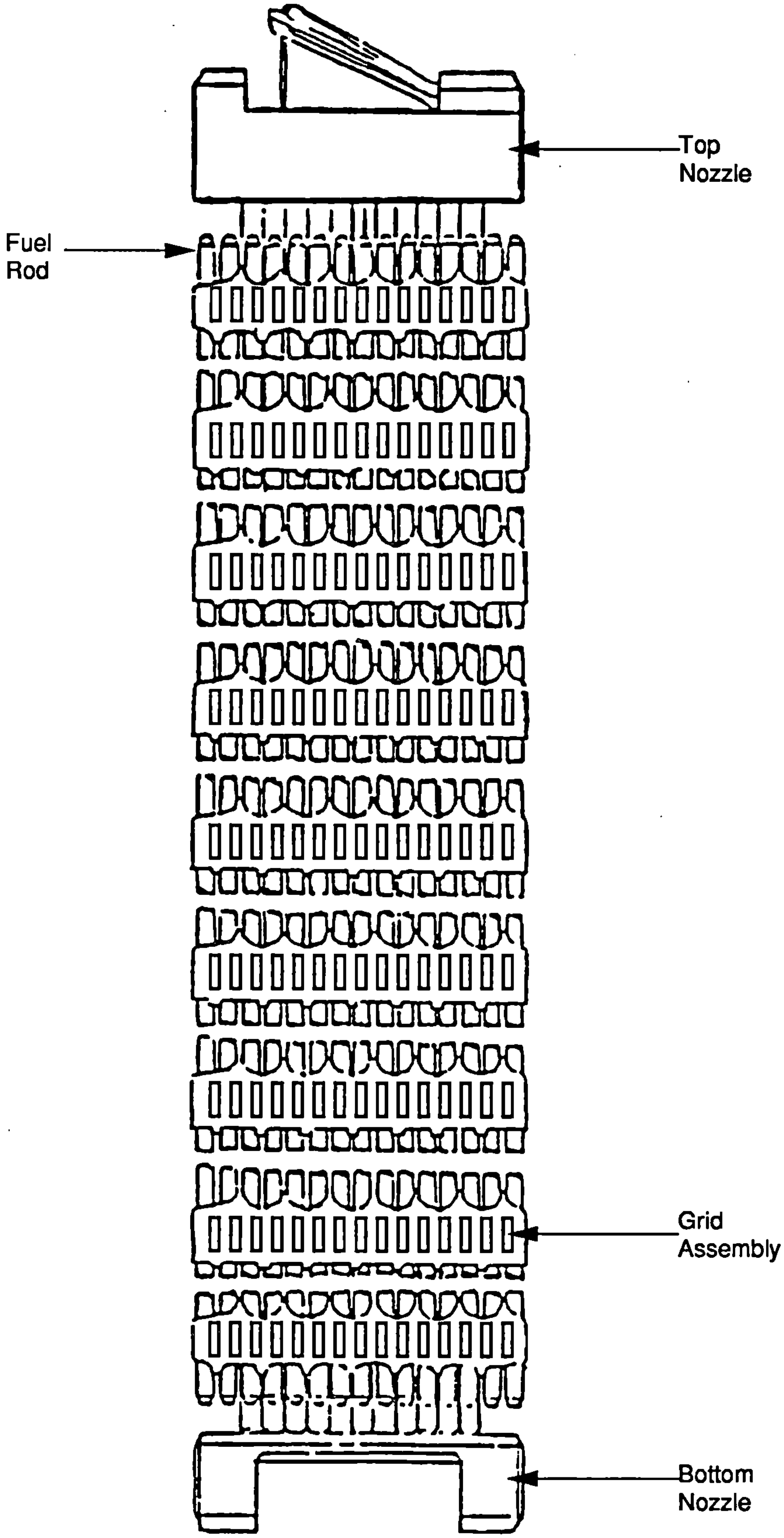


Figure 3.1-2. Westinghouse 15 x 15 Fuel Assembly

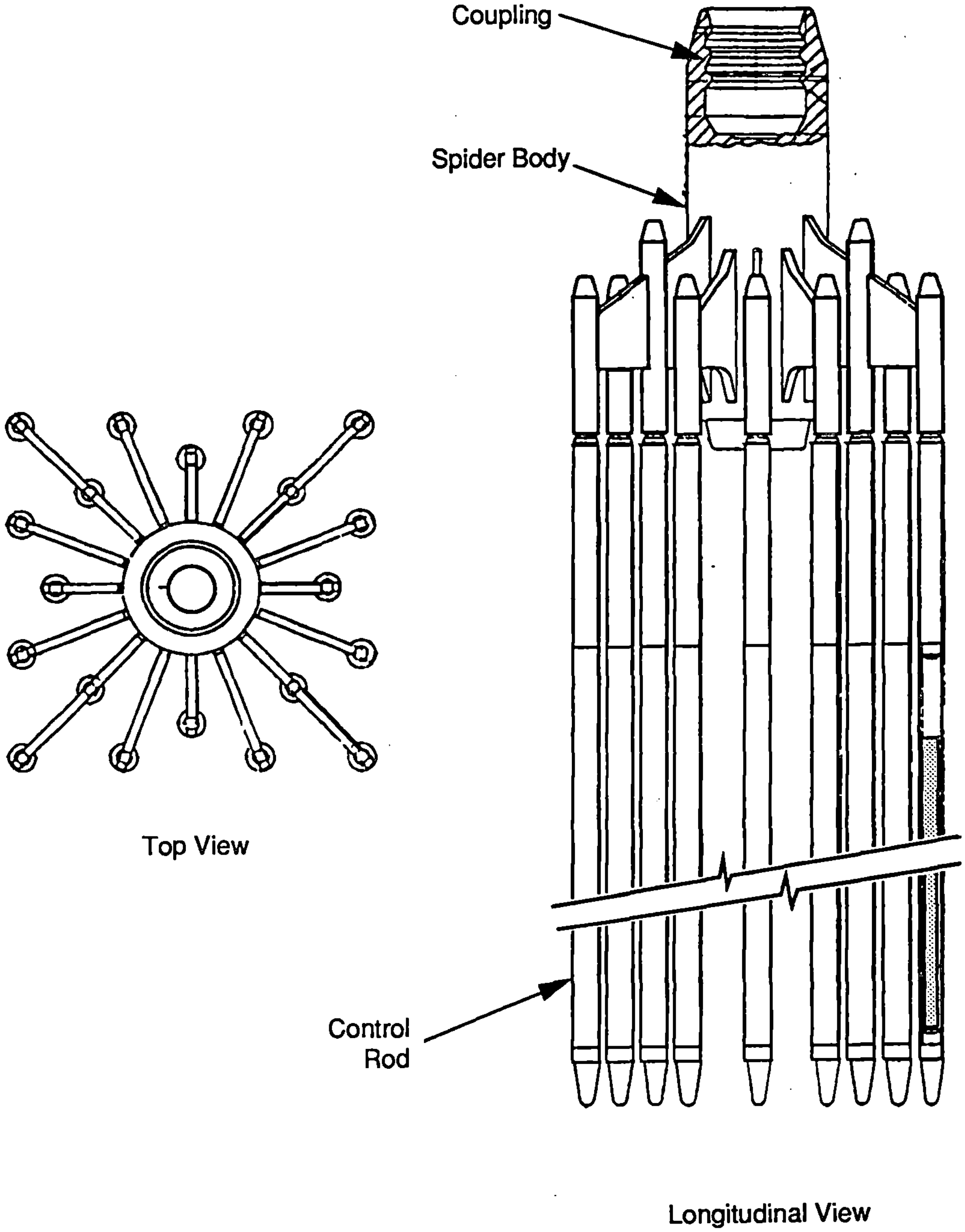


Figure 3.1-3 Westinghouse Rod Cluster Control Assembly (RCCA, Typical for 15 x15 Fuel Assembly)

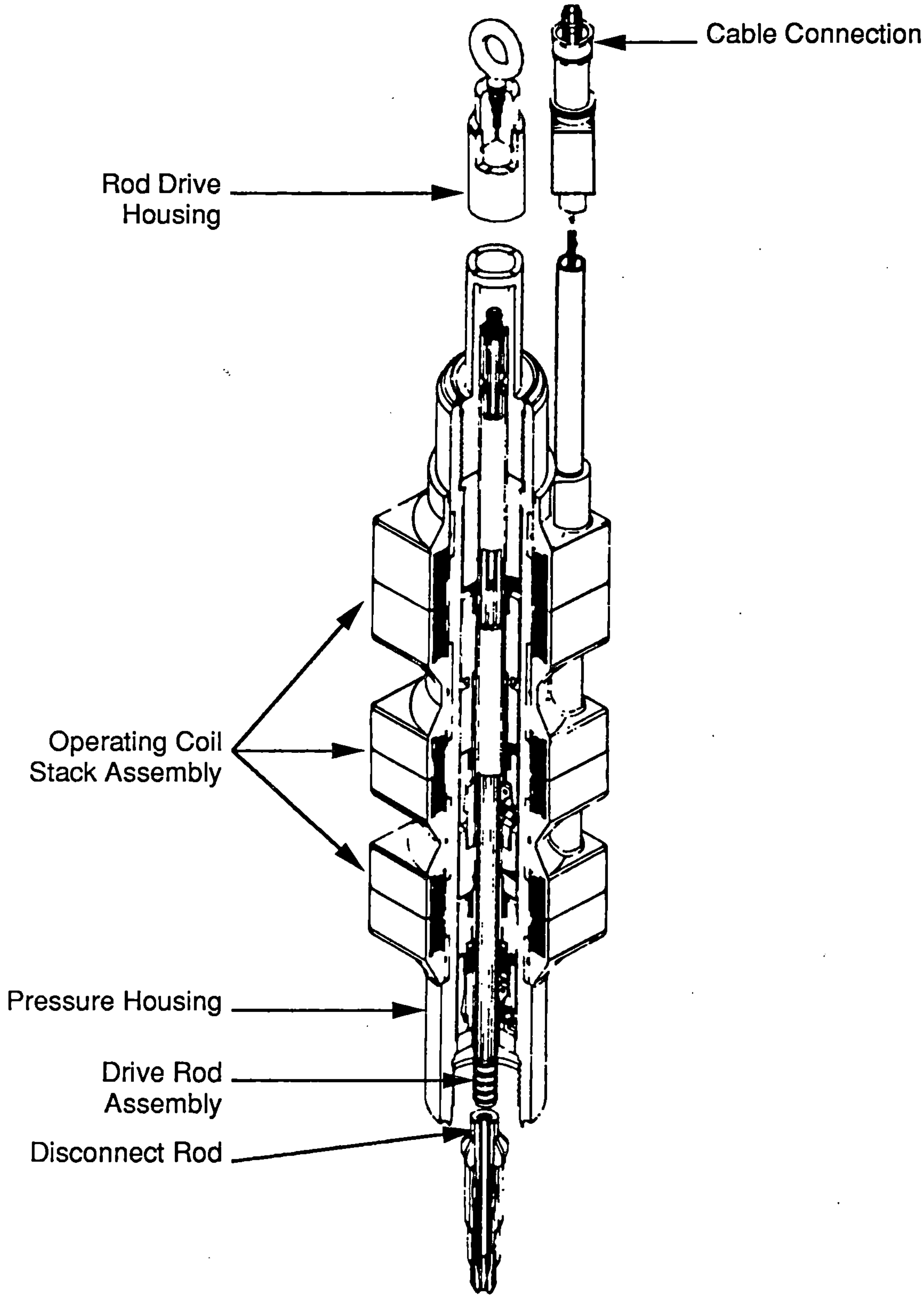


Figure 3.1-4. Details of a Westinghouse Magnetic Jack Full-Length Control Rod Drive Mechanism

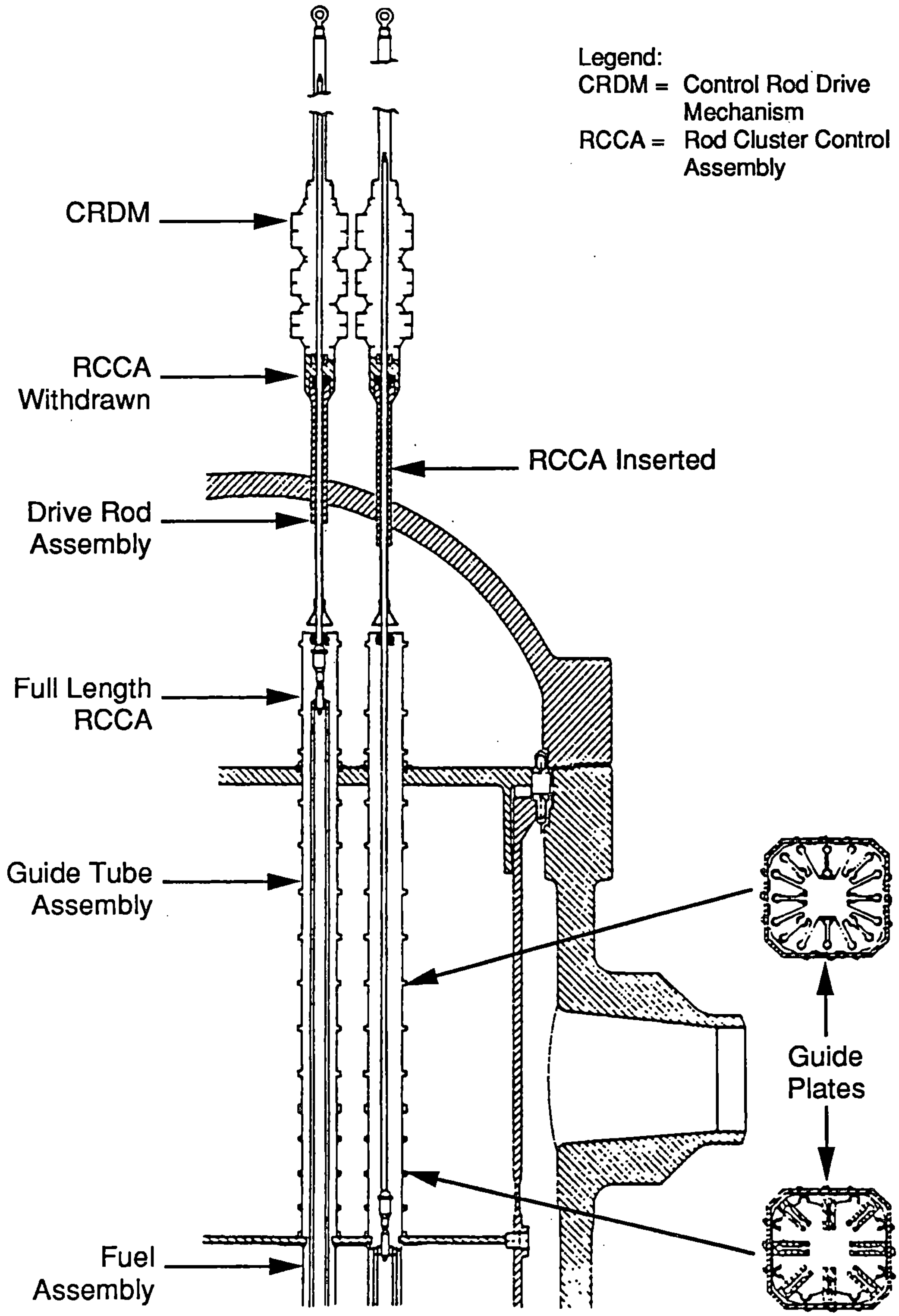


Figure 3.1-5. General Arrangement of Westinghouse CRDMs and RCCAs

3.2 REACTOR COOLANT SYSTEM (RCS)

3.2.1 System Function

The RCS transfers heat from the reactor core to the secondary coolant system via the steam generators. The RCS pressure boundary also establishes a boundary against the uncontrolled release of radioactive material from the reactor core and primary coolant.

3.2.2 System Definition

The RCS includes: (a) the reactor vessel, (b) four parallel reactor coolant loops, (c) reactor coolant pumps, (d) the primary side of the steam generators (e) a pressurizer, and (f) connected piping out to a suitable isolation valve boundary. Simplified diagrams of the RCS and important system interfaces are shown in Figures 3.2-1 and 3.2-2. An isometric drawing of a four-loop Westinghouse RCS is shown in Figure 3.2-3.

The general arrangement of the reactor vessel and internals for a Westinghouse 4-loop plant is shown in Figure 3.2-4, and a series 51 steam generator is shown in Figure 3.2-5.

A summary of data on selected RCS Components is presented in Table 3.2-1. RCS pressure boundary interfaces shown in this Sourcebook are listed in Table 3.2-2.

3.2.3 System Operation

During power operation, circulation in the RCS is maintained by one reactor coolant pump in each of the four reactor coolant loops. RCS pressure is maintained within a prescribed band by the combined action of pressurizer heaters and pressurizer spray. RCS coolant inventory is measured by pressurizer water level which is maintained within a prescribed band by the chemical and volume control system (CVCS).

At power, core heat is transferred to secondary coolant (feedwater) in the steam generators. The heat transfer path to the ultimate heat sink is completed by the main steam and power conversion system and the circulating water system.

Following a transient or small LOCA (if RCS inventory is maintained), reactor core heat is still transferred to secondary coolant in the steam generators. Flow in the RCS is maintained by the reactor coolant pumps or by natural circulation. The heat transfer path to the ultimate heat sink can be established by using the secondary steam relief system to vent main steam to atmosphere when the power conversion and circulating water systems are not available. If reactor core heat removal by this alternate path is not adequate, the RCS pressure will increase and a heat balance will be established in the RCS by venting steam or reactor coolant to the quench tank through the pressurizer relief valves. There are two power-operated relief valves (each in series with a motor-operated block valve) and three safety valves on the pressurizer. A continued inability to establish adequate heat transfer to the steam generators will result in a LOCA-like condition (i.e., continuing loss of reactor coolant through the pressurizer relief valves). Repeated cycling of these relief valves has resulted in valve failure (i.e., relief valve stuck open).

Following a large LOCA, reactor core heat is dumped to the containment as reactor coolant and ECCS makeup water spills from the break. For a short period, the containment can act as a heat sink; however, the containment cooling systems must operate in order to complete a heat transfer path to the ultimate heat sink.

3.2.4 System Success Criteria

The RCS "success" criteria can be represented in terms of LOCA and transient mitigation, as follows:

- An unmitigatable LOCA is not initiated.
- If a mitigatable LOCA is initiated, then LOCA mitigating systems are successful.
- If a transient is initiated, then either:

- RCS integrity is maintained and transient mitigating systems are successful, or
- RCS integrity is not maintained, leading to a LOCA-like condition (i.e. stuck-open safety or relief valve, reactor coolant pump seal failure), and LOCA mitigating systems are successful.

3.2.5 Component Information

A. RCS
1. Total system volume, including pressurizer: 12,710 ft^3
2. Normal operating pressure: 2235 psig

B. Pressurizer
1. Water volume, full power: 1080 ft^3
2. Steam volume, full power: 720 ft^3

C. Reactor Coolant Pumps (4)
1. Rated flow: 87,500 gpm @ 282 ft. head
2. Type: Vertical single-stage mixed flow

D. Power-Operated Relief Valves (2)
1. Set pressure: 2335 psig
2. Relief capacity: 210,000 lb/hr (each)

E. Safety Valves (3)
1. Set pressure: 2485 psig
2. Relief capacity: 420,000 lb/hr (each)

F. Steam Generators (4)
1. Type: Vertical shell and U-Tube
2. Heat Transfer Rate: 2.772 x 10^9 Btu/hr

3.2.6 Support Systems and Interfaces

A. Motive Power
1. The reactor coolant pumps are supplied from Non-Class 1E switchgear.
2. The pressurizer heaters are Class 1E AC loads that can be supplied from the standby diesel generators as described in Section 3.10.

B. Reactor Coolant Pump Seal Injection Water System
The chemical and volume control system supplies seal water to cool the reactor coolant pump shaft seals and to maintain a controlled in leakage of seal water into the RCS (Ref. 1). Loss of seal water flow may result in RCS leakage through the pump shaft seals which will resemble a small LOCA.

3.2.7 Section 3.2 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 4.0.

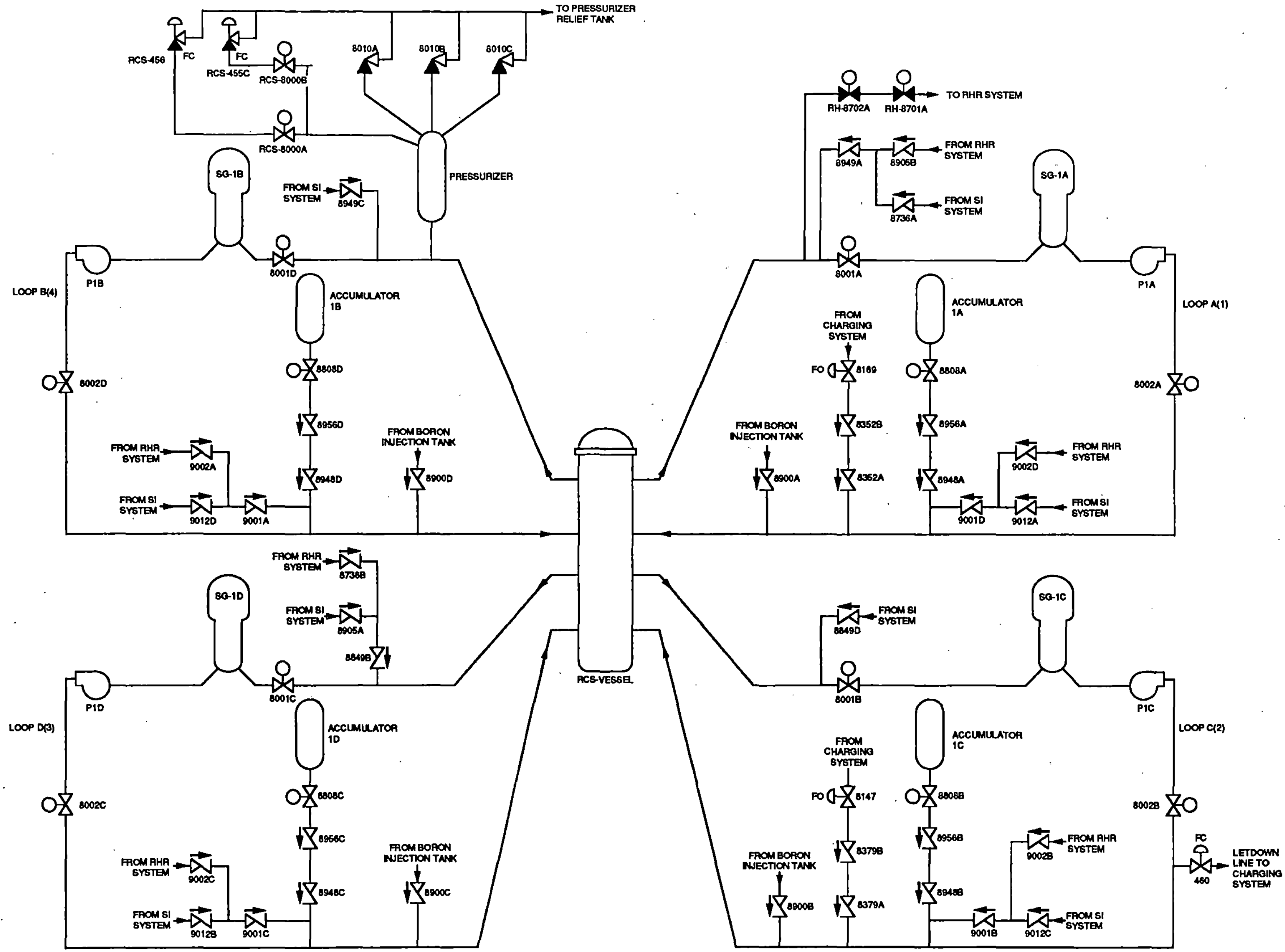


Figure 3.2-1. Zion 1 Reactor Coolant System

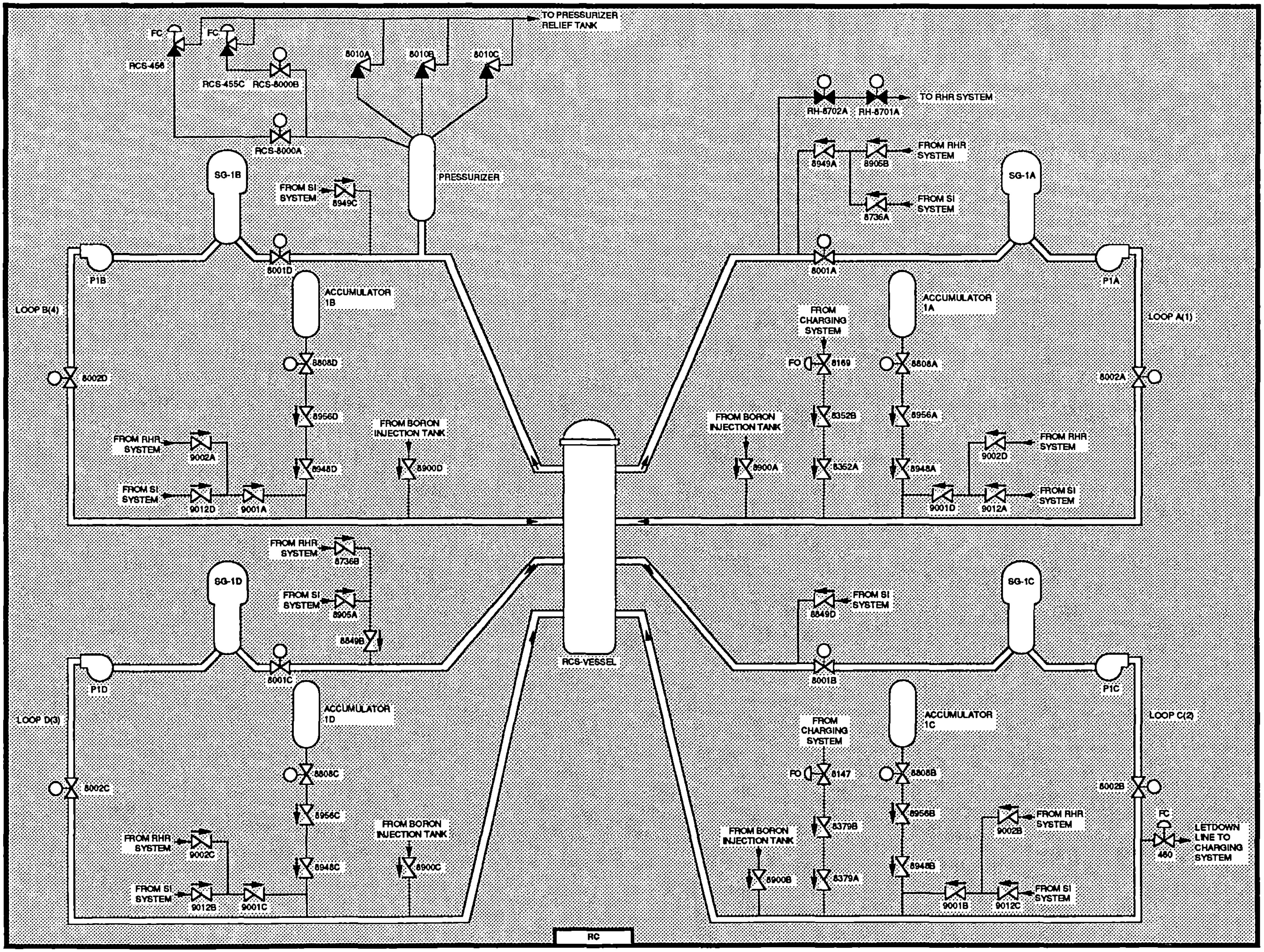


Figure 3.2-2. Zion 1 Reactor Coolant System Showing Component Locations

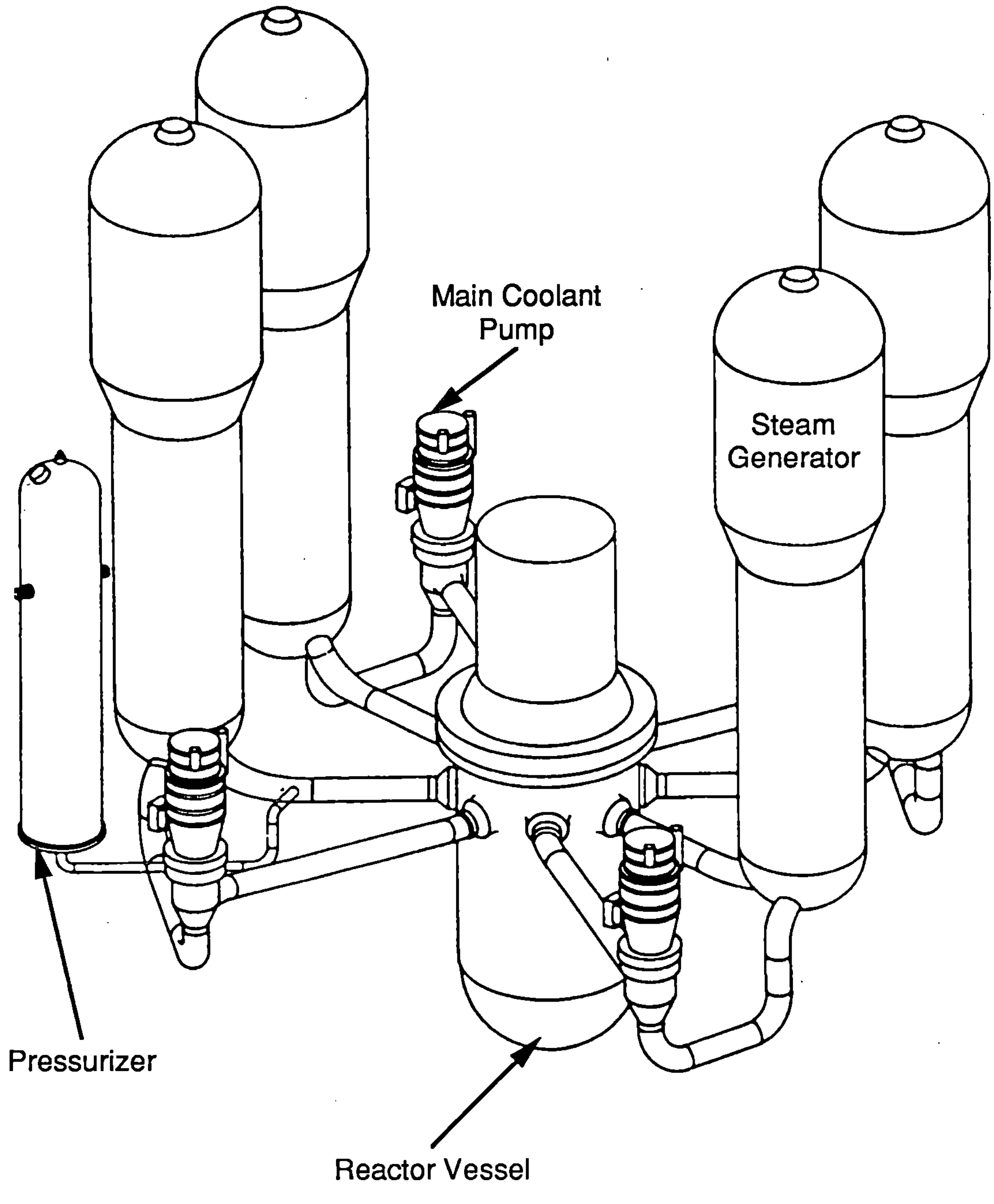


Figure. 3.2-3. Isometric View of a 4-Loop Westinghouse RCS

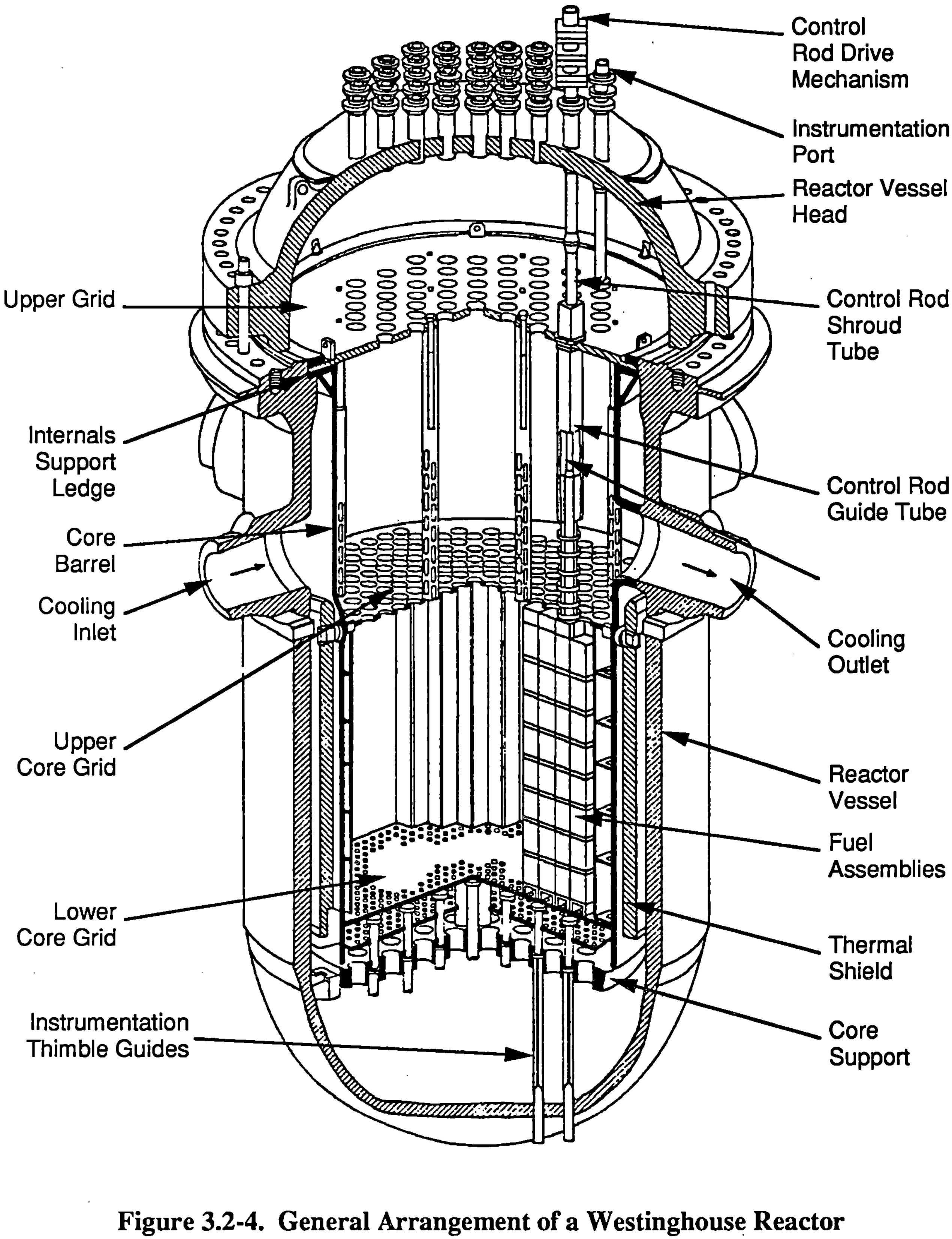


Figure 3.2-4. General Arrangement of a Westinghouse Reactor Vessel and Internals

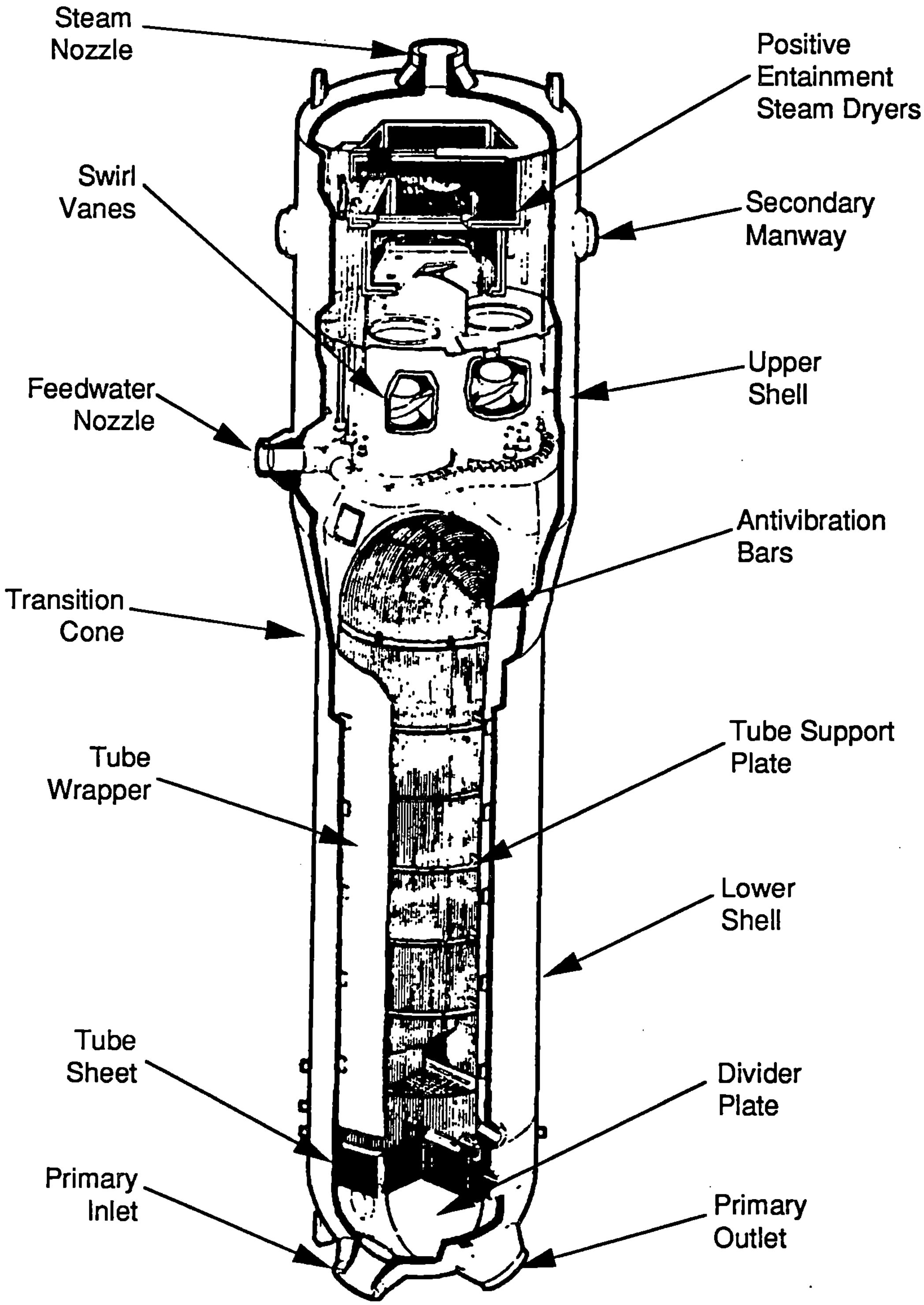


Figure 3.2-5. Westinghouse U-Tube Steam Generator (Typical of Series 33, 44 and 51 Steam Generators)

Table 3.2-1. Zion 1 Reactor Coolant System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
SG-A	SG	RC				
SG-B	SG	RC				
SG-C	SG	RC				
SG-D	SG	RC				
SI-8800A	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800B	MOV	RC	MCC-1393A	480	1393A	AC/19
SI-8800C	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800D	MOV	RC	MCC-1372	480	1372	AC/17
SI-8800A	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800B	MOV	RC	MCC-1393A	480	1393A	AC/19
SI-8800C	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800D	MOV	RC	MCC-1372	480	1372	AC/17
SI-SUMP	TANK	RC				
P1A	MDP	RC	UNKNOWN	UNKNOWN	UNKNOWN	NON-CLASS 1E
P1B	MDP	RC	UNKNOWN	UNKNOWN	UNKNOWN	NON-CLASS 1E
P1C	MDP	RC	UNKNOWN	UNKNOWN	UNKNOWN	NON-CLASS 1E
P1D	MDP	RC	UNKNOWN	UNKNOWN	UNKNOWN	NON-CLASS 1E
RCS-455C	NV	RC				
RCS-456	NV	RC				
RCS-8000A	MOV	RC	MCC-1393A	480	1393A	AC/19
RCS-8000B	MOV	RC	MCC-1393A	480	1393A	AC/19
RCS-VESSEL	RV	RC				
RH-8701	MOV	RC	MCC-1391	480	SWGRM149	AC/19
RH-8702	MOV	RC	MCC-1381A	480	SWGRM148	AC/18

Table 3.2-2. Zion 1 RCS Pressure Boundary Interfaces for Systems Covered in This Sourcebook

Line description	Interface with RCS	Line size (in.)	Direction of flow (Rel. to RCS)	RCS interface valve configuration	Remarks
RCS hot leg loops 1, 2, 3, & 4	N/A	29	N/A	See Figure 3.2-2	
RCS cold leg loops 1, 2, 3,& 4	N/A	27.5	N/A	See Figure 3.2-2	
RCS pressurizer surge	RCS hot leg loop 4	14	Out	See Figure 3.2-2	
RCS pressurizer safety valves (3)	Top of pressurizer	6	Out	See Figure 3.2-2	
RCS pressurizer PORVs (2)	Top of pressurizer	6	Out	See Figure 3.2-2	a
CVCS letdown	RCS cold leg loop 2	3	Out	See Figure 3.2-2	
CVCS boron injection	RCS cold leg loops 1, 2, 3, & 4	1.5	Out	See Figure 3.2-2	
CVCS charging	RCS cold leg loops 1 & 2	3	In	See Figure 3.2-2	
Shutdown cooling (RHR) suction	RCS hot leg loop 1	14	Out	See Figure 3.2-2	
ECCS cold leg injection	RCS cold leg loops 1, 2, 3, & 4	10	In	See Figures 3.2-2 and 3.4-6	b
ECCS hot leg injection	RCS hot leg loops 1, 2, 3, & 4	8	In	See Figures 3.2-2 and 3.4-7	c

Notes:

a. A single 6" header from the RCS pressurizer serves two 3" PORV trains to the pressurizer relief tank.

b. The 8" RHR and the 2" SI join to form an 8" header and then join the 10" line from the Accumulator to form a 10" header to the RCS cold legs 1, 2, 3, & 4.

c. The 8" RHR and the 2" SI join and form an 8" header to the RCS hot legs 1 and 3

3.3 AUXILIARY FEEDWATER SYSTEM (AFWS) AND SECONDARY STEAM RELIEF SYSTEM (SSRS)

3.3.1 System Function

The AFWS provides a source of feedwater to the steam generators to remove heat from the reactor coolant system (RCS) when: (a) the main feedwater system is not available, and (b) RCS pressure is too high to permit heat removal by the residual heat removal (RHR) system. The Secondary Steam Relief System (SSRS) provides a steam vent path from the steam generators to the atmosphere, thereby completing the heat transfer path to an ultimate heat sink when the main steam and power conversion systems are not available. Together, the AFWS and SSRS constitute an open-loop fluid system that provides for heat transfer from the RCS following transients and small-break LOCAs.

3.3.2 System Definition

The AFWS consists of two subsystems. One subsystem utilizes a turbine-driven pump, the other utilizes two motor-driven pumps. Both subsystems can deliver feedwater to all four steam generators. A normally closed crosstie exists between the two subsystems. The turbine-driven pump can be supplied with steam from either steam line A or D. The water supply for the pumps is the condensate storage tank (CST). As a backup, the service water system can supply water to the AFW pumps suction.

The SSRS consists of five safety valves and one pneumatically operated atmospheric dump valve on each of the four main steam lines.

Simplified drawings of the AFWS and the SSRS are shown in Figures 3.3-1 and 3.3-2. A summary of data on selected AFWS components is presented in Table 3.3-1.

3.3.3 System Operation

During normal operation the AFWS is in standby. The motor-driven pumps are started on either a low-low level in any steam generator, a safety injection signal, or a loss of electrical power. The turbine-driven pump will start on either a low-low level in any two steam generators or a complete loss of electrical power.

Suction to the pumps is provided by the CST, with the service water system as a back-up. The capacity of the CST is 500,000 gallons. A minimum of 170,000 gallons are required for 2 hours at hot standby, followed by 4 hours of cooldown at 50°F/hour. An alarm is provided on the CST to indicate that the 170,000 gallon level has been reached and that makeup to the tank is required. It should be noted that for a single motor-driven pump to maintain full flow (450 gpm) over the 8 hour extended hot shutdown period, 216,000 gallons are required. However, flow can be throttled as the decay heat is reduced.

All three pumps have sufficient head to deliver their rated capacity to the steam generators at the safety valve setpoint. At any pressure condition, steam from either line A or D will be adequate for operation of the turbine-driven pump.

Auxiliary feedwater control is accomplished manually by means of an air-operated control valve in each line to the steam generators. Should the air supply fail, motor-operated valves can be utilized for flow control.

3.3.4 System Success Criteria

For the decay heat removal function to be successful, both the AFWS and the SSRS must operate successfully. The AFWS success criteria are the following:

- Makeup to any two of four steam generators provides adequate decay heat removal from the Reactor Coolant System (Ref. 1).

- The turbine driven pump or either of the motor driven pumps can provide adequate flow.

- The condensate storage tank or the service water system is an adequate source of water for the AFWS pumps.

3.3.5 Component Information

A. Motor-driven AFWS pumps 1B, 1C
   1. Rated flow: 450 gpm @ 3099 ft. head (1344 psid)
   2. Rated capacity: 100%
   3. Type: Horizontal centrifugal

B. Turbine-driven AFWS pump 1A
   1. Rated flow: 900 gpm @ 3099 ft. head (1344 psid)
   2. Rated capacity: greater than 100%
   3. Type: Horizontal centrifugal

C. Condensate Storage Tank
   1. Capacity: 500,000 gallons

3.3.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      The AFW motor-driven pumps are automatically actuated on either a low-low level in any steam generator, a safety injection signal, or a loss of electrical power. The AFW turbine-driven pump is automatically actuated on either a low-low level in any two steam generators or a complete loss of electrical power.
   2. Remote manual
      The AFWS can be operated from the control room.

B. Motive Power
   1. The motor driven AFWS pumps and motor operated valves are Class 1E loads that can be supplied from the standby diesel generators as described in Section 3.10.
   2. The turbine-driven pump is supplied with steam from the main steam lines of either steam generator A or D upstream of the main steam line isolation valves. The power and controls for the steam supply valves are assumed to be supplied from the Class 1E DC system.

C. Other
   1. Lubrication and cooling are provided locally for the AFWS pumps.
   2. Systems for AFWS pump room cooling have not been identified.

3.3.7 Section 3.3 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 6.7

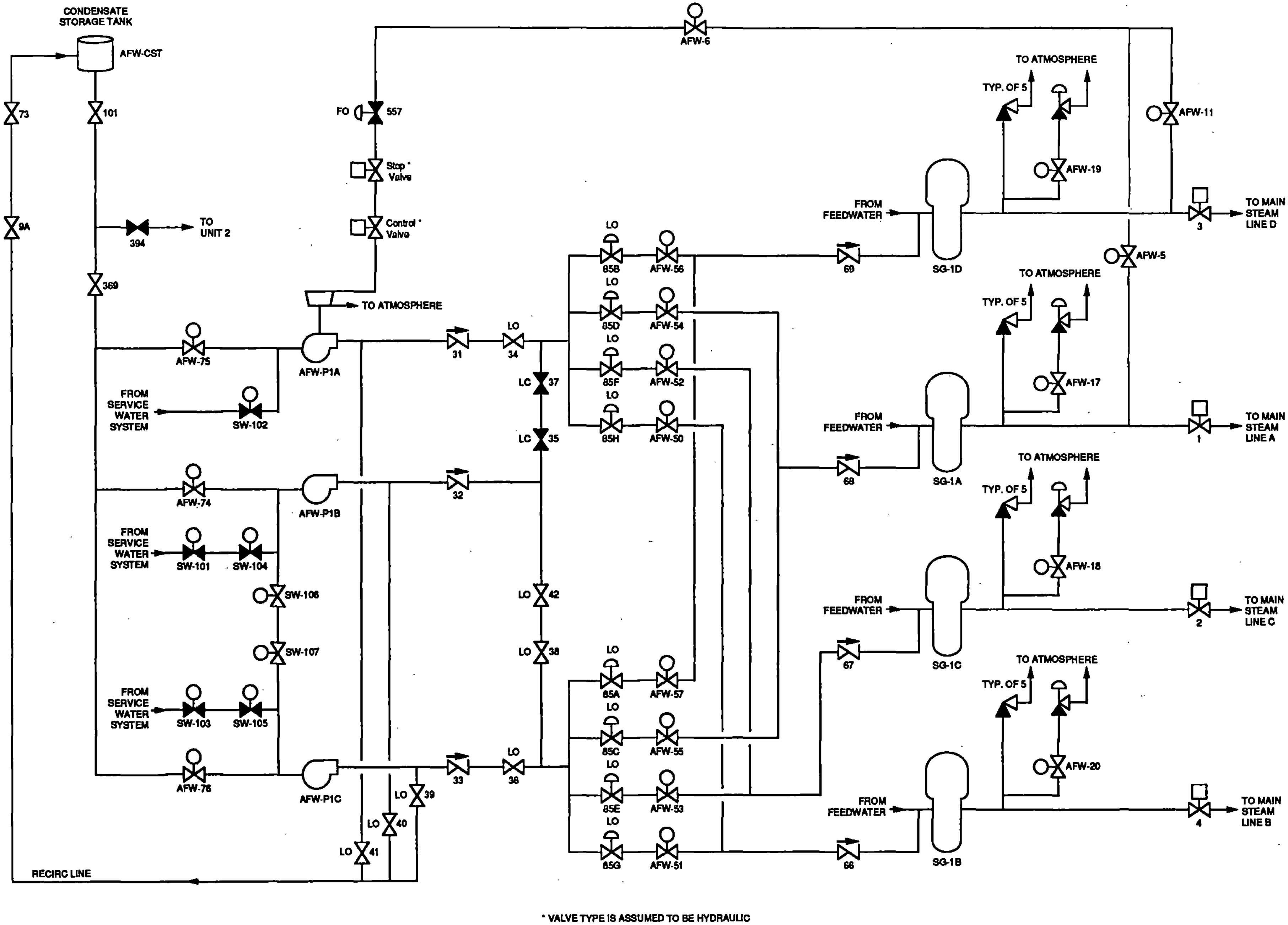
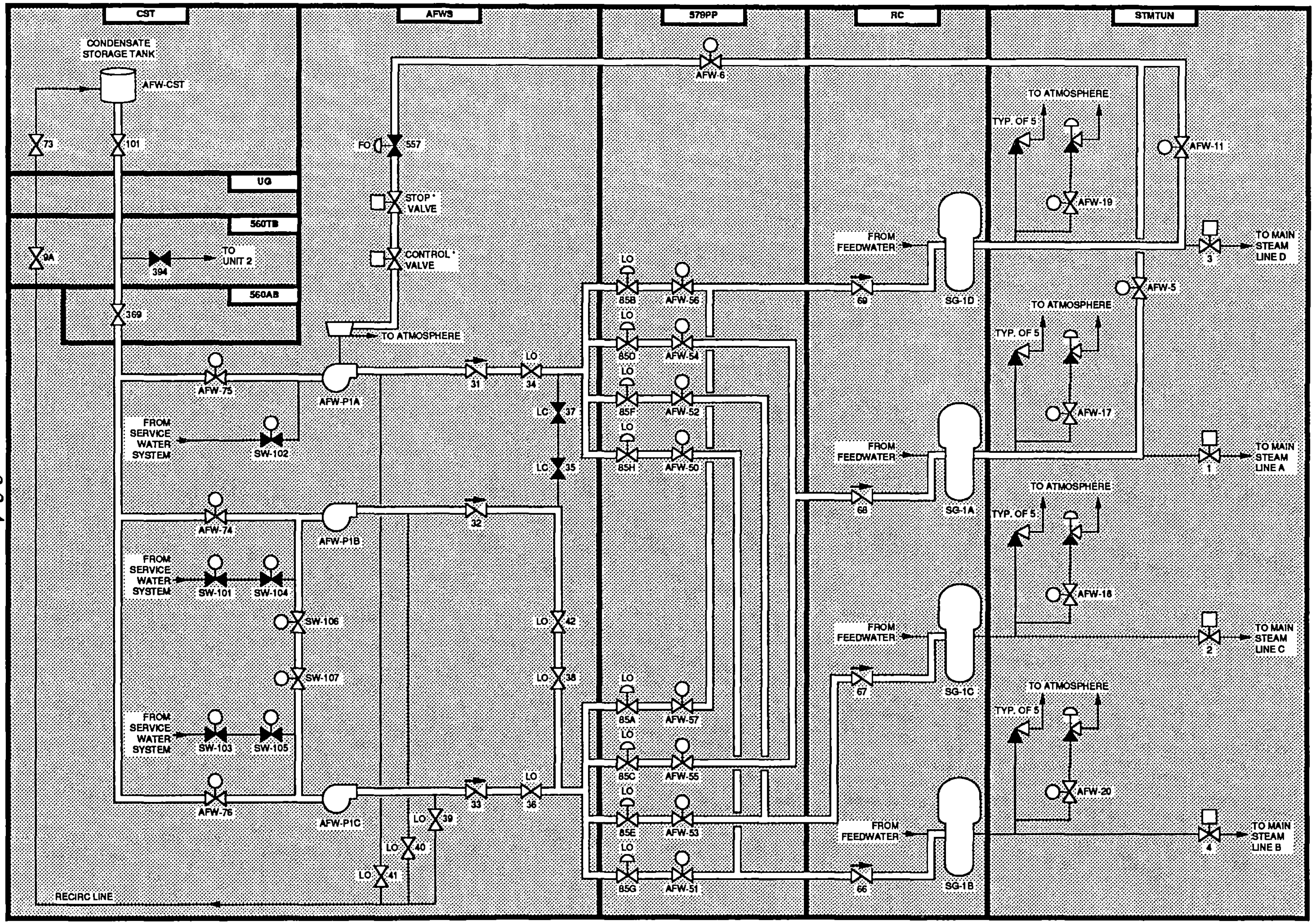


Figure 3.3-1. Zion 1 Auxiliary Feedwater System



* VALVE TYPE IS ASSUMED TO BE HYDRAULIC

Figure 3.3-2. Zion 1 Auxiliary Feedwater System Showing Component Locations

Table 3.3-1. Zion 1 Auxiliary Feedwater System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
AFW-11	MOV	STMTUN	MCC-1391	480	SWGRM149	AC/19
AFW-17	MOV	STMTUN	MCC-1371	480	SWGRM147	AC/17
AFW-18	MOV	STMTUN	MCC-1381B	480	SWGRM148	AC/18
AFW-19	MOV	STMTUN	MCC-1391	480	SWGRM149	AC/19
AFW-20	MOV	STMTUN	MCC-1391	480	SWGRM149	AC/19
AFW-5	MOV	STMTUN	MCC-1371	480	SWGRM147	AC/17
AFW-50	MOV	579PP	MCC-1383A	480	1383A	AC/18
AFW-51	MOV	579PP	MCC-1393A	480	1393A	AC/19
AFW-52	MOV	579PP	MCC-1393C	480	1393C	AC/19
AFW-53	MOV	579PP	MCC-1383A	480	1383A	AC/18
AFW-54	MOV	579PP	MCC-1393A	480	1393A	AC/19
AFW-55	MOV	579PP	MCC-1383A	480	1383A	AC/18
AFW-56	MOV	579PP	MCC-1383A	480	1383A	AC/18
AFW-57	MOV	579PP	MCC-1393C	480	1393C	AC/19
AFW-6	MOV	579PP	MCC-1381A	480	SWGRM148	AC/18
AFW-74	MOV	AFWS	MCC-1383A	480	1383A	AC/18
AFW-75	MOV	AFWS	MCC-1393B	480	1393B	AC/18
AFW-76	MOV	AFWS	MCC-1393A	480	1393A	AC/19
AFW-CST	TANK	CST				
AFW-P1A	TDP	AFWS				
AFW-P1B	MDP	AFWS	BUS-148	4160	SWGRM148	AC/18
AFW-P1C	MDP	AFWS	BUS-149	4160	SWGRM149	AC/19
SG-A	SG	PC				
SG-B	SG	PC				
SG-C	SG	PC				
SG-D	SG	PC				
SW-101	MOV	AFWS	MCC-1383A	480	1383A	AC/18
SW-102	MOV	AFWS	MCC-1393A	480	1393A	AC/19
SW-103	MOV	AFWS	MCC-1393A	480	1393A	AC/19
SW-104	MOV	AFWS	MCC-1383A	480	1383A	AC/18
SW-105	MOV	AFWS	MCC-1393C	480	1393C	AC/19

Table 3.3-1. Zion 1 Auxiliary Feedwater System Data Summary
for Selected Components (Continued)

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
SW-106	MOV	AFWS	MCC-1383A	480	1383A	AC/18
SW-107	MOV	AFWS	MCC-1383A	480	1383A	AC/18

3.4 EMERGENCY CORE COOLING SYSTEM (ECCS)

3.4.1 System Function

The ECCS, or Safety Injection System (SIS), is an integrated set of subsystems that perform emergency coolant injection and recirculation functions to maintain reactor core coolant inventory and adequate decay heat removal following a LOCA. The coolant injection function is performed during a relatively short-term period after LOCA initiation, followed by realignment to a recirculation mode of operation to maintain long-term, post-LOCA core cooling. Heat from the reactor core is transferred to the containment. The heat transfer path to the ultimate heat sink is completed by the containment heat removal systems.

3.4.2 System Definition

The emergency coolant injection (ECI) function is performed by the following subsystems:

- Accumulators
- Charging System (CVCS, see Section 3.5)
- Safety Injection System
- Residual Heat Removal System

There are four accumulators, one attached to each cold leg, that discharge their contents when RCS pressure drops below the tank pressure. The charging system's two centrifugal charging pumps pump through the boron injection tank to deliver borated water to the RCS. The charging pumps can also inject into the RCS through the normal charging path via the regenerative heat exchanger. The safety injection system consists of two motor driven pumps that deliver water to an injection header. The header directs flow to the four cold legs. The RHR system consists of two motor driven pumps that deliver water to the four cold legs. During the recirculation phase the RHR pumps can also deliver water to the suction of the charging and safety injection pumps. The RHR pumps also provide the shutdown cooling function. The Refueling Water Storage Tank (RWST) is the water source for the ECCS pumps during the injection phase. During recirculation the RHR pumps take suction on the containment sump.

Simplified drawings of the safety injection system in the injection and high pressure recirculation modes are shown in Figures 3.4-1 through 3.4-3. The RHR system in the ECCS low pressure injection, low pressure recirculation, and high pressure recirculation modes are shown in Figures 3.4-4 through 3.4-7. The charging system is discussed in Section 3.5. A summary of data on selected ECCS components is presented in Table 3.4-1.

3.4.3 System Operation

During normal operation, the ECCS is in standby. The ECCS pumps are automatically actuated by any of the following Safety Injection Signals (Ref. 1):

- Low pressurizer pressure coincident with low pressurizer water level
- High containment pressure
- High differential pressure between any two steam lines outside containment
- High steam flow in two of four lines in coincidence with either low T_{avg} or low steam line pressure
- Manual actuation

The accumulators constitute a passive injection system, discharging their contents automatically when RCS pressure drops below the tank pressure. Sufficient borated water is supplied in the four tanks to rapidly fill the volume outside of the core barrel below the nozzles, the bottom plenum, and a portion of the core with the contents of one tank assumed to be lost through the break. During injection, the charging, safety injection, and RHR pumps take suction on the RWST and deliver borated water to the four cold legs. The relative importance of the charging and safety injection pumps is increased for small breaks when the RCS is still at high pressure, while the RHR pumps are important in responding to large breaks.

When the RWST reaches a low level alarm setpoint, the operator takes action to begin the recirculation phase. This phase of operation has two modes, cold leg recirculation and hot leg recirculation. In both modes the RHR pumps take suction on the containment sump and deliver water through the RHR heat exchangers directly to the RCS and to the suction of the charging and safety injection pumps. Initially, the discharge of these three sets of pumps flows to the same cold leg injection points used during the injection phase. Later, the safety injection and RHR pumps are realigned to deliver to two separate hot leg injection points. The switch to hot leg recirculation is made in order that subcooling of the core may be completed.

3.4.4 System Success Criteria

The success criteria for the ECCS is not clearly defined in the Zion 1 and 2 FSAR (Ref. 1). LOCA mitigation requires both the emergency coolant injection (ECI) and emergency coolant recirculation (ECR) functions. The four accumulators, two centrifugal charging pumps, two safety injection pumps, and two residual heat removal pumps are all utilized to respond to both large and small LOCAs, with the accumulators and RHR pumps more important for large LOCAs and the charging and safety injection pumps more important for small LOCAs. The ECCS is designed to be successful with a single active failure and one RCS loop assumed to be out of service due to the break.

The RWST is required for system success during the injection phase. The containment sump and one of two RHR pumps is required for system success during the recirculation phase.

For small LOCAs that do not result in RCS depressurization below the safety injection pump shutoff head the charging pumps are required (number unknown), or the RCS must be depressurized by other means if the safety injection pumps are to provide makeup. Options for depressurizing the RCS may include:

- Opening power-operated relief valves on the pressurizer (two PORVs are available, see Section 3.2)
- RCS cooldown (i.e. using auxiliary feedwater system, see Section 3.3)

The capacity of the centrifugal charging pumps is 150 gpm at RCS operating pressure.

3.4.5 Component Information

A. Safety Injection pumps 1A, 1B
  1. Rated flow: 400 gpm @ 2500 ft. head
  2. Maximum flow: 650 gpm @ 1500 ft. head (1084 psid)
  3. Shutoff head: 1500 psig (650 psid)
  4. Type: Horizontal multistage centrifugal

B. Residual Heat Removal pumps 1A, 1B
  1. Rated flow: 3000 gpm @ 350 ft. head (152 psid)
  2. Maximum flow: 4500 gpm @ 300 ft. head (130 psid)
  3. Type: Vertical single stage centrifugal

C. Centrifugal charging pumps 1A, 1B
   1. Rated flow: 150 gpm @ 5800 ft. head (2515 psid)
   2. Maximum flow: 550 gpm @ 1300 ft. head (564 psid)
   3. Type: Horizontal multi-stage centrifugal

D. Accumulators (4)
   1. Volume, Total: 1350 ft^3
   2. Minimum water volume: 850 ft^3
   3. Normal operating pressure: 650 psig

E. Refueling Water Storage Tank
   1. Capacity: 389,000 gallons
   2. Operating pressure: atmospheric

F. Boron Injection Tank
   1. Volume: 900 gallons
   2. Operating pressure: 2340 psig

G. RHR Heat Exchangers (2)
   1. Type: Vertical shell and U-tube

3.4.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      The ECCS subsystems are automatically actuated on any of the following safety injection signals (Ref. 1):

      - Low pressurizer pressure coincident with low pressurizer water level
      - High containment pressure
      - High differential pressure between any two steam lines outside of containment
      - High steam flow in two of four lines in coincidence with either low T_{avg} or low steam line pressure
      - Manual actuation

      The SIAS automatically initiates the following actions:

      - reactor trip
      - starts the diesel generators
      - starts the charging, safety injection, and RHR pumps
      - opens the boron injection tank isolation valves and charging pump RWST suction valves
      - produces a phase A containment isolation signal

   2. Remote manual
      a. A safety injection signal can be initiated by remote manual means from the control room. ECCS operation can be initiated by remote manual means.

      b. The switchover to the recirculation mode requires operator action.

B. Motive Power
All ECCS motor driven pumps and motor operated valves are Class 1E AC loads that can be supplied from the standby diesel generators as described in Section 3.10.

C. Other
1. Lube oil cooling for the charging, safety injection, and RHR pumps is provided by the Component Cooling Water System (see Section 3.11).
2. Cooling water is provided locally for the ECCS pumps and motors.
3. Systems for ECCS pump room cooling have not been identified.
4. The RHR heat exchanges are cooled by the Component Cooling Water System.

3.4.7 Section 3.4 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 6.2

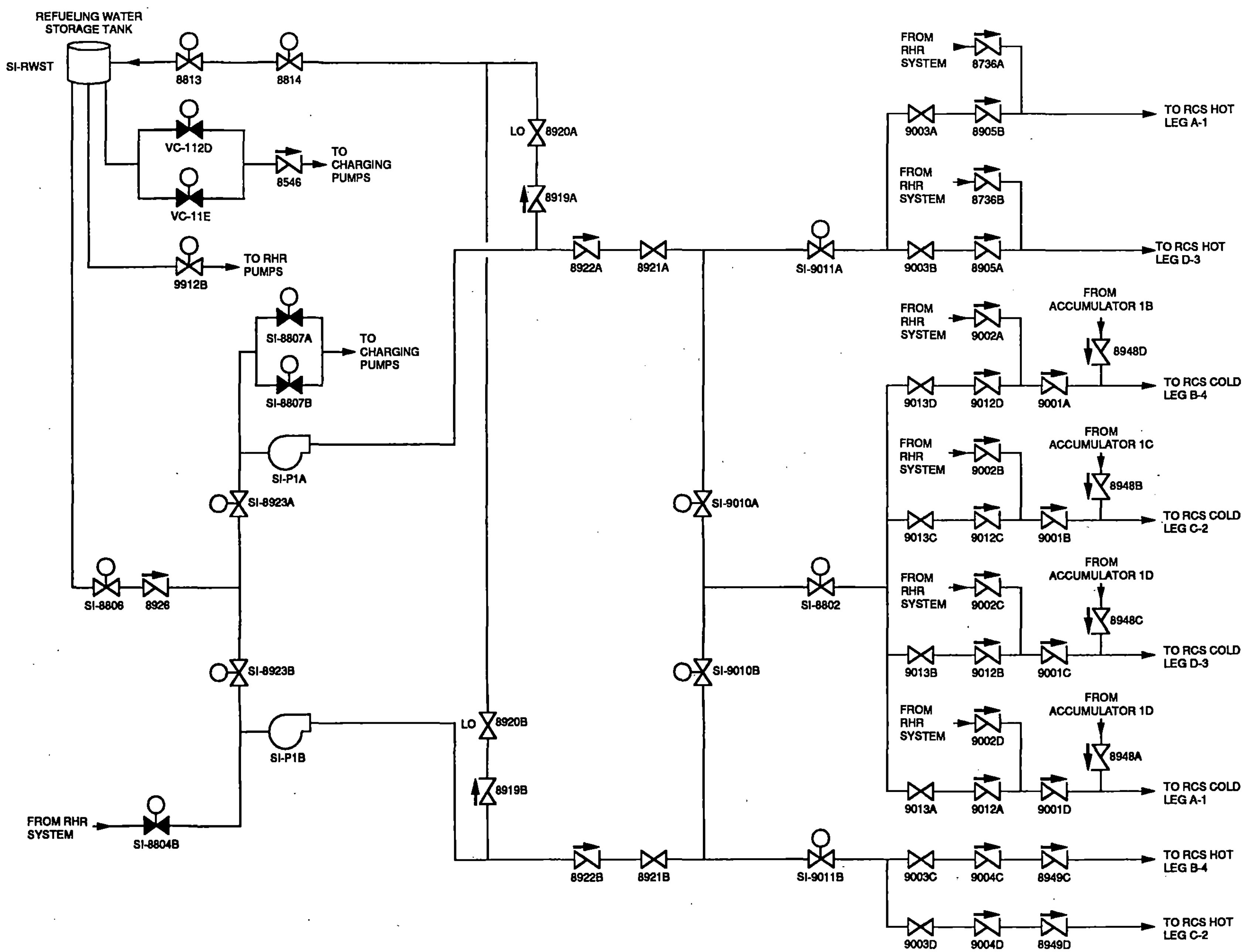


Figure 3.4-1. Zion 1 Safety Injection System

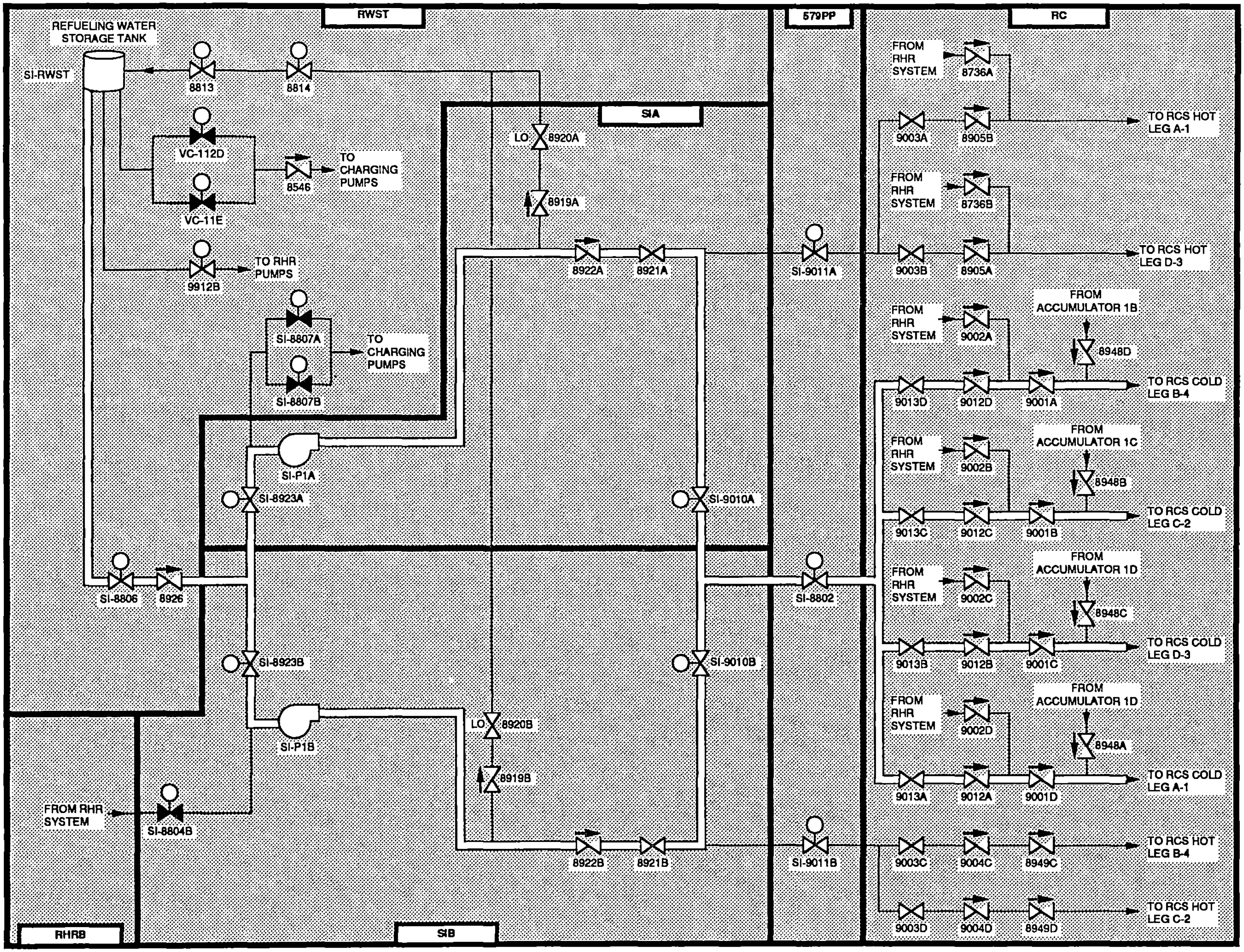


Figure 3.4-2. Zion 1 Safety Injection System, Injection Mode Showing Component Locations

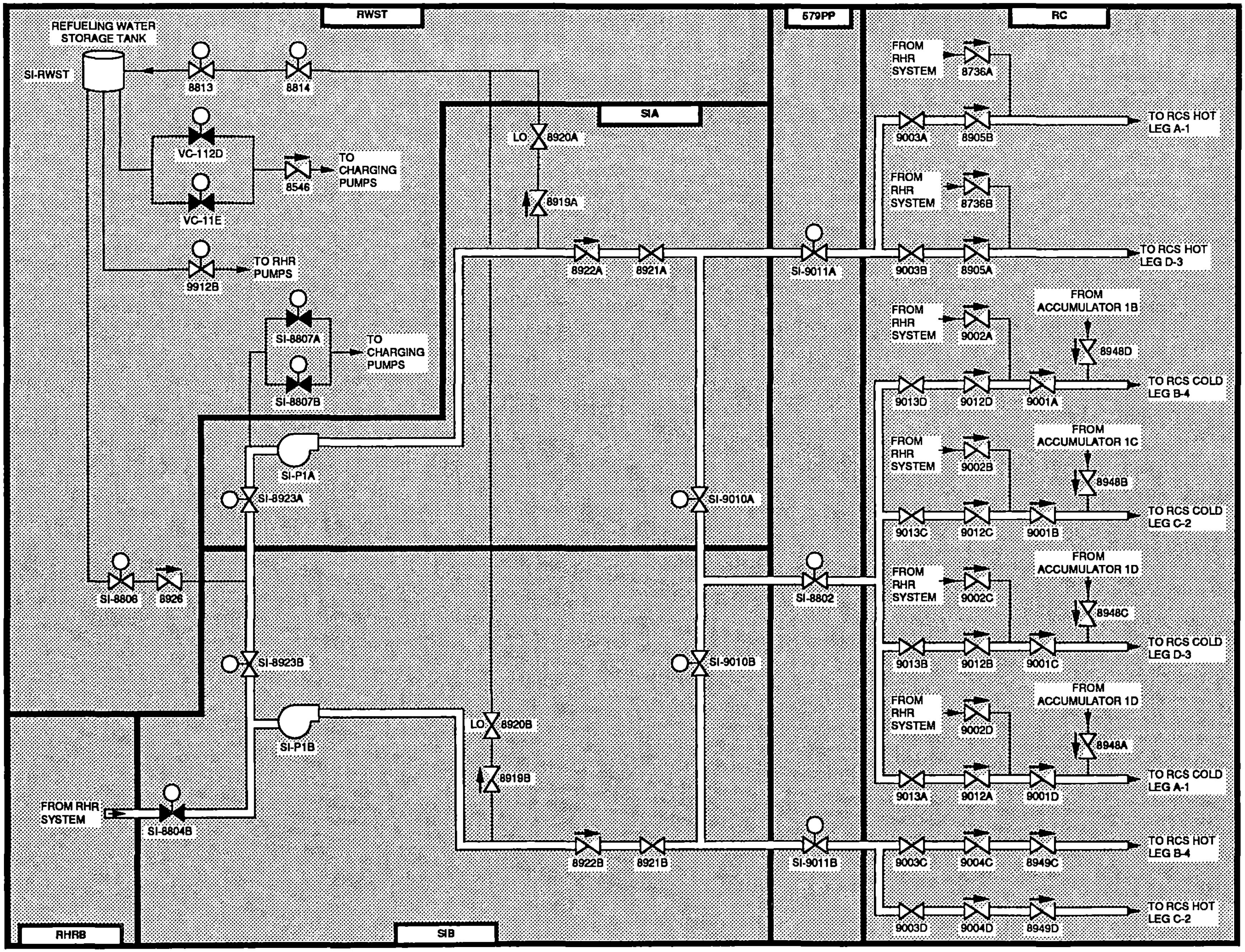


Figure 3.4-3. Zion 1 Safety Injection System, High Pressure Recirculation Mode Showing Component Locations

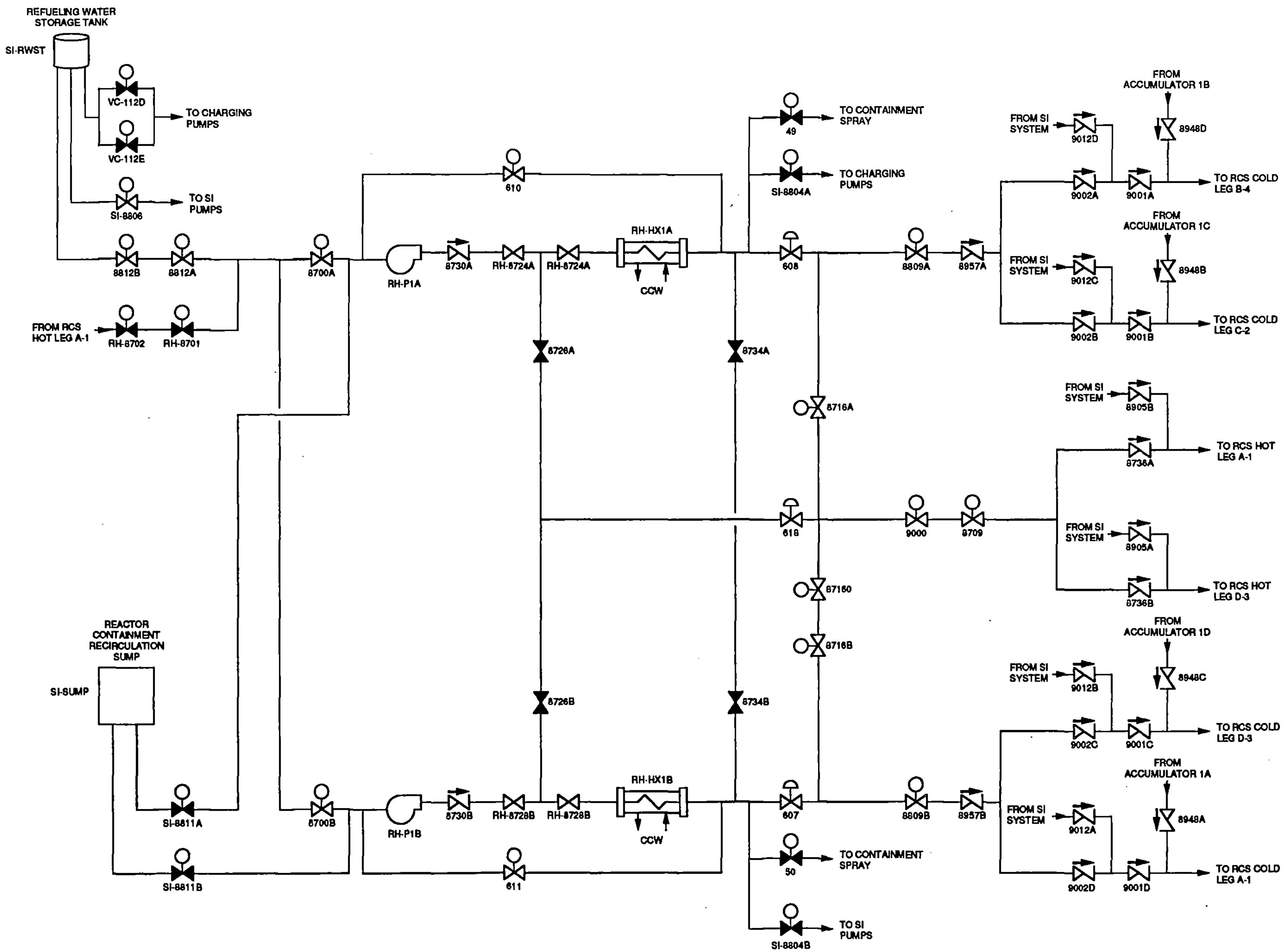


Figure 3.4-4. Zion 1 Residual Heat Removal System

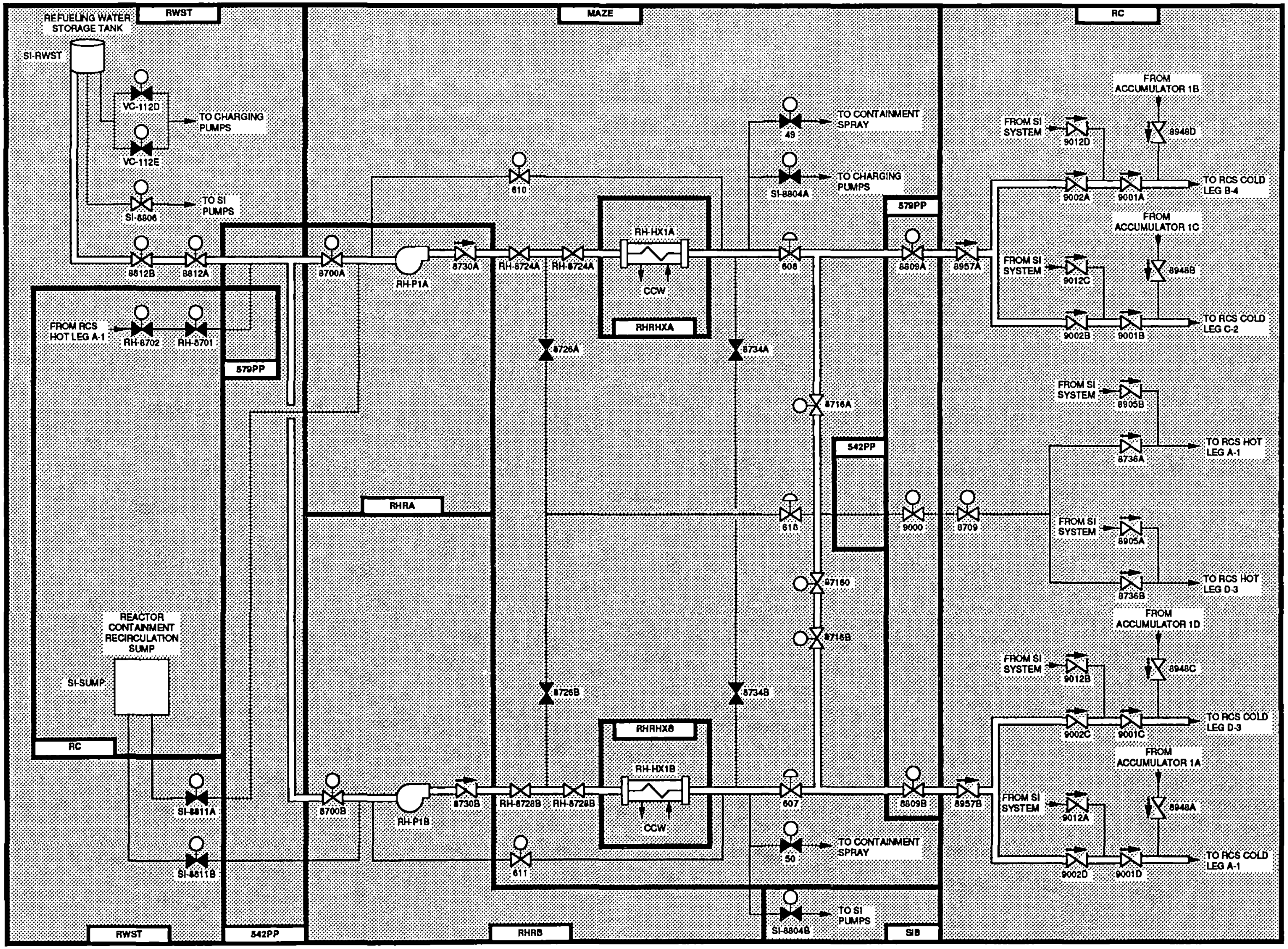


Figure 3.4-5. Zion 1 Residual Heat Removal System, Low Pressure Injection Mode Showing Component Locations

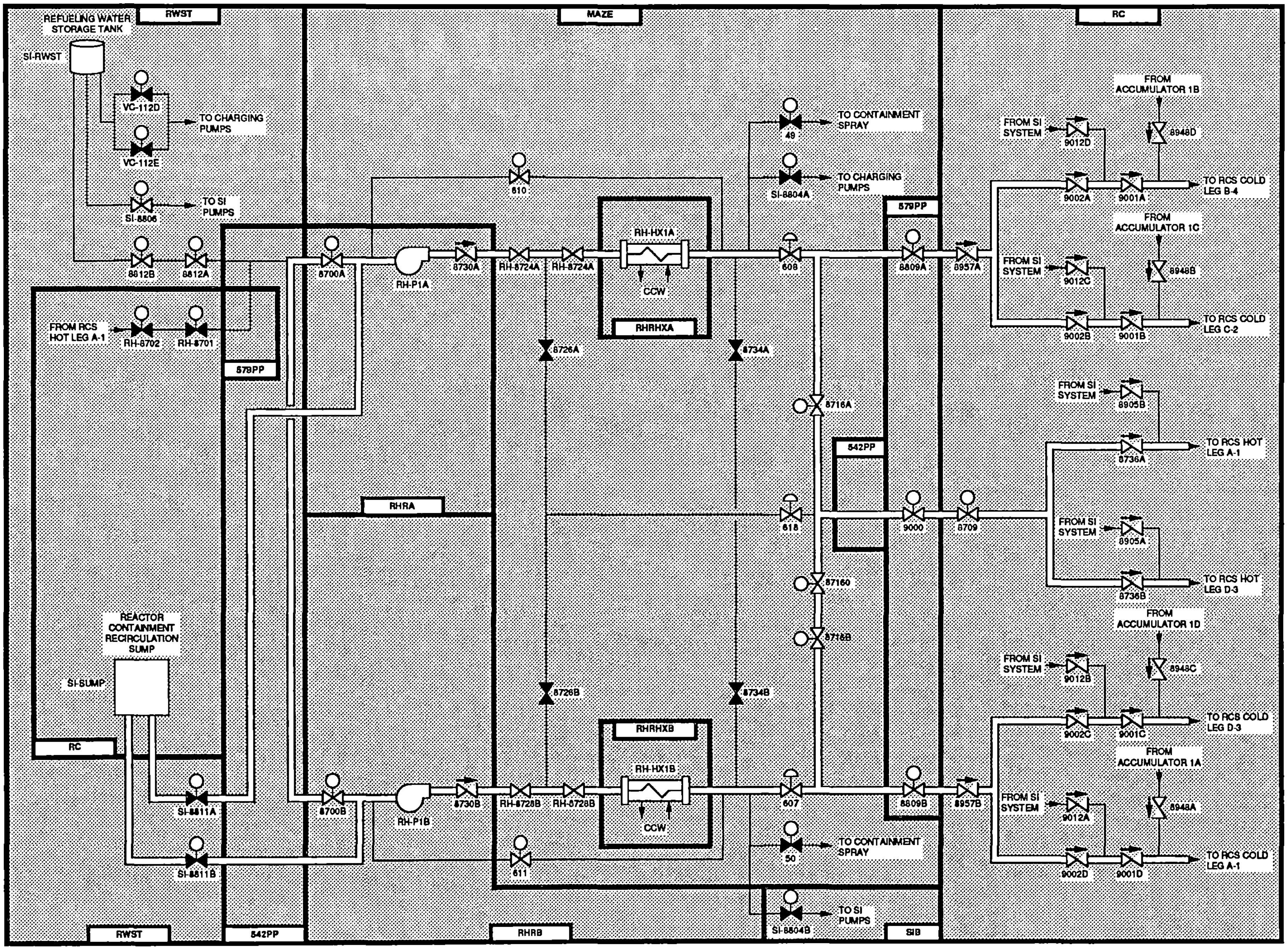


Figure 3.4-6. Zion 1 Residual Heat Removal System, Low Pressure Recirculation Mode Showing Component Locations

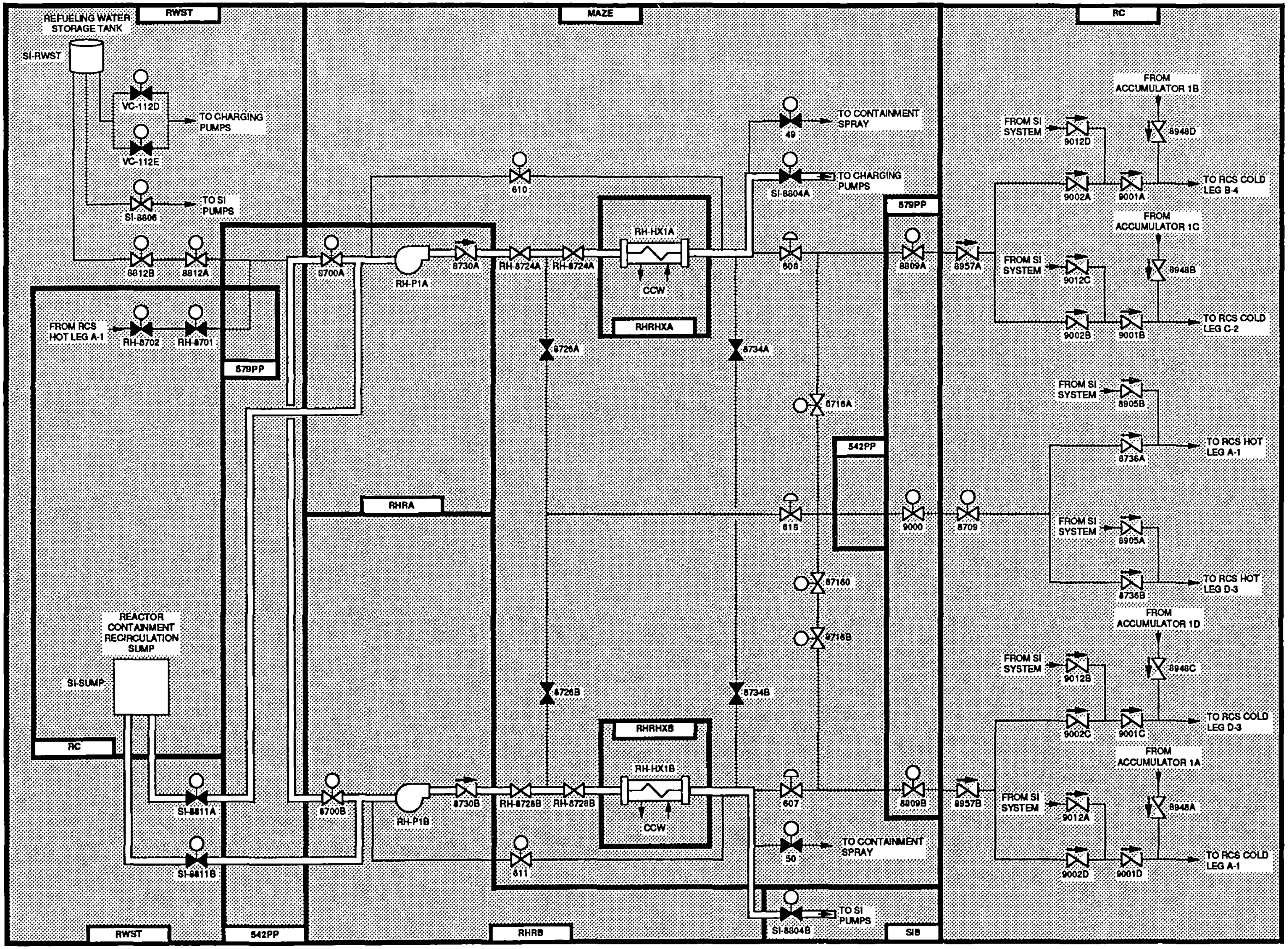


Figure 3.4-7. Zion 1 Residual Heat Removal System, High Pressure Recirculation Mode Showing Component Locations

Table 3.4-1. Zion 1 Emergency Core Cooling System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
CCW-9412A	MOV	RHRHXA	MCC-1391	480	SWGRM149	AC/19
CCW-9412B	MOV	RHRHXB	MCC-1381B	480	SWGRM148	AC/18
RH-8724A	XV	MAZE				
RH-8724B	XV	MAZE				
RH-8728A	XV	MAZE				
RH-8728B	XV	MAZE				
RH-HX1A	HX	RHRHXA				
RH-HX1B	HX	RHRHXB				
RH-P1A	MDP	RHRA	BUS-149	4160	SWGRM149	AC/19
RH-P1B	MDP	RHRB	BUS-148	4160	SWGRM148	AC/18
SI-8800A	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800B	MOV	RC	MCC-1393A	480	1393A	AC/19
SI-8800C	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800D	MOV	RC	MCC-1372	480	1372	AC/17
SI-8801A	MOV	579PP	MCC-1371	480	SWGRM147	AC/17
SI-8801B	MOV	579PP	MCC-1393B	480	1393B	AC/19
SI-8802	MOV	579PP	MCC-1383A	480	1383A	AC/18
SI-8803A	MOV	579PP	MCC-1371	480	SWGRM147	AC/17
SI-8803B	MOV	579PP	MCC-1393B	480	1393B	AC/19
SI-8804A	MOV	MAZE	MCC-1393A	480	1393A	AC/19
SI-8804A	MOV	MAZE	MCC-1393A	480	1393A	AC/19
SI-8804B	MOV	SIB	MCC-1383A	480	1383A	AC/18
SI-8804B	MOV	RWST	MCC-1383A	480	1383A	AC/18
SI-8806	MOV	RWST	MCC-1383A	480	1383A	AC/18
SI-8807A	MOV	RWST	MCC-1393A	480	1393A	AC/19
SI-8807B	MOV	RWST	MCC-1383B	480	1383B	AC/18
SI-8811A	MOV	RWST	MCC-1393A	480	1393A	AC/19
SI-8811B	MOV	RWST	MCC-1383A	480	1383A	AC/18
SI-8923A	MOV	SIA	MCC-1372	480	1372	AC/17
SI-8923B	MOV	SIB	MCC-1383A	480	1383A	AC/18
SI-9010A	MOV	SIA	MCC-1372	480	1372	AC/17

Table 3.4-1. Zion 1 Emergency Core Cooling System Data Summary for Selected Components (Continued)

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
SI-9010B	MOV	SIB	MCC-1383B	480	1383B	AC/18
SI-9011A	MOV	579PP	MCC-1372	480	1372	AC/17
SI-9011B	MOV	579PP	MCC-1383B	480	1383B	AC/18
SI-P1A	MDP	SIA	BUS-147	4160	SWGRM147	AC/17
SI-P1B	MDP	SIB	BUS-148	4160	SWGRM148	AC/18
SI-SUMP	TANK	RC				
VC-8105	MOV	579PP	MCC-1371	480	SWGRM147	AC/17
VC-8106	MOV	579PP	MCC-1393C	480	1393C	AC/19

3.5 CHEMICAL AND VOLUME CONTROL SYSTEM (CVCS)

3.5.1 System Function

The charging system is part of the Chemical and Volume Control System (CVCS). The CVCS is responsible for maintaining the proper water inventory in the Reactor Coolant System, providing required seal water flow to the reactor coolant pump seals, and maintaining water purity and the proper concentration of neutron absorbing and corrosion inhibiting chemicals in the reactor coolant. The charging system also provides borated water for safety injection (see ECCS, Section 3.4). The makeup function of the CVCS is required to maintain the plant in an extended hot shutdown condition following a transient.

3.5.2 System Definition

The CVCS consists of several subsystems that perform the functions of maintaining RCS coolant inventory control, coolant chemistry and purity control, and reactivity control. The charging system consists of two centrifugal and one positive displacement charging pumps that, during normal operation, take suction from the volume control tank and inject into the RCS. The normal charging path is through the regenerative heat exchanger. The charging pumps can also be aligned to take suction from the RWST and inject through the boron injection tank or through the regenerative heat exchanger, following a LOCA.

Simplified drawings of the charging system in the normal charging and ECCS injection modes are shown in Figures 3.5-1 through 3.5-3. A summary of data on selected charging system components is presented in Table 3.5-1.

3.5.3 System Operation

During normal operation, reactor coolant flows through the letdown line and is returned by the charging pumps. Letdown flow from RCS cold leg C(2) passes through the shell side of the regenerative heat exchanger for an initial temperature reduction. The pressure is then reduced by a letdown orifice. The cooled, low pressure water leaves the containment and enters the auxiliary building where it undergoes a second temperature reduction in the tube side of the letdown heat exchanger, followed by a second pressure reduction by the low pressure letdown valve. Flow is then directed through various filters and ion exchangers before being sprayed into the volume control tank (VCT) where it is returned to the RCS by the charging pumps.

The charging flow passes through the tube side of the regenerative heat exchanger for recovery of heat from the letdown flow before being returned to the RCS. Charging flow is split into two charging lines, to cold legs A(1) and C(2). Should the charging line inside the reactor containment building be inoperative for any reason, the line may be isolated outside the containment, and the charging flow may be injected via the pressurizer auxiliary spray line. A portion of the charging flow is filtered and injected into the reactor coolant pump seals.

The centrifugal charging pumps serve as part of the ECCS following a LOCA. Suction is switched from the VCT to the RWST, and the boron injection tank isolation valves are opened. In the recirculation phase the RHR pumps deliver water from the containment sump to the suction of the charging pumps.

3.5.4 System Success Criteria

The following success criteria is assumed for CVCS makeup to the RCS following a transient:

- 1 of 3 charging pumps taking suction on the RWST is required for adequate post-transient makeup to the RCS.

The charging pump success criteria for LOCA mitigation is discussed with the ECCS in Section 3.4.

3.5.5 Component Information

A. Centrifugal charging pumps 1A, 1B
  1. Rated flow: 150 gpm @ 5800 ft: head (2515 psid)
  2. Maximum flow: 550 gpm @ 1300 ft. head (564 psid)
  3. Type: Horizontal multi-stage centrifugal

B. Positive displacement charging pump 1C
  1. Rated flow: 98 gpm @ 5800 ft. head (2515 psid)
  2. Type: Positive displacement

C. Refueling Water Storage Tank
  1. Capacity: 389,000 gallons
  2. Operating pressure: atmospheric

D. Boron Injection Tank
  1. Volume: 900 gallons
  2. Operating pressure: 2340 psig

E. Volume control tank
  1. Volume: 400 ft^3
  2. Operating pressure: 15 psig

3.5.6 Support Systems and Interfaces

A. Control Signals
  1. Automatic
     A safety injection signal automatically starts all 3 charging pumps, causes pump suction to change from the VCT to the RWST, and opens the boron injection tank isolation valves (Ref. 1).
  2. Remote manual
     The charging pumps and associated motor operated valves can be actuated by remote means from the control room.

B. Motive Power
   The charging pumps and motor operated valves of the CVCS are Class 1E AC loads that can be supplied from the standby diesel generators as described in Section 3.10.

C. Other
  1. Lube oil cooling for the charging pumps is provided by the Component Cooling Water System (see Section 3.11).
  2. Cooling water for the charging pumps is provided locally.
  3. Charging pump room cooling systems have not been identified.

3.5.7 Section 3.5 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 9.2.

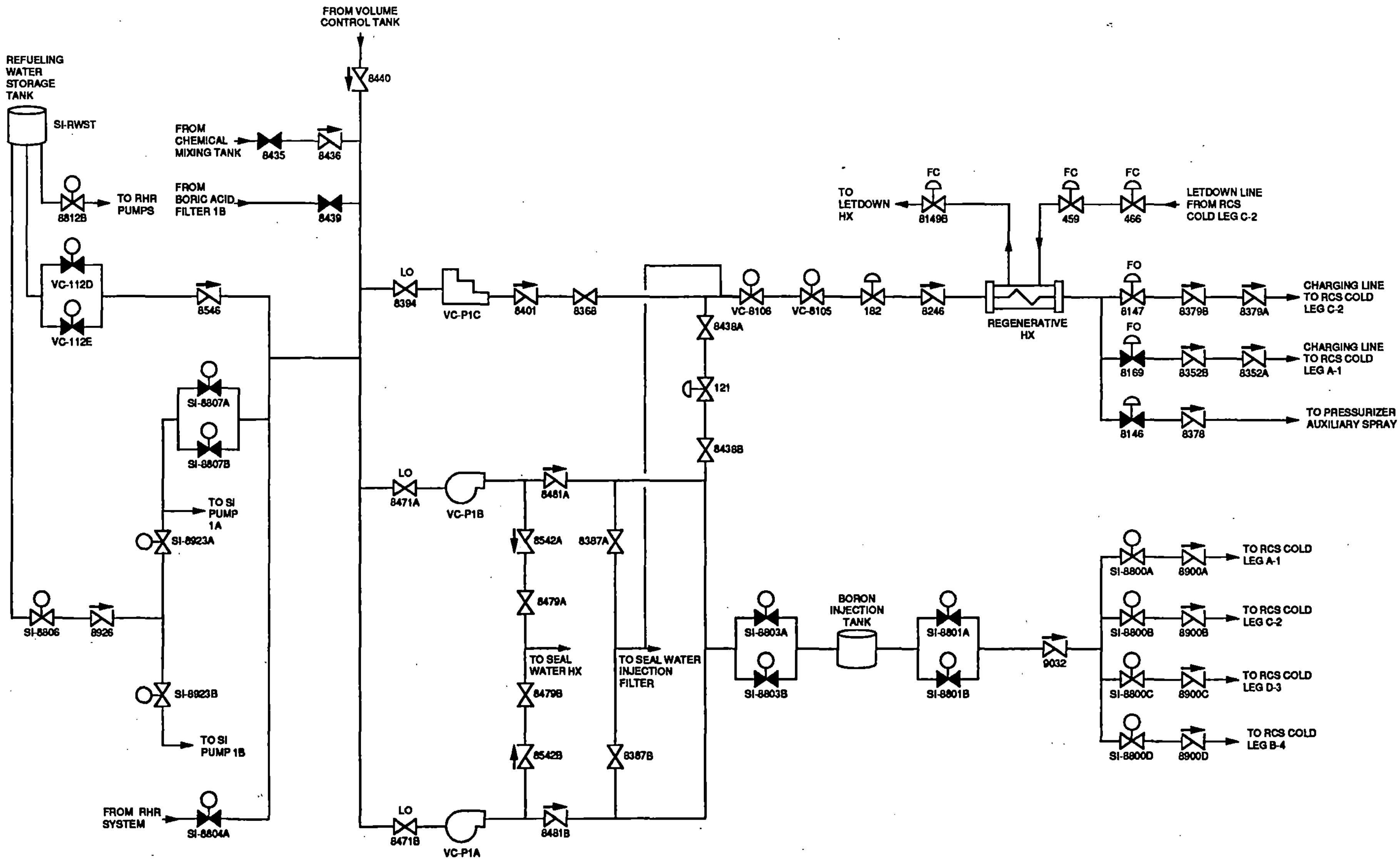


Figure 3.5-1. Zion 1 Chemical and Volume Control System (Charging)

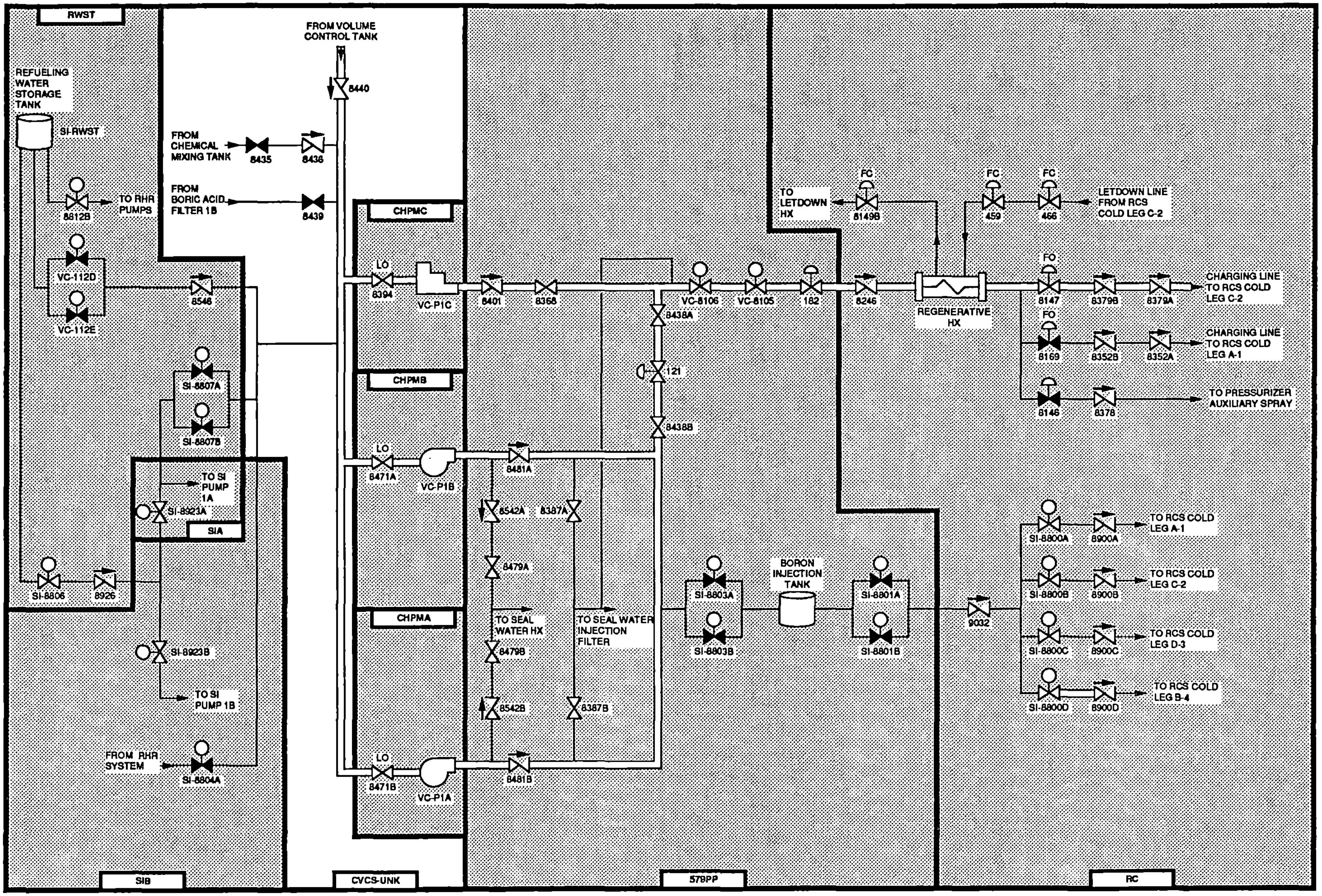


Figure 3.5-2. Zion 1 Chemical and Volume Control System (Charging), Normal Charging Mode Showing Component Locations

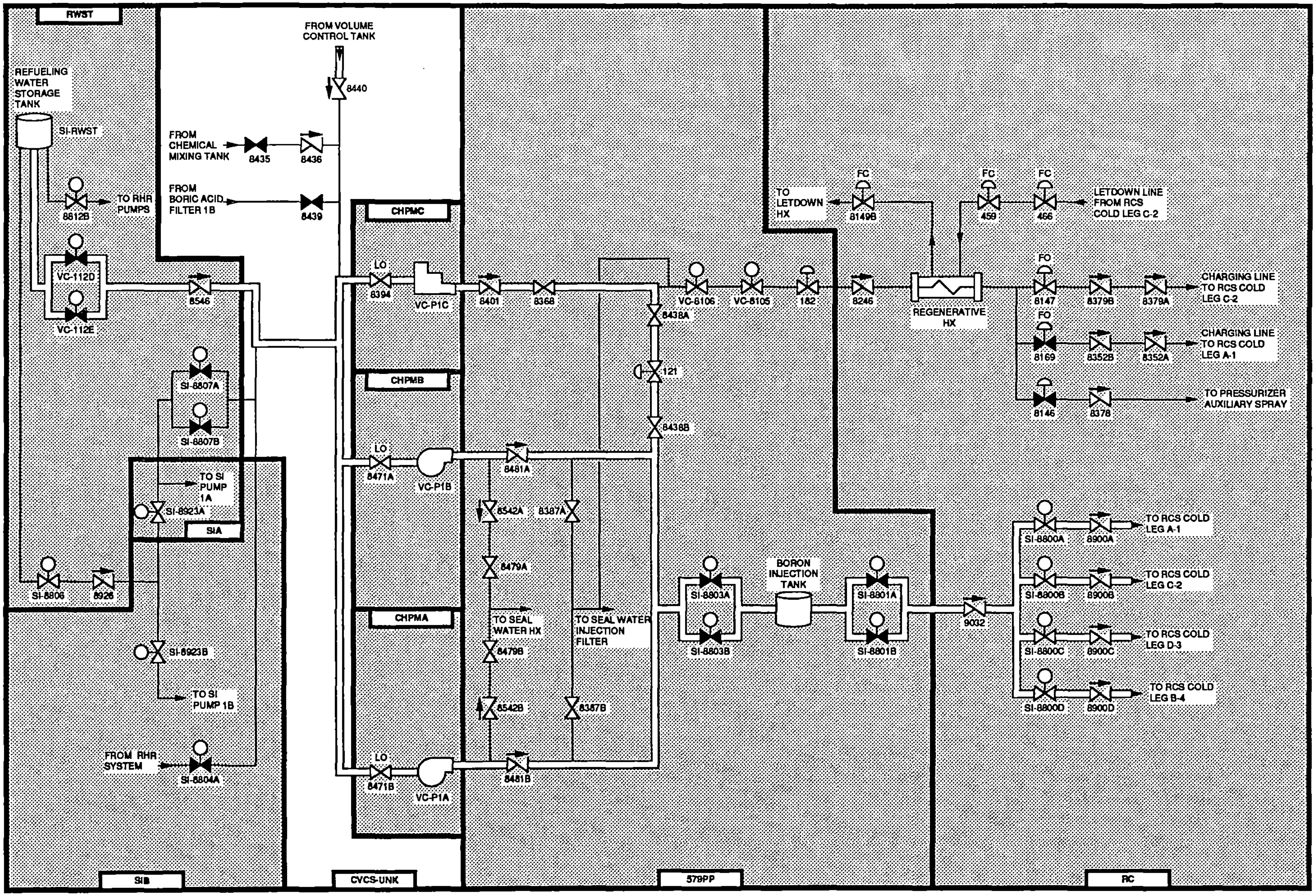


Figure 3.5-3. Zion 1 Chemical and Volume Control System (Charging), ECCS Injection Mode Showing Component Locations

Table 3.5-1. Zion 1 Charging System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
SI-8800A	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800B	MOV	RC	MCC-1393A	480	1393A	AC/19
SI-8800C	MOV	RC	MCC-1371	480	SWGRM147	AC/17
SI-8800D	MOV	RC	MCC-1372	480	1372	AC/17
SI-8801A	MOV	579PP	MCC-1371	480	SWGRM147	AC/17
SI-8801B	MOV	579PP	MCC-1393B	480	1393B	AC/19
SI-8803A	MOV	579PP	MCC-1371	480	SWGRM147	AC/17
SI-8803B	MOV	579PP	MCC-1393B	480	1393B	AC/19
SI-8806	MOV	RWST	MCC-1383A	480	1383A	AC/18
SI-8807A	MOV	RWST	MCC-1393A	480	1393A	AC/19
SI-8807B	MOV	RWST	MCC-1383B	480	1383B	AC/18
SI-8923	MOV	SIA	MCC-1372	480	1372	AC/17
SI-RWST	TANK	RWST				
VC-112D	MOV	RWST	MCC-1372	480	1372	AC/17
VC-112E	MOV	RWST	MCC-1393A	480	1393A	AC/19
VC-8105	MOV	579PP	MCC-1371	480	SWGRM147	AC/17
VC-8106	MOV	579PP	MCC-1393C	480	1393C	AC/19
VC-P1A	MDP	CHPMA	BUS-149	4160	SWGRM149	AC/19
VC-P1B	MDP	CHPMB	BUS-147	4160	SWGRM147	AC/17
VC-P1C	PDP	CHPMC	BUS-138	480	SWGRM148	AC/18

3.6 RESIDUAL HEAT REMOVAL (RHR) SYSTEM

3.6.1 System Function

The Residual Heat Removal System (RHR) provides for shutdown cooling of the reactor after the RCS has been depressurized to less than the RHR design pressure and cooled to less than 350°F. The RHR transfers decay heat from the RCS to the Component Cooling Water System (CCW, see Section 3.11).

3.6.2 System Definition

The RHR consists of two independent loops that are located entirely within the containment. Each RHR loop consists of a suction line connected to an RCS hot leg, a pump, a heat exchanger, and a return line connected to an RCS cold leg. Simplified drawings of the RHR system in the shutdown cooling mode are shown in Figures 3.6-1 and 3.6-2. Simplified drawings of the RHR system in the ECCS injection and recirculation modes are shown in Section 3.4. Simplified drawings of the RHR system in the containment heat removal mode are shown in Section 3.8.

3.6.3 System Operation

The RHR is isolated from the RCS whenever RCS pressure exceeds the RHR design pressure. The RHR is isolated from the RCS on the suction side by two series motor-operated valves which are interlocked to prevent a closed valve from being opened if RCS pressure exceeds RHR design pressure. The RHR is isolated from the RCS on the discharge side by two series check valves. Each RHR loop has a safety valve that is designed to relieve the combined capacity of the three charging pumps (two centrifugal and one positive displacement pumps) at the relief valve set pressure.

During a normal shutdown, initial shutdown cooling is accomplished by using the main turbine bypass system to direct steam to the main condenser, and the condensate and feedwater systems to return the secondary coolant to the steam generators. The circulating water system completes the heat transfer path to the ultimate heat sink. This essentially is the same heat transport path as is used during power operation except that the main turbine is tripped and bypassed and the steam, condensate, and feedwater systems are operating at a greatly reduced flow rate. When the Steam and Power Conversion System is not available, heat may be removed from the RCS by the combined operation of the Auxiliary Feedwater (AFW) System and the secondary steam relief system (SSRS) (see Section 3.3).

The RHR is placed in operation when the temperature of the RCS has been reduced below 350°F and the RCS pressure has been reduced below the design pressure of the RHR. The RCS cooldown rate is controlled manually by regulating the split of RCS flow between the RHR heat exchangers and the lines bypassing each heat exchanger. A flow control valve in each bypass line is used to regulate the portion of RCS flow passing through the RHR heat exchangers, and hence, the transfer of heat to the Component Cooling Water System (CCW, see Section 3.11).

During operation of the RHR, a portion of the flow from each loop is diverted to the Chemical and Volume Control System (CVCS, see Section 3.5) for purification and adjustment of water chemistry.

The RHR also is used to transfer refueling water from the refueling cavity to the refueling water storage tank (RWST) after a refueling is completed.

3.6.4 System Success Criteria

The RHR is designed to cool the RCS using both RHR loops from 350°F to 140°F in 16 hours . However, cooldown can be accomplished with only one RHR loop in about 30 hours (Ref. 1).

The Component Cooling Water System (CCW) must be in operation in order to complete the heat transfer path from an RHR loop to the ultimate heat sink.

3.6.5 Component Information

A. RHR pumps 1A and 1B
1. Design flow: 3000 gpm @ 350 ft. head (152psid)
2. Shutoff head: 170 psig
3. Design pressure: 600 psig
4. Design temperature: 400°F
5. Type: Vertical, centrifugal
6. Rated capacity: 100%

B. RHR heat exchangers 1A and 1B
1. Heat transfer rate: 28.0 x 10^6 Btu/hr each
2. Type: Vertical shell and U-tube
3. Design pressure: 150/600 psig
4. Design temperature: 200/400 °F
5. Rated capacity: 100%

3.6.6 Support Systems and Interfaces

A. Control Signals
1. Automatic
   Interlocks prevent opening the suction isolation valves in all RHR loops when RCS pressure is above RHR design pressure.

2. Manual
   Manually controlled valves isolate the RHR loops from the RCS when RCS pressure exceeds RHR design pressure.

B. Motive Power
1. The RHR pumps and motor-operated valves are Class 1E AC loads that can be powered from the standby diesel generators as described in Section 3.10.
2. The series suction isolation valves in each RHR loop are powered from different AC load groups.

C. Cooling
The RHR heat exchangers and the pump mechanical seals are cooled by the Component Cooling Water System (CCW, see Section 3.11).

3.6.7 Section 3.6 References

1. Zion 1 & 2 Final Safety Analysis Report, Section 9.4.

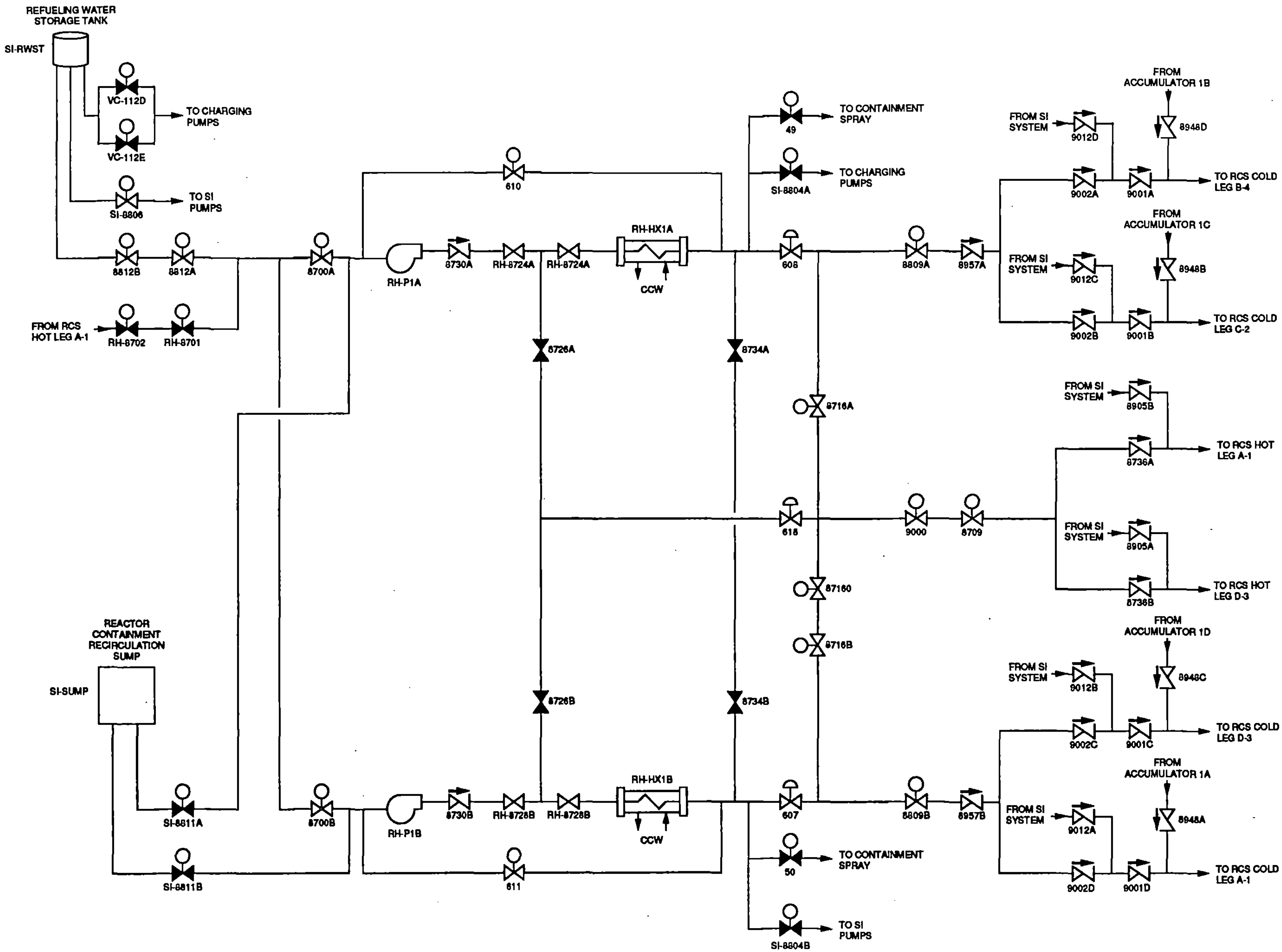


Figure 3.6-1. Zion 1 Residual Heat Removal System

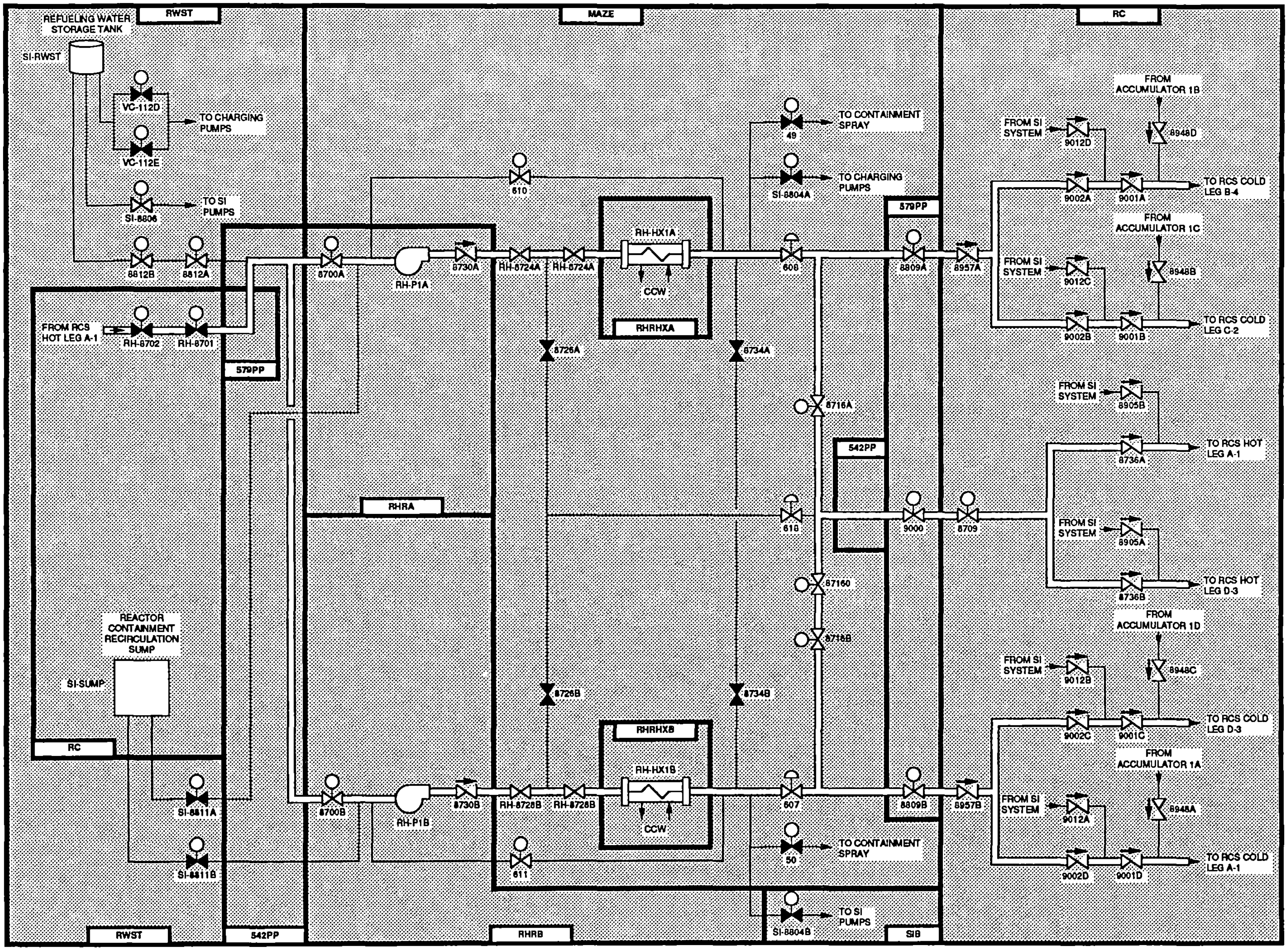


Figure 3.6-2. Zion 1 Residual Heat Removal System, Shutdown Cooling Mode Showing Component Locations

3.7 CONTAINMENT AND ASSOCIATED SYSTEMS

3.7.1 System Function

The function of the containment and associated systems is to establish an essentially leak-tight barrier against an uncontrolled release of radioactive material to the environment during postulated accident conditions. Some systems associated with the containment perform the following functions as needed to assure that containment design conditions important to safety are not exceeded for as long as postulated accident conditions require:

Associated Safety System	Safety Function
- Containment Isolation System	- Containment isolation
- Reactor Containment Fan Cooler (RCFC) Subsystem	- Containment heat removal (pressure and temperature control) under accident conditions
- Containment Spray System (CSS)	- Containment heat removal and fission product control in the containment under accident conditions
- Containment Hydrogen Control System (Hydrogen Recombiner, Hydrogen Monitoring, and RCFC Subsystems)	- Combustible gas control in the containment under accident conditions

The following additional containment support systems are not required for safety, but are important to the normal operation of the containment system:

Associated Non-safety System	Function
- Containment Purge Subsystem	- Purge the containment with fresh air during all normal operating modes.
- Containment Activated Charcoal Subsystem	- Reduce containment activity levels during normal operation.
- Pressure and Vacuum Relief Subsystem	- Handles normal pressure changes in the containment
- Other Containment Heating, Ventilation, and Air-conditioning (HVAC) Subsystems	- Provide ventilation for other containment areas including reactor cavity and support area and control rod drive area

The containment building is a safety class structure that provides protection for enclosed components and systems against the effects of certain external hazards (i.e., extreme wind and tornado-, turbine-, or blast-generated missiles) and internal hazards (i.e., pipe whip and jet impingement).

3.7.2 System Definition

The large, dry primary containment is a steel-lined 3-D prestressed concrete structure designed to operate normally at atmospheric pressure. There is no secondary containment enclosure building. Elevation and plan view drawings of the containment are shown in Figures 3.7-1 to 3.7-4.

A large, dry containment consists of a pressure-retaining structural shell with numerous sealed penetrations for fluid and pneumatic system piping, electric power and instrumentation and control system cabling, ventilation system piping, new and spent fuel transfer, and equipment and personnel access. The containment isolation capability is established by power- and self-operating devices (i.e., valves and dampers) in the various fluid, pneumatic, and ventilation lines penetrating the containment pressure boundary. The isolation devices form part of the containment pressure boundary. The Containment Isolation System is an actuation subsystem of the Engineered Safety Feature Actuation System (ESFAS, See Section 3.9) which causes certain power-operated containment isolation valves to close when plant conditions exceed one or more specified limits. Containment isolation valve provisions shown in the system drawings in this Sourcebook are listed in Table 3.7-1.

The Containment Spray System (CSS) and the Reactor Containment Fan Cooler (RCFC) Subsystem constitute the main containment heat removal systems. Other HVAC subsystems responsible for containment heat removal include the Control Rod Drive Mechanism (CRDM) Ventilation Subsystem, the Reactor Cavity and Out-of-core Instrumentation Ventilation Subsystem, and the Tendon Access Tunnel Ventilation Subsystem. Containment heat removal systems are described in Section 3.8.

The Containment Activated Charcoal Filter Unit Subsystem consists of two 50% capacity trains each consisting of a fan and a filtration unit. The filter unit consist of a prefilter, HEPA filter, and a charcoal bed.

The Containment Hydrogen Control System consists of two hydrogen recombiners for hydrogen removal and the RCFCs for mixing the containment atmosphere. Each hydrogen recombiner is located inside containment and consists of an inlet preheater section, a heater-recombination section, and a discharge mixing chamber that lowers the exit temperature of the air. Air is drawn into the recombiner by natural convection. A monitoring system is provided to determine the percent hydrogen in the containment atmosphere.

The Containment Purge Subsystem consists of a supply train and an exhaust train. Each train consists of one fan and two filter banks. The filter banks consist of independent prefilter and HEPA filter modules with a rated capacity of 20,000 cfm.

The Pressure and Vacuum Relief Subsystem consists of a single 10" diameter line that penetrates the containment and two fast acting isolation gate valves located outside containment. The pressure relief line discharges to the plant ventilation stack. Inlet flow is supplied from the Containment Purge System supply train.

3.7.3 System Operation, General

During normal operation the primary containment is maintained at atmospheric pressure by the Pressure and Vacuum Relief Subsystem. The Containment Purge Subsystem is only operating during shutdown and refueling conditions. The Pressure and Vacuum Relief Subsystem and Containment Purge Subsystem are shown in Figure 3.7-5.

3.7.4 Containment Isolation System Operation

Containment isolation is accomplished in two phases by the containment isolation system (CIS). Initiation of containment isolation Phase A (CIA) shuts all containment automatic isolation valves in nonessential lines except for component cooling water to the RCFC units. These latter lines are isolated when containment isolation Phase B (CIB) is initiated. The Containment Purge Subsystem is isolated by a CIA signal. Isolation valves in essential lines (i.e., ECCS injection and recirculation lines) are not closed by the CIS.

3.7.5 Containment Heat Removal System Operation

See Section 3.8 for details on the operation of the CSS, the RCFC system, the CRDM Ventilation Subsystem, and the Reactor Cavity and Out-of-core Instrumentation Ventilation Subsystem.

3.7.6 Containment Fission Product Control System Operation

During normal operation, the nonsafety Containment Carbon Unit Subsystem circulates containment air through HEPA/charcoal/HEPA filter banks to reduce airborne activity levels. Following a LOCA, containment fission product control is performed by the CSS which is effective in removing iodine from the containment atmosphere. A chemical addition system injects sodium hydroxide (NaOH) to the spray water during CSS operation. The addition of NaOH improves the effectiveness of the CSS for removal of iodine from the containment atmosphere by raising the pH of the spray water (from 8.7 to 10.5). See Section 3.8 for additional information on the operation of the CSS.

3.7.7 Containment Hydrogen Control System Operation

The Containment Hydrogen Control System is intended to mix and monitor the hydrogen concentration within containment and maintain this concentration within safe limits following a design basis accident. The RCFC air coolers, which are used for containment heat removal, also provide for mixing of the containment atmosphere to prevent high concentrations of combustible gases from accumulating in stagnant areas of the containment. Two independant and redundant hydrogen monitoring units are provided to detect the percent hydrogen in the containment. The Hydrogen Recombiner Subsystem requires one of two of the recombiner units shown in Figure 3.7-6 to maintain hydrogen concentration below 4.0 volume percent following a design basis LOCA.

3.7.8 Pressure Vacuum Relief System Operation

The Pressure and Vacuum Relief System functions to maintain the reactor containment pressure between 0.1 psig and 0.3 psig during normal operations. Alarms signal the operators in the control room to open the Presure and Vacuum Relief isolation valves in the event that containment pressures exceed the desired operating range. These isolation valves are automatically closed in case of an accident. In the case of high containment pressure, the flow from the isolation valves is discharged to the plant ventilation stack using the containment pressure as the driving force. In the case of vacuum in the containment, the isolation valves will be opened to allow outside air to equalize the pressure. The intake air in this mode of operation is filtered through the Containment Purge Supply filter trains.

3.7.9 System Success Criteria

For the containment function to be successful, the integrity of the containment pressure boundary must be maintained. For design purposes, this can be interpreted to mean that containment post-accident conditions do not exceed design limits for the spectrum of events included in the containment design basis. These events are as follows (Ref. 1):

- Design basis LOCA
  - Double-ended reactor coolant pipe break
  - Various reactor coolant pump suction breaks up to a double-ended offset rupture (between steam generator and pump suction)
- Various design basis single main steam line breaks
- Various primary, secondary, and other high-energy line breaks yielding subcompartment peak pressures
- Inadvertent spray actuation yielding maximum external pressure

The LOCAs considered include the largest cold or hot leg break (i.e., offset rupture at the reactor vessel inlet or outlet nozzle), and a range of pump suction breaks from the largest to a 3.0 ft^2 break.

One of two hydrogen recombiners is needed to maintain containment hydrogen concentration below 4.0 volume percent following a design basis LOCA.

Success criteria related to containment heat removal systems is discussed in Section 3.8.

Containment success criteria related to severe accidents (i.e., beyond design basis accidents) have not been determined.

3.7.10 Component and Structure Information

Data on the containment structure and components in associated systems (except containment heat removal systems) is presented below. See Section 3.8 for data on containment heat removal system components.

A. Primary Containment Building
   1. Type: Large, dry
   2. Construction: Concrete cylinder with a steel liner
   3. Concrete construction subtype: 3-dimension (3-D) prestressed
   4. Internal diameter: 140 ft
   5. Free volume: 2.860×10^6 ft^3 (minimum)
   6. Normal operating pressure: atmospheric
   7. Design pressure: 47 psig
   8. Structural design temperature: 271 °F
   9. Design leak rate: 0.1 % vol/day

B. Containment Purge Supply Fans (2) and Exhaust Fans (2)
   1. Type: Vane axial
   2. Airflow: 20,000 cfm each
   3. Rated capacity: 100% each (based on purge requirements during nonpower operating modes)

C. Containment Activated Charcoal Circulating Fans (2)
   1. Type: Vaneaxial
   2. Airflow: 8,000 cfm
   3. Rated capacity: 50%

D. Hydrogen Recombiners (2)
   1. Type: Thermal recombiner
   2. Influent H2 maximum concentration: 4%
   3. Effluent H2 maximum concentration: not stated
   4. Process gas flow rate per recombiner: 40 cfm (minimum) by natural convection
   5. Rated capacity: 100% each recombiner unit based on design basis LOCA hydrogen removal requirements

3.7.11 Support Systems and Interfaces

Information on support systems and interfaces for the containment and associated systems (except containment heat removal systems) is presented below. See Section 3.8 for similar information on containment heat removal systems.

A. Control Signals
   1. Automatic
      a. Containment isolation Phase A (CIA) is initiated by a safety injection signal (SIS, see Section 3.9).

b. Containment isolation Phase B (CIB) is initiated by a containment spray signal based on two-out-of-four containment pressure HI-3.
c. The Containment Purge Subsystem is isolated by any of the following conditions:

- a safety signal (SIS, see Section 3.9)
- a high radiation signal from one of three monitors (One in containment, two in purge line)
- manual actuation of containment isolation Phase A (CIA)
- manual actuation of containment spray

2. Remote Manual
   a. SIS and containment spray signals (CIA and CIB) can be initiated from manual switches on the main control board.
   b. Operation of the hydrogen recombiners is performed remote manually from the main control room.
   c. Containment hydrogen monitoring/post-accident sampling lines are isolated by a containment isolation signal. When operation of the system is needed, the operators must reset the containment isolation signal and open the valves by remote manual operation.

3. Local Manual
   The personnel airlock and the equipment hatch are operated locally.

B. Motive Power
1. The components of the Containment Isolation System and the hydrogen recombiners are Class 1E loads that can be supplied from the standby diesel generators as described in Section 3.10.
2. The purge fans and containment activated charcoal unit fans are powered from normal (non-Class 1E) buses.

C. New and Spent Fuel Handling
During refueling, fuel assemblies are handled underwater as they are moved between the reactor core and the new and spent fuel storage facilities outside containment. The fuel transfer tube penetrates containment underwater. When not in use during refueling, the transfer tube is isolated by a blank flange inside containment and a normally-closed manual valve outside containment.

D. Other
All fan motors inside containment are air-cooled and have local lubrication.

3.7.12 Section 3.7 References

1. Zion 1 & 2 Final Safety Analysis Report, Sections 5.0, 6.6, 6.8, and 9.10.

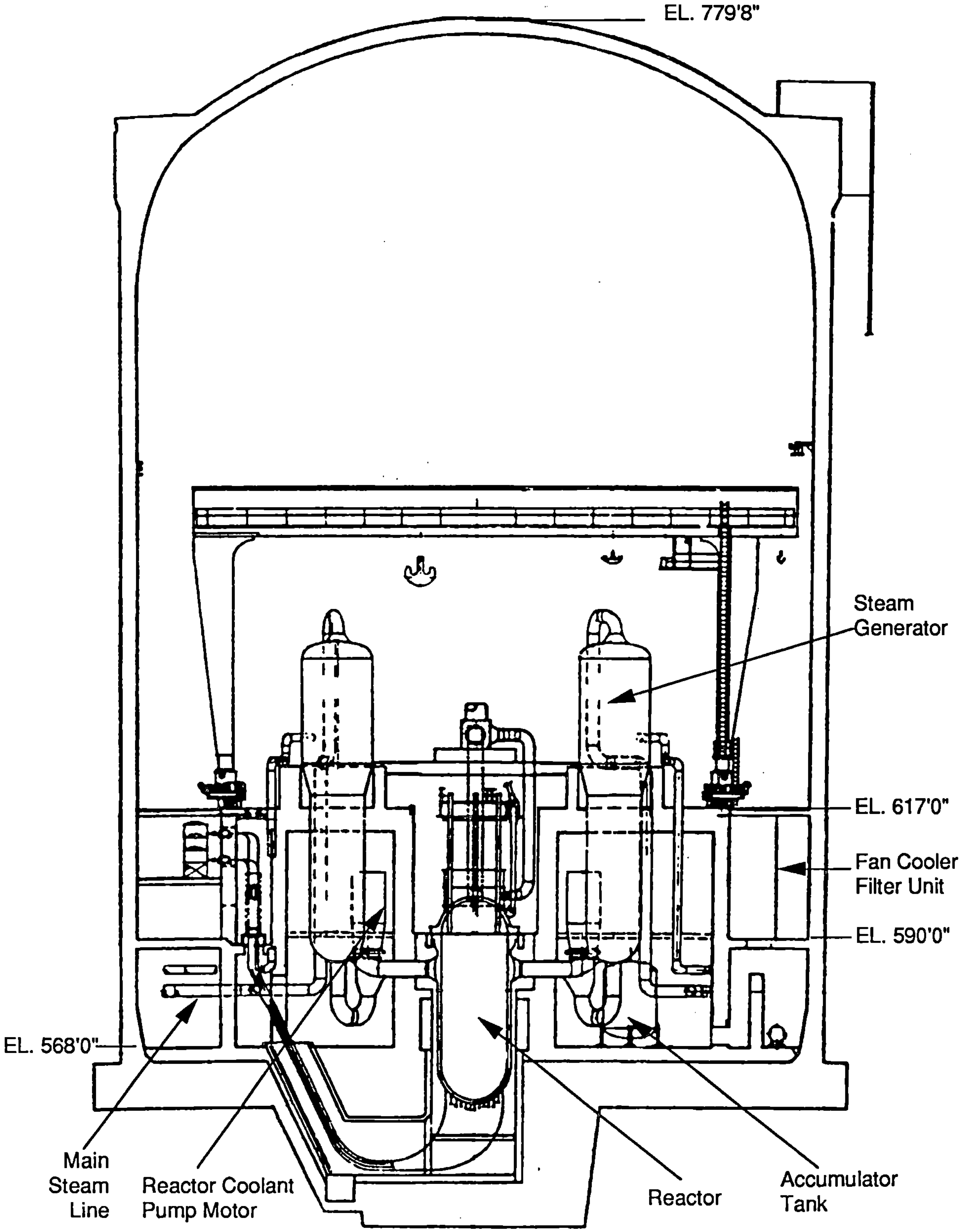


Figure 3.7-1. Zion 1 Containment, Elevation View

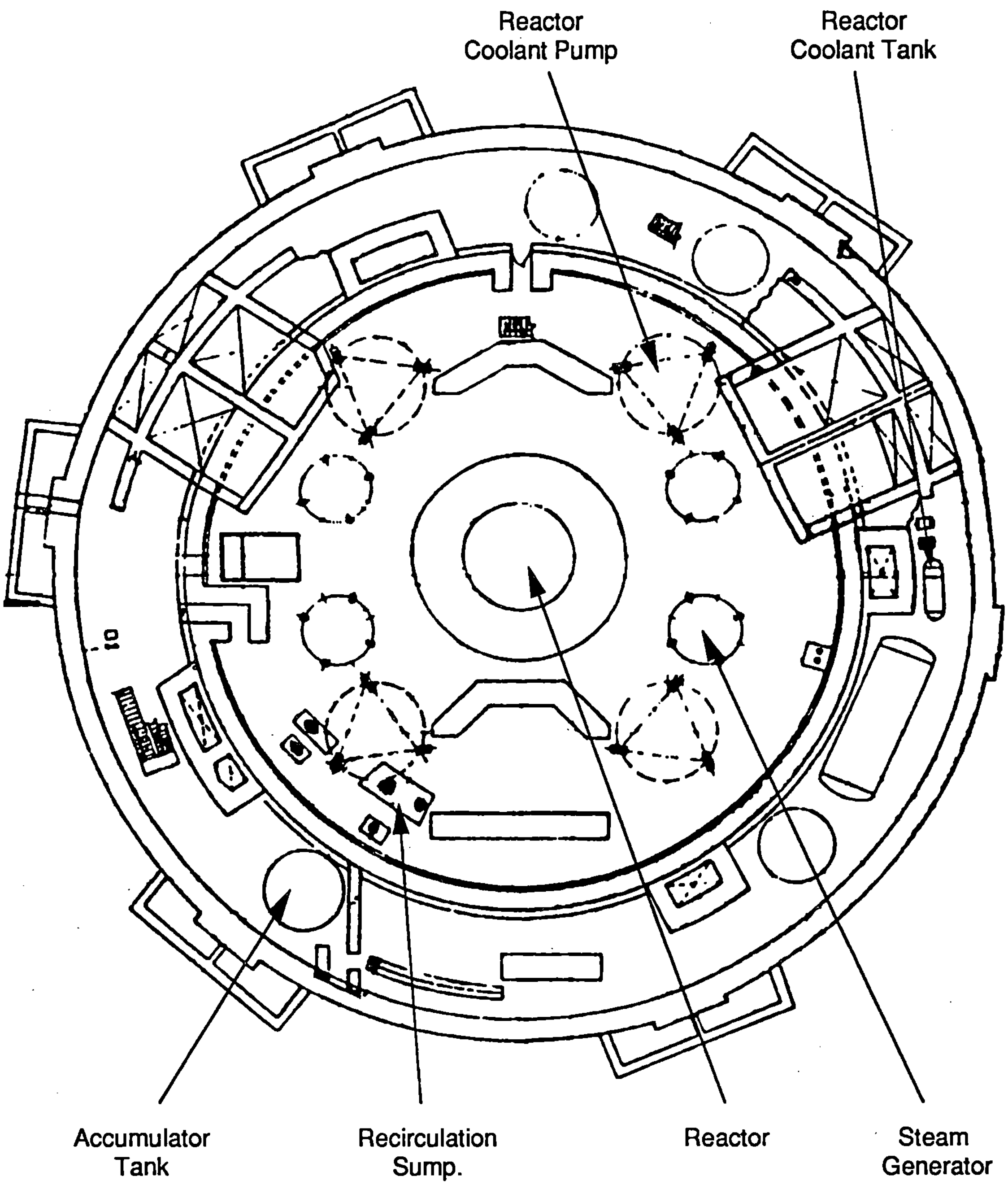


Figure 3.7-2. Zion 1 Containment, Elevation 560'0"

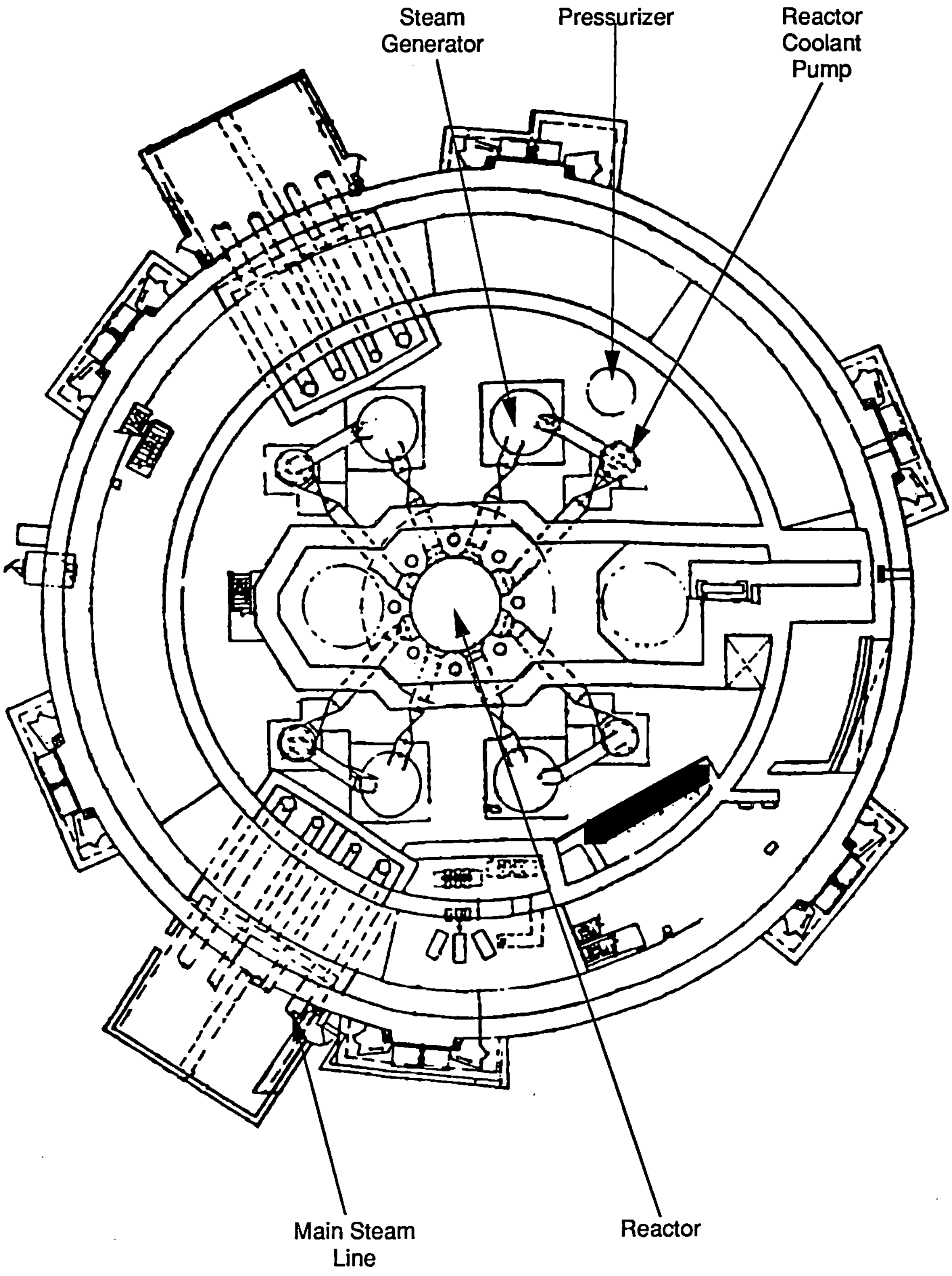


Figure 3.7-3. Zion 1 Containment, Elevation 590'0"

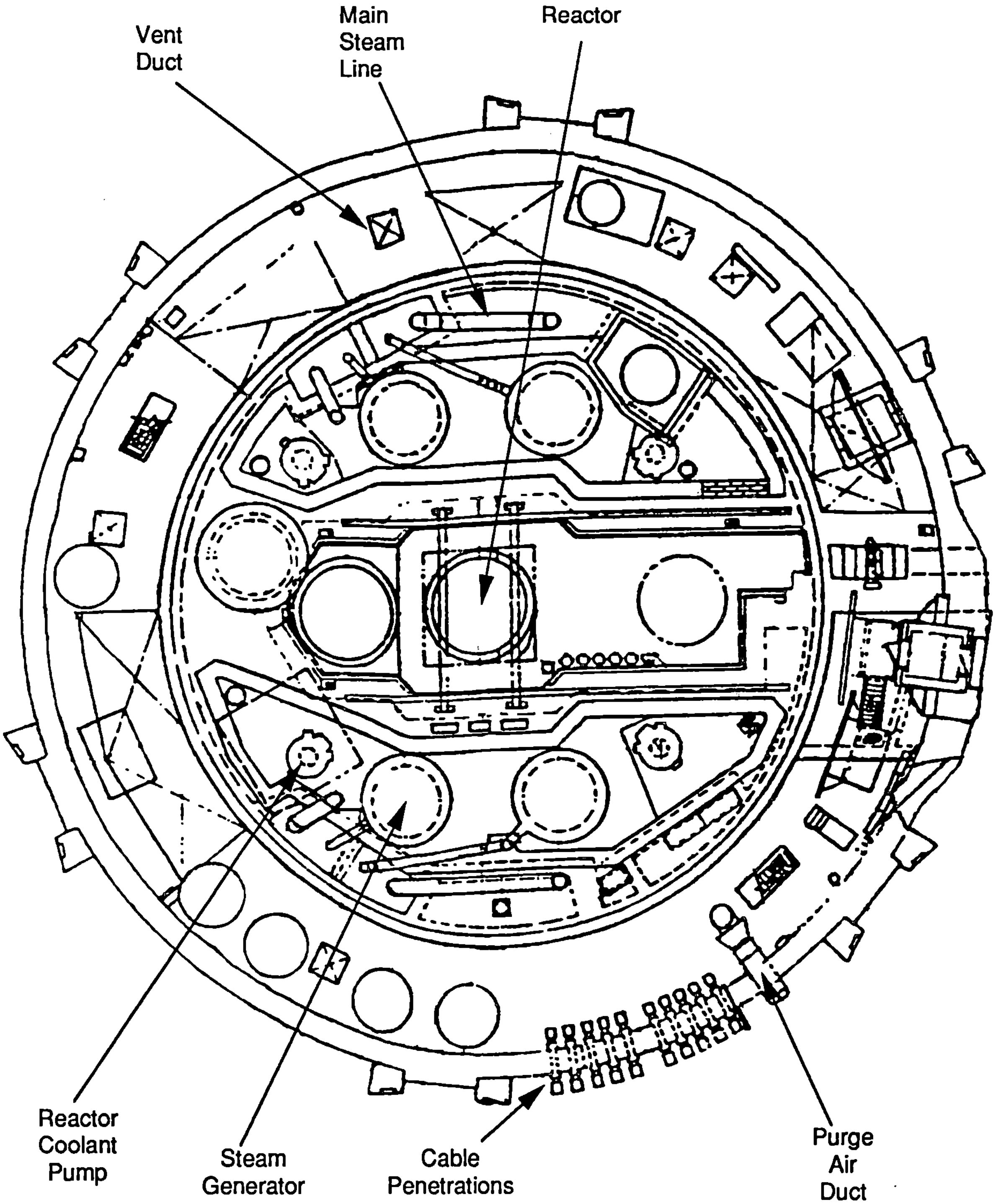


Figure 3.7-4. Zion 1 Containment, Elevation 617'0"

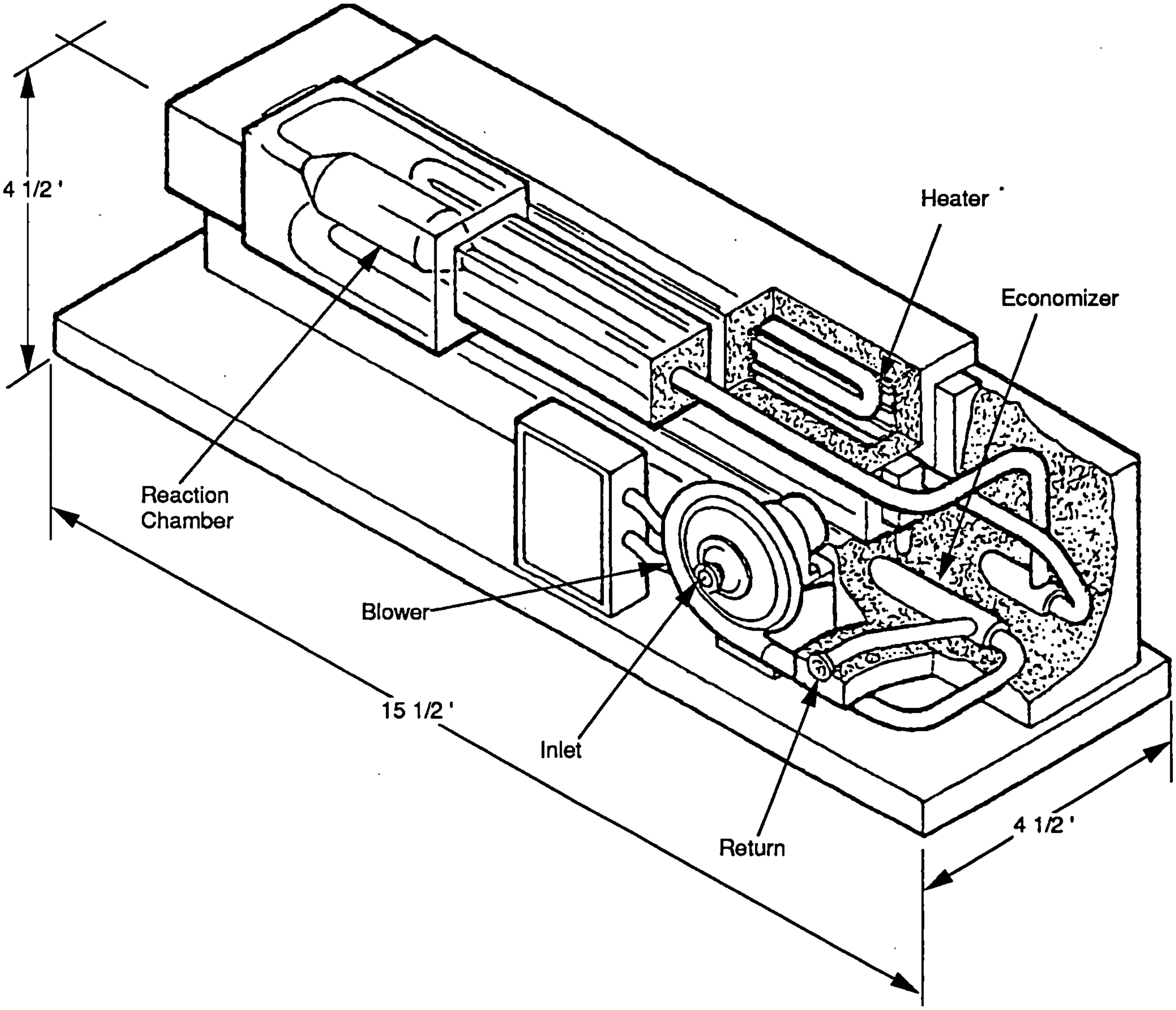


Figure 3.7-5. Zion 1 & 2 Hydrogen Recombiner

Table 3.7-1. Zion 1 and 2 Containment Boundary Interfaces for Systems Covered in This Sourcebook

Line description	Number of lines	Line size (in.)	Direction of flow (Rel. to Ctmt.)	Containment interface valve configuration
CVCS Letdown	1	3	Out	See Figures 3.2-2, 3.5-2, and 3.5-3
CVCS Charging	1	3	In	See Figures 3.2-2 and 3.5-2
CVCS (boron injection)	1	5	In	See Figures 3.2-2 and 3.5-3
AFWS Feedwater	4	16	In	See Figure 3.3-2
Main Steam	4	31	Out	See Figure 3.3-2
Safety Injection System, Injection Mode	1	4	In	See Figure 3.4-2
Safety Injection System, Recirculation Mode	3	4	In	See Figure 3.4-3
Residual Heat Removal System Injection	3	10	In	See Figures 3.4-5, 3.4-6, 3.4-7, and 3.6-2
Residual Heat Removal System Sump Suction	2	8	Out	See Figures 3.4-6, 3.4-7, and 3.8-5
RHR Containment Spray	1	8	In	See Figure 3.8-5
Personnel Hatch	1	unk.	In/Out	See Figure 4-7

3.8 CONTAINMENT HEAT REMOVAL SYSTEMS (CHRS)

3.8.1 System Function

The CHRS is an integrated set of subsystems that provide the functions of containment heat removal and containment pressure control both during normal operations and following a loss of coolant accident (LOCA). In conjunction with the ECCS, the CHRS completes the post-LOCA heat transfer path from the reactor core to the ultimate heat sink.

3.8.2 System Definition

The CHRS consists of two non-safety related systems and two safety-related systems as follows:

Non-Safety related
- Reactor Cavity and Out-of-core Instrumentation Ventilation Subsystem
- Control Rod Drive Mechanism (CRDM) Ventilation Subsystem

Safety related
- Containment Spray System (CSS)
- Reactor Containment Fan Cooling (RCFC) System

The Reactor Cavity and Out-of-core Instrumentation Ventilation Subsystem consists of two 100% capacity direct-drive vaneaxial fans located in line with ductwork that supplies the reactor cavity area with air from the upper containment atmosphere.

The CRDM Ventilation Subsystem consists of a supply train and a discharge train. The supply train consists of four 33% capacity booster fans that take a suction on cooler containment air and discharge to the CRDM shroud area. The discharge train consists of two 100% capacity fans mounted on the CRDM shroud plenum that discharge air to the upper containment atmosphere.

The CSS consists of three parallel redundant trains and a chemical addition system. Each CSS train consists of a pump, two spray headers, and associated valves and piping. One of the CSS pumps is diesel driven. The CSS is crosstied to the Residual Heat Removal (RHR) System, which provides recirculation flow to the spray headers (see Section 3.4). The chemical addition system consists of a chemical addition tank and an eductor in each CSS train. Simplified drawings of the CSS in the injection and recirculation modes are shown in Figures 3.8-1 through 3.8-3. Simplified drawings of the RHR system in the containment spray recirculation mode are shwon in Figures 3.8-4 and 3.8-5.

The RCFC system consists of five air handling units. Each air handling unit consists of a two-speed motor-driven vane axial fan, a demister/moisture separator, a High Efficiency Particulate Air (HEPA) filter, cooling coils, a diversion damper, and a backdraft damper. The cooling coils are supplied with water from the Service Water System (see Section 3.12). There are two airflow risers utilized by each RCFC unit: the normal riser and post-accident riser. The normal riser utilizes only the fan and cooling coils. The post-accident riser circuit ties in the demister/moisture separator and HEPA filter upstream of the respective RCFC fan and cooling coils. A simplified drawing of the RCFC system is shown in Figure 3.8-6.

A summary of data on selected CHRS components is presented in Table 3.8-1.

3.8.3 System Operation

During normal operation, heat is transported from the reactor coolant pump and steam generator areas by the 4 of 5 RCFC units utilizing only the cooling coils and fans operating at the high speed setting. Heat from the reactor vessel cavity is transported to the general containment atmosphere by the Reactor Cavity and Out-of-core Instrumentation

Ventilation Subsystem. A similar function for the CRDM shroud area is performed by the CRDM Ventilation Subsystem.

Following a LOCA, RCFC operation is automatically altered as follows: the fifth air cooler unit is started, all coolers are switched to the low speed setting, and the diversion damper in the supply ductwork to each air handling unit re-routes airflow through post-accident riser circuit. The RCFCs are capable of operating at the full post-accident containment design pressure.

During normal operation the CSS is in standby. A safety injection signal coincident with a containment high pressure signal will start the CSS pumps and open the isolation valves to the spray headers. The chemical addition system injects sodium hydroxide (NaOH) into the spray stream via the inductors during the injection mode of spray operation. The NaOH serves to remove iodine from the containment atmosphere as the spray water falls through the containment atmosphere and retain it in the reactor sump.

When the RWST reaches a low level alarm setpoint, the CSS pumps are automatically stopped. The RHR system is remote manually aligned to provide containment spray during the ECCS recirculation mode, and containment heat is transferred to the Component Cooling Water System via the RHR heat exchangers (see Section 3.11).

3.8.4 System Success Criteria

During normal operation, 1 of 2 reactor cavity supply fans, 3 of 4 CRDM vent booster fans, and 1 of 2 CRDM exhaust fans, are required to operate in conjunction with 4 of 5 RCFC air handling units (Ref. 1).

Following a large LOCA, the following combinations of equipment can provide adequate containment heat removal and pressure control (Ref. 1):

- 4 of 5 RCFC air handling units
- 1 of 3 CSS trains (ECCS injection mode)
- 1 of 2 RHR trains (ECCS recirculation mode)

Related to this success criteria is assumed ECCS performance outlined in Section 3.4.

3.8.5 Component Information

A. Containment Spray Pumps (3)
   1. Rated flow: 3000 gpm @ 206 psig
   2. Type: centrifugal
   3. Rated Capacity: 50%

C. Containment Air Coolers (5)
   1. Design heat removal rate: 80 x 10^6 Btu/hr each (post-accident operation)
   2. Fan type: vaneaxial (two-speed)
   3. Air side flow rate: 85,000 / 53,000 scfm (normal / post-accident)
   4. Rated capacity: 25%

E. Containment Auxiliary Circulation Fans (2)
   1. Type: vaneaxial (two-speed)
   2. Airflow: 75,000 / 37,500 cfm
   3. Design capacity: 100%

F. CRDM Ventilation Fans (3)
   1. Type: centrifugal
   2. Airflow: 31,000 scfm
   3. Design capacity: 50%

D. CRDM Ventilation Booster Fans(4)
   1. Type: Vane axial
   2. Airflow: 25,000 cfm
   3. Rated Capacity: 33 1/3% each

E. Reactor Cavity and Out-of-Core Ventilation Fans (2)
   1. Type: vaneaxial
   2. Airflow: 20,000 cfm
   3. Rated capacity: 50% each

3.8.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      a. The CSS pumps and spray header discharge valves are automatically actuated by a safety injection (SI) signal coincident with a high-high containment pressure (P) signal.
      b. The CSS pumps are automatically stopped when the RWST reaches low-low level.
      d. All containment air coolers are automatically actuated by an SI signal, which also actuates the diversion dampers to reroute air cooler flow to the demister-HEPA filtration circuit.

   2. Remote Manual
      The CSS, the containment air coolers, the reactor cavity and out-of-core ventilation fans, and the CEDM fans can be actuated by remote manual means from the control room.

B. Motive Power
   1. The containment air coolers, CEDM fans, CSS pumps, and motor-operated valves are Class 1E AC loads that can be supplied from the standby diesel generators as described in Section 3.10.
   2. The reactor cavity and out-of-core ventilation fans are powered from normal (non-Class 1E) busses.

C. Cooling
   1. The containment air coolers are cooled by the Service Water System (see Section 3.12).
   1. The RHR Heat Exchangers are cooled by the Component Cooling Water System (see Section 3.11).
   2. All fan motors inside containment are air-cooled and have local lubrication.

3.8.7 Section 3.8 References

1. Zion 1 & 2 Final Safety Analysis Report, Sections 6.3, 6.4, and 9.10.6.

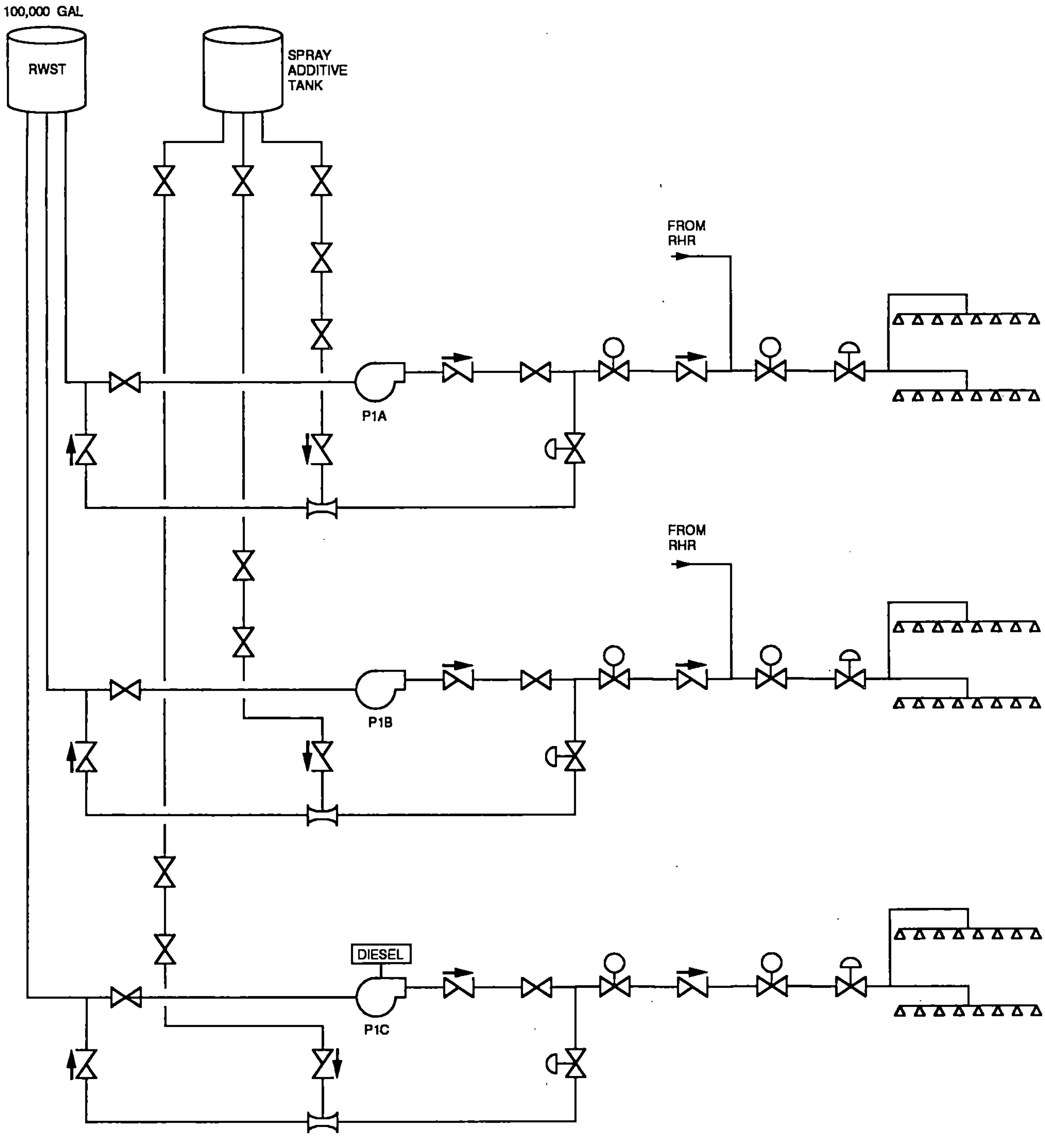


Figure 3.8-1. Zion 1 Containment Spray System

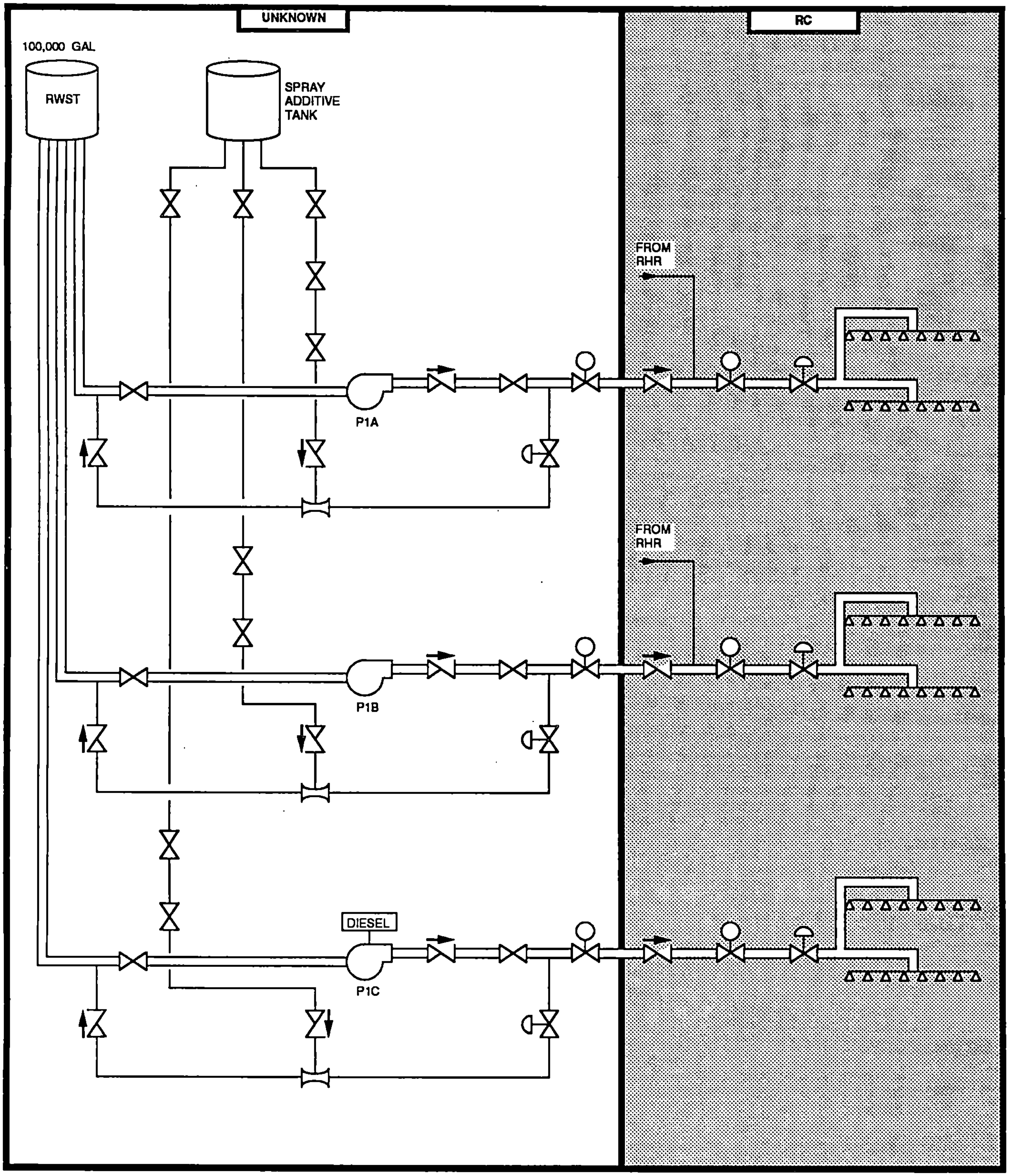


Figure 3.8-2. Zion 1 Containment Spray System, Injection Mode Showing Component Locations

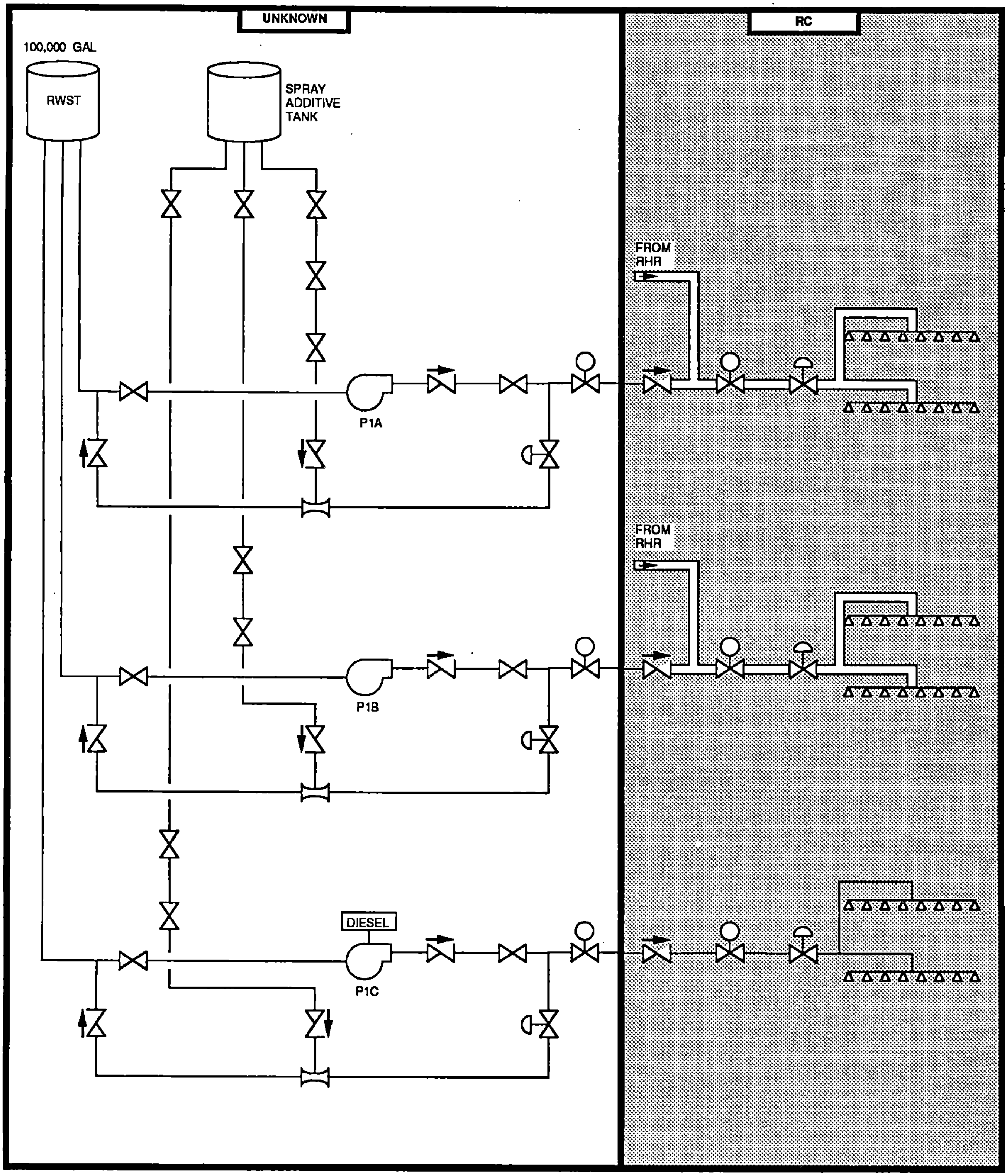


Figure 3.8-3. Zion 1 Containment Spray System, Recirculation Mode Showing Component Locations

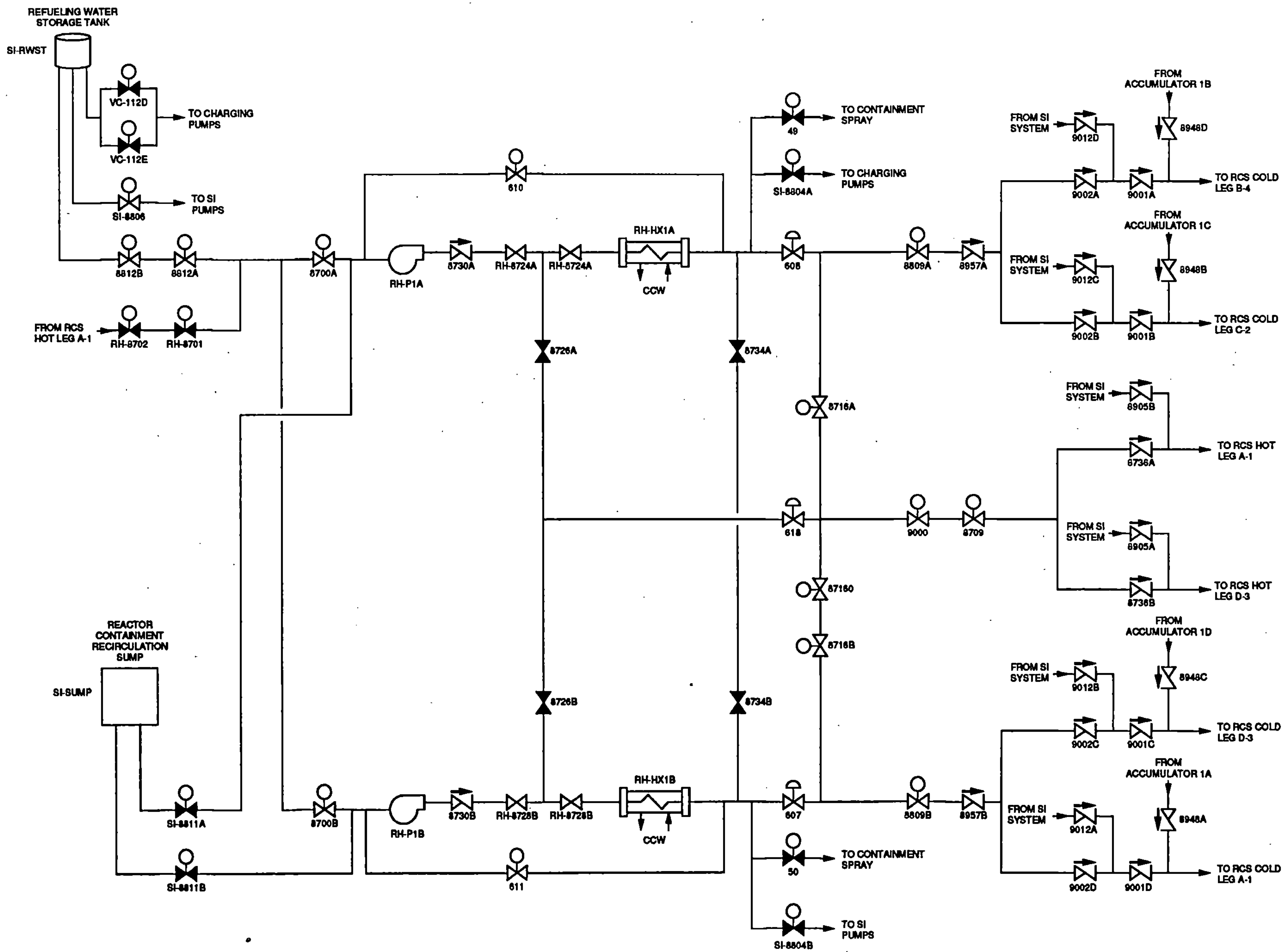


Figure 3.8-4. Zion 1 Residual Heat Removal System

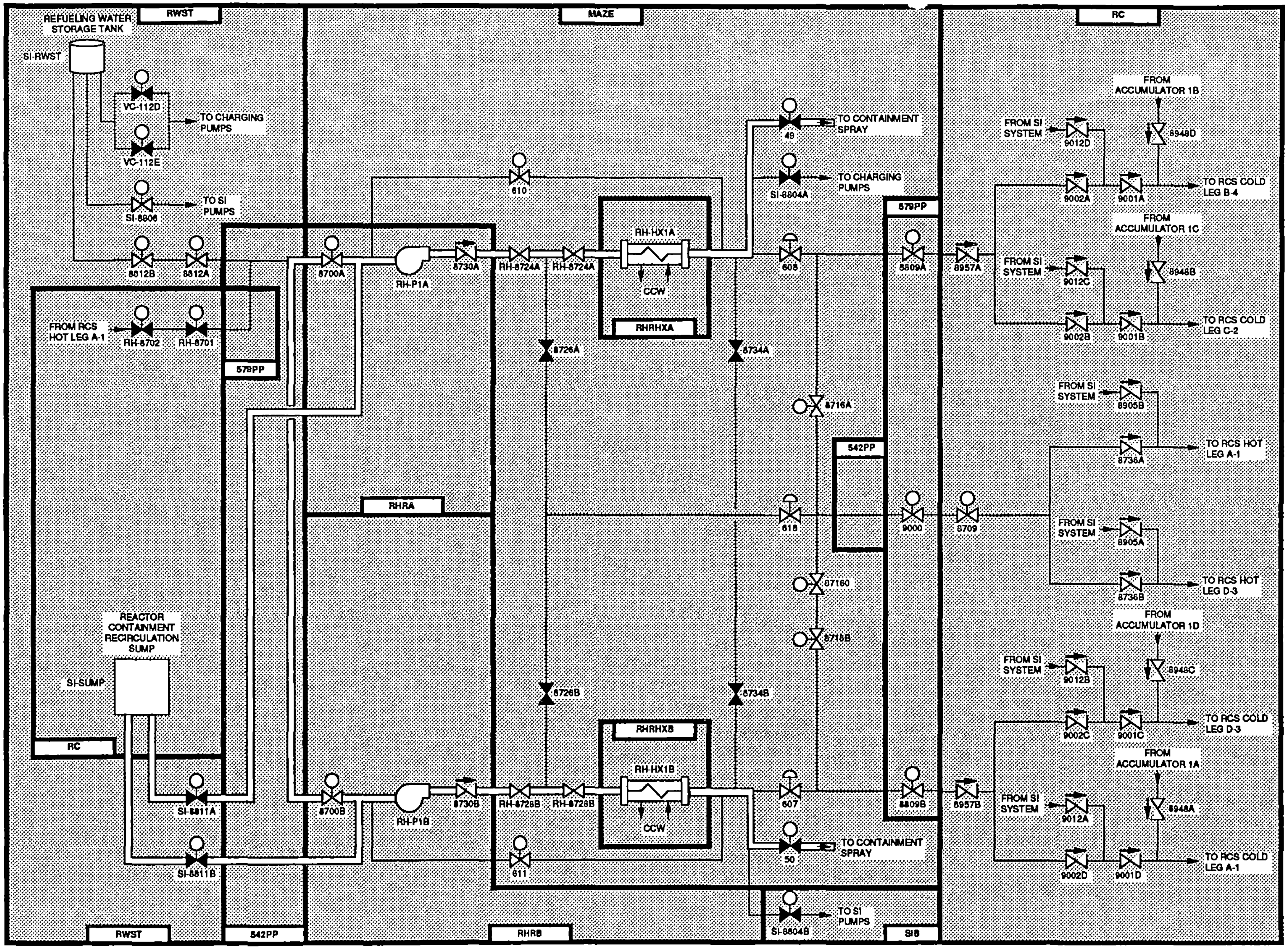


Figure 3.8-5. Zion 1 Residual Heat Removal System, Containment Spray Recirculation Mode Showing Component Locations

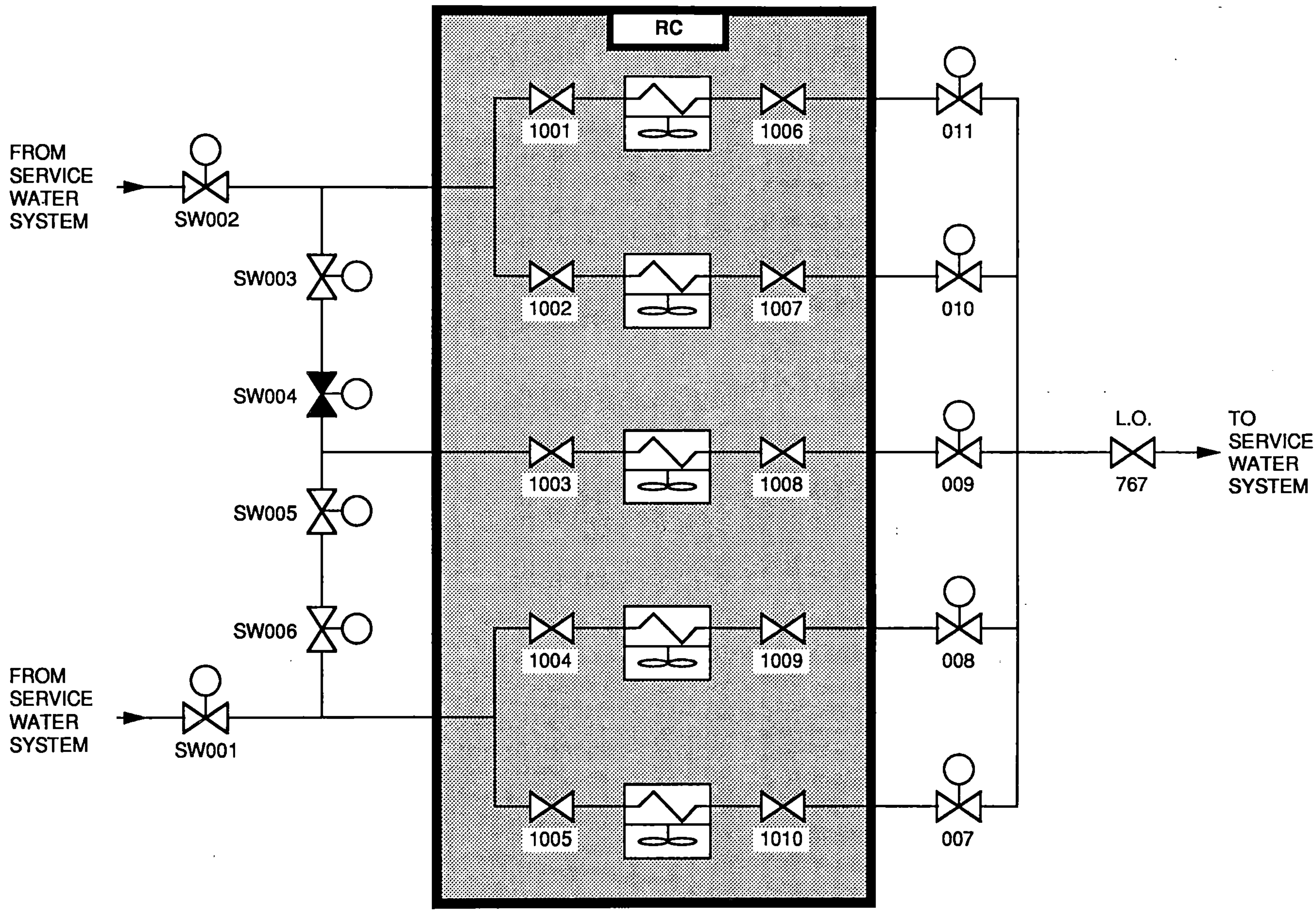


Figure 3.8-6. Zion 1 Reactor Containment Fan Cooler (RCFC) System

3.9 INSTRUMENTATION AND CONTROL (I & C) SYSTEMS

3.9.1 System Function

The instrumentation and control systems consist of the Reactor Protection System (RPS), the Engineered Safety Features (ESF) actuation systems, and systems for the display of plant information to the operators. The RPS and the Engineered Safety Features actuation systems monitor the reactor plant, and alert the operator to take corrective action before specified limits are exceeded. The RPS will initiate an automatic reactor trip (scram) to rapidly shutdown the reactor when plant conditions exceed one or more specified limits. The Engineered Safety Features actuation systems will automatically actuate selected safety systems based on the specific limits or combinations of limits that are exceeded.

3.9.2 System Definition

The RPS includes sensor and transmitter units, logic units, and output trip relays that generate a reactor trip signal. The reactor trip signal deenergizes the control rod magnetic latch mechanisms, allowing all control rod assemblies to drop into the core. The Engineered Safety Features actuation systems include independent sensor and transmitter units, logic units and relays that interface with the control circuits for the many different sets of engineered safety features components that can be actuated. Operator instrumentation display systems consist of display panels in the control room and at local control stations that are powered by the 120 VAC electric power system (see Section 3.10)

3.9.3 System Operation

A. RPS

The RPS has four redundant input instrument channels for each sensed parameter. Two reactor trip breakers are actuated by two separate RPS logic matrices. The reactor trip breakers interrupt power to the rod cluster control assembly drive mechanisms. Certain reactor trip channels are automatically bypassed at power levels where they are not required for safety. The following conditions result in reactor trip (Ref. 1):

- High neutron flux
- High neutron flux rate
- Negative neutron flux rate
- Overtemperature delta T
- Overpower delta T
- Low pressurizer pressure
- High pressurizer pressure
- High pressurizer water level
- Low reactor coolant flow
- Safety injection system actuation
- Turbine trip
- Low feedwater flow
- Low-low steam generator water level
- Manual

B. ESF Systems

The ESF systems are actuated by redundant logic and coincidence networks similar to those used by the RPS. Each network actuates a device that operates the associated ESF equipment, motor starters, and valve operators. Up to four independent measurement channels are used for each sensed parameter. The following vital functions are actuated:

- Safety injection system actuation
- Containment isolation
- Main steam line isolation
- Feedwater isolation
- Auxiliary feedwater actuation
- Containment spray system actuation

The actuation systems provide an actuation signal to each individual component in the required engineered safety features system.

C. Remote Shutdown
Equipment is provided in appropriate locations outside the control room to allow the plant to maintain a hot shutdown condition. (Ref. 1, Section 7.7.6). To maintain a hot shutdown capability, local controls are provided for the following systems, in addition to those controls in the main control room:

1. Auxiliary Feedwater System
   A local panel with three subpanels, one for each AFW pump, is provided. Selector switches on the subpanels permit transferring of pump controls from remote to local. Feedwater flow control and steam generator level control can be accomplished from the local panel. An alarm is sounded in the control room when pump controls are transferred to local.
2. Service Water
   Pushbuttons are installed at the 4160 VAC buses 147, 148, and 149 for local start of the service water pumps. Some valves in the service water system are provided with local controls.
3. Atmospheric Steam Dump
   The valves of the SSRS can be operated locally.
4. Component Cooling Water
   Local controls are available for the CCWS pumps and valves.
5. Instrument Air
   Instrument air is supplied by the service air system through filters and dryers. The service air compressors can be started and stopped locally at compressor control panels. The air filter and dryer controls can be operated locally.
6. Chemical and Volume Control System
   Local controls are available for operating this system outside the control room. Valves can be operated by hand locally.

3.9.4 System Success Criteria

A. RPS
The RPS uses hindrance logic (normal = 1, trip = 0) in both the input and output logic. Therefore, a channel will be in a trip state when input signals are lost, when control power is lost, or when the channel is temporarily removed from service for testing or maintenance (i.e. the channel has a fail-safe failure mode). A reactor scram will occur upon loss of control power to the RPS. A reactor scram usually is implemented by the scram circuit breakers which must open in response to a scram signal. Typically, there are two series scram circuit breakers in the power path to the scram rods. In this case, one of two circuit breakers must open. Details of the scram system for Zion 1 and 2 have not been determined.

B. ESF Systems
In general, the loss of instrument power to the sensors, instruments, or logic devices places that channel in the trip mode. The one exception is the containment spray initiating channels, which require instrument power for actuation. Details of the ESF actuation systems for Zion 1 and 2 have not been determined.

C. Manually-Initiated Protective Actions
When reasonable time is available, certain protective actions may be performed manually by plant personnel. The control room operators are capable of operating individual components using normal control circuitry, or operating groups of components by manually tripping the RPS or an ESF subsystem. The control room operators also may send qualified persons into the plant to operate components locally or from some other remote control location (i.e., the remote shutdown panel or a motor control center). To make these judgments, data on key plant parameters must be available to the operators.

3.9.5 Support Systems and Interfaces

A. Control Power
Operator instrumentation displays are powered from the 120 VAC instrument buses.

3.9.6 Section 3.9 References

1. Zion 1 and 2 Final Safety Analysis Report, Sections 7.2 through 7.5 and 7.7.

3.10 ELECTRIC POWER SYSTEM

3.10.1 System Function

The electric power system supplies power to various equipment and systems needed for normal operation and/or response to accidents. The onsite Class 1E electric power system supports the operation of safety class systems and instrumentation needed to establish and maintain a safe shutdown plant condition following an accident, when the normal electric power sources are not available.

3.10.2 System Definition

All of the engineered safety features receive power from three 4160 volt buses, designated 147 (Div. 17), 148 (Div. 18), and 149 (Div. 19) for Unit 1, and 247 (Div. 27), 248 (Div. 28) and 249 (Div. 29) for Unit 2. The emergency source of power for these buses are five diesel generators. Diesel generator 1A is connected to 4160 VAC bus 148, diesel 1B is connected to bus 149, diesel 2A is connected to bus 248, diesel 2B is connected to bus 249, and diesel 0 is connected to buses 147 and 247. The fifth diesel is therefore available to both units. The generator feed breakers for buses 147 and 247 are electrically interlocked to preclude parallel operation of the two buses (Ref. 1).

Each 4160 VAC bus feeds one 480 VAC bus through a transformer. The 480 VAC buses in turn supply power to various motor control centers.

The 125 VDC system provides power for control and instrumentation and other loads. The system consists of five buses, two for each unit and a fifth that can supply loads in either unit. Each 125 VDC bus is powered by a dedicated battery, with a battery charger that is supplied by a 480 VAC bus.

The 120 VAC system consists of four instrument buses. Each bus can be supplied from an inverter/rectifier or from a 480 VAC MCC through a transformer. Each inverter/rectifier can convert both 125 VDC and 480 VAC to 120 VAC.

Simplified one-line diagrams of the Unit 1 station electric power system are shown in Figures 3.10-1 and 3.10-2. The Unit 2 station power system is shown in Figure 3.10-3. The 4160 and 480 VAC systems for Unit 1 are shown in Figures 3.10-4 and 3.10-5, and the 125 VDC and 120 VAC systems for Unit 1 are shown in Figures 3.10-6 and 3.10-7. A summary of data on selected electric power system components is presented in Table 3.10-1. Selected loads and components supplied by the Class 1E electric power system are listed in Table 3.10-2.

3.10.3 System Operation

During normal operation, the Class 1E electric power system is supplied from the switchyard through the unit auxiliary transformer and the system auxiliary transformer. A cross-connect exists between the two units. The emergency sources of AC power are the diesel generators. The transfer from the preferred power source to the diesel generators is accomplished automatically by opening the normal source circuit breakers and then reenergizing the Class 1E portion of the electric power system from the diesel generators.

The DC power system normally is supplied through the battery chargers, with the batteries "floating" on the system, maintaining a full charge. Upon loss of AC power, the entire DC load draws from the batteries. The batteries are rated for approximately 4 hours of operation without assistance from the battery chargers.

Each 120 VAC instrumentation bus normally receives power from an inverter connected to one of the Class 1E DC buses. The 120 VAC buses can also be supplied via its respective 480/120 volt transformer if the inverter is taken out of service.

Redundant safeguards equipment such as motor driven pumps and motor operated valves are supplied by different VAC buses. For the purpose of discussion, this equipment has been grouped into "load groups". Load group AC/17 contains components powered either directly or indirectly from 4160 bus 147. Load group AC/18 contains components powered either directly or indirectly by bus 148. Load group AC/19 contains components powered by 4160 VAC bus 149. Components receiving DC power are assigned to load groups DC/1, DC/2, or DC/0, based on the battery power source.

3.10.4 System Success Criteria

Basic system success criteria for mitigating transients and loss-of-coolant accidents are defined by front-line systems, which then create demands on support systems. Electric power system success criteria are defined as follows, without taking credit for cross-ties that may exist between independent load groups:

- Each Class 1E DC load group is supplied initially from its respective battery (also needed for diesel starting)
- Each Class 1E AC load group is isolated from the non-Class 1E system and is supplied from its respective emergency power source (i.e. diesel generator)
- Power distribution paths to essential loads are intact
- Power to the battery chargers is restored before the batteries are exhausted

3.10.5 Component Information

A. Standby diesel generators 1A, 1B, 0
   1. Rated load: 4000 kW
   2. Rated voltage: 4160 VAC
   3. Manufacturer: Cooper Bessemer

B. Batteries 1A, 1B, 0
   1. Rated voltage: 125 VDC
   2. Rated capacity: approximately 4 hours with design loads

3.10.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      The standby diesel generators are automatically started based on loss of offsite power or a safety injection signal.
   2. Remote manual
      The diesel generators can be started, and many distribution circuit breakers can be operated, from the control room.

B. Diesel Generator Auxiliary Systems
   1. Diesel Cooling Water System
      Each diesel generator can be cooled by either the service water system or the fire water system.
   2. Diesel Starting System
      Each diesel has an independent air starting system.
   3. Diesel Fuel Oil Transfer and Storage System
      A "day tank" supplies short-term fuel needs of each diesel. Each day tank can be replenished from a separate 50,000 gallon fuel oil storage tank. The long-term storage tanks are located in the auxiliary building above the diesel generators.
   4. Diesel Lubrication System
      Each diesel generator has its own lubrication system.
   5. Diesel Room Ventilation System
      This system consists of exhaust fans which maintain the environmental conditions in the diesel room within limits for which the diesel generator

and switchgear have been qualified. This system may be needed for long-term operation of the diesel generator.

C. Switchgear and Battery Room Ventilation Systems
These systems maintain acceptable environmental conditions in the switchgear and battery rooms, and may be needed for long-term operation of the electric power systems. Details of these systems are not known.

3.10.7 Section 3.10 References

1. Zion 1 and 2 Final Safety Analysis Report, Sections 8.2 through 8.4.

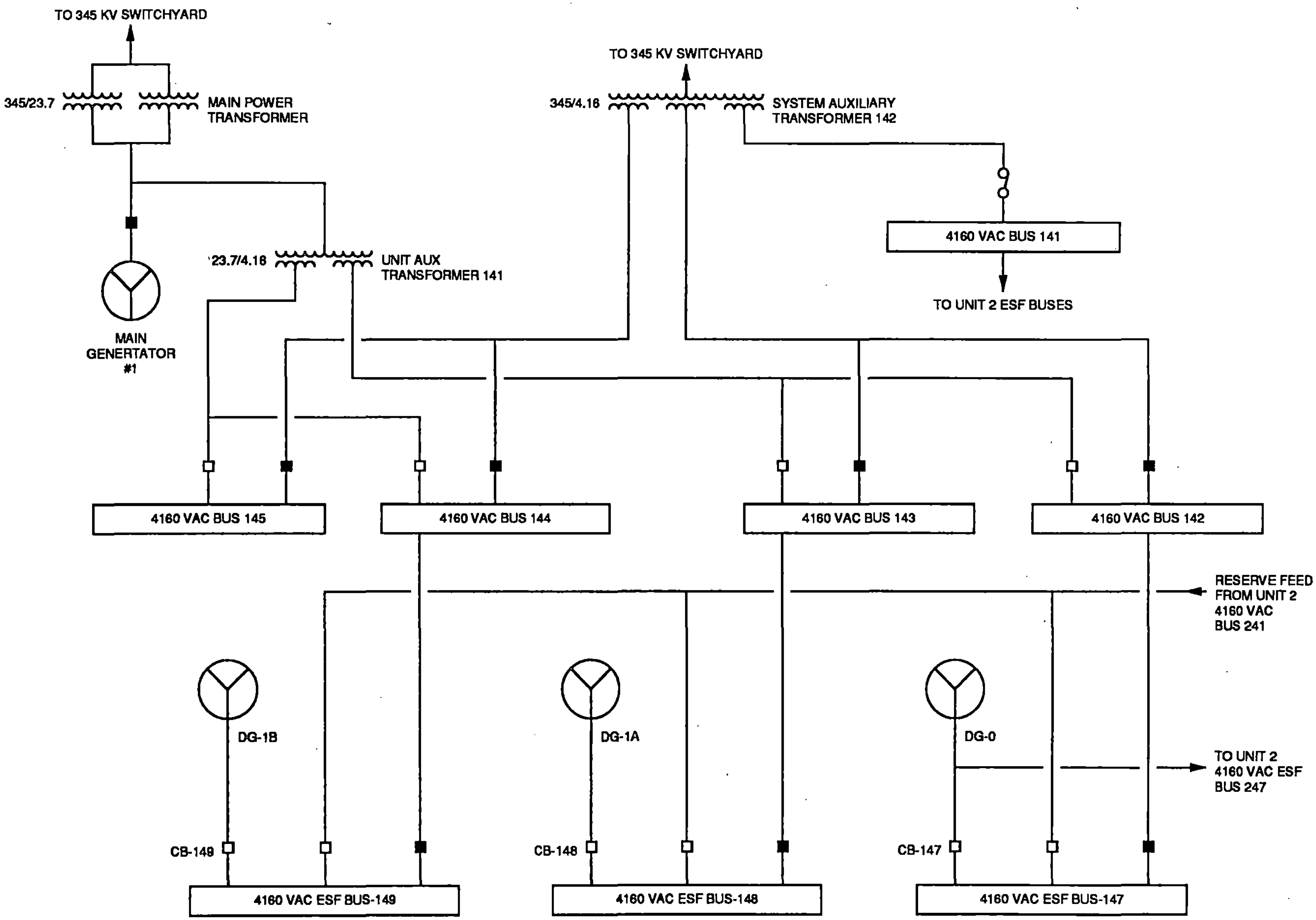


Figure 3.10-1. Zion 1 Station Electric Power System

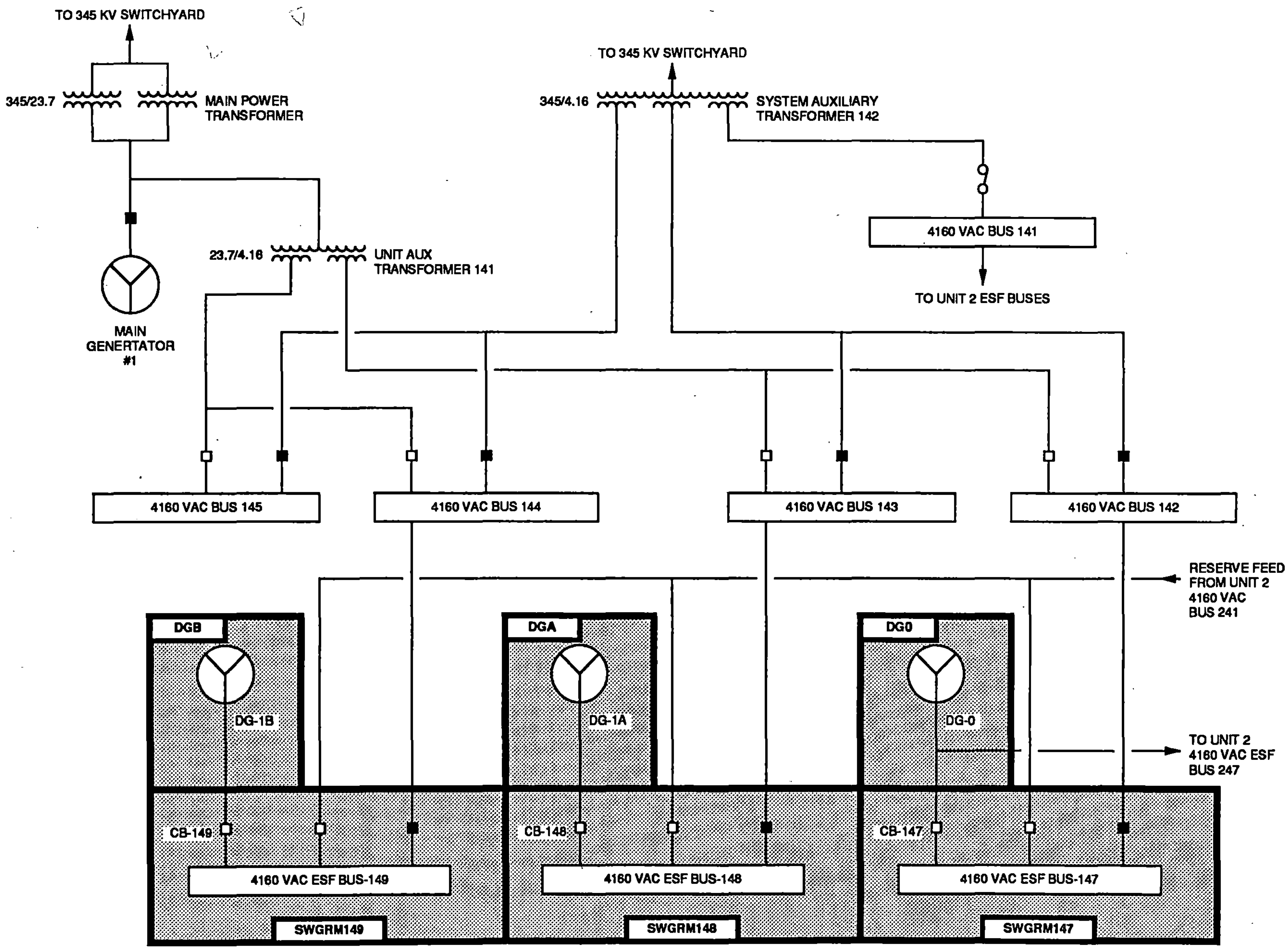


Figure 3.10-2. Zion 1 Station Electric Power System Showing Component Locations

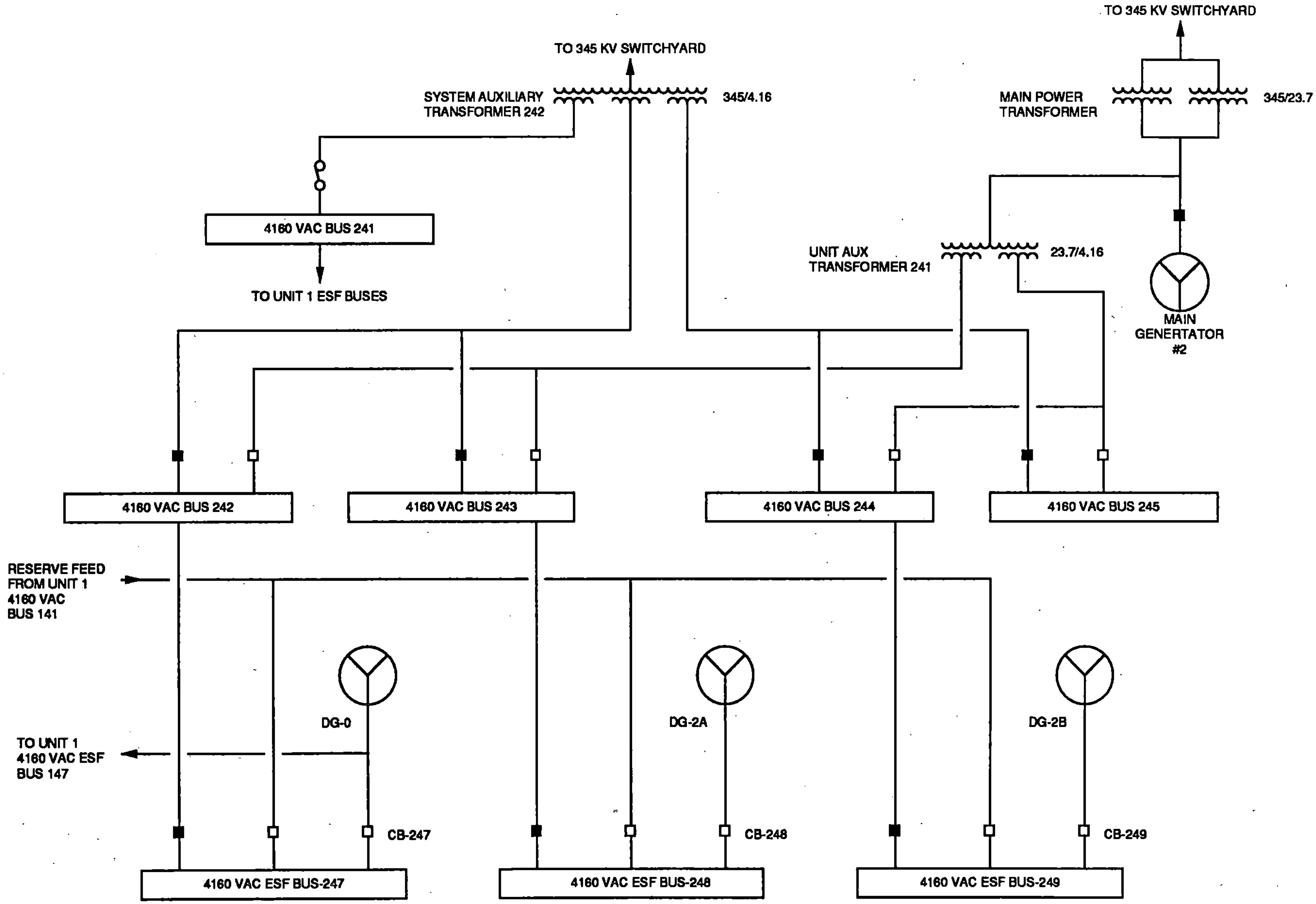


Figure 3.10-3. Zion 2 Station Electric Power System

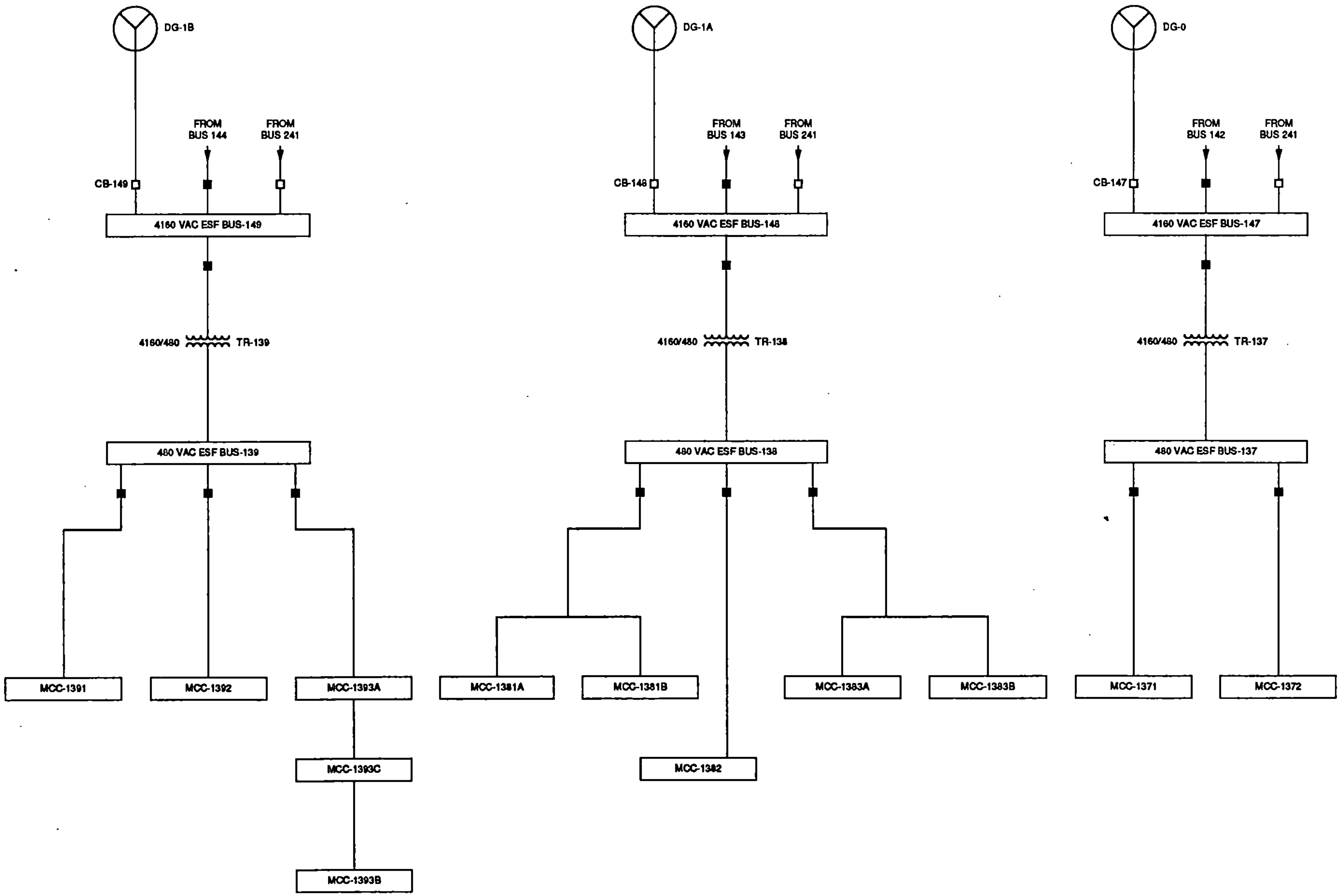


Figure 3.10-4. Zion 1 4160 and 480 VAC Electric Power Systems

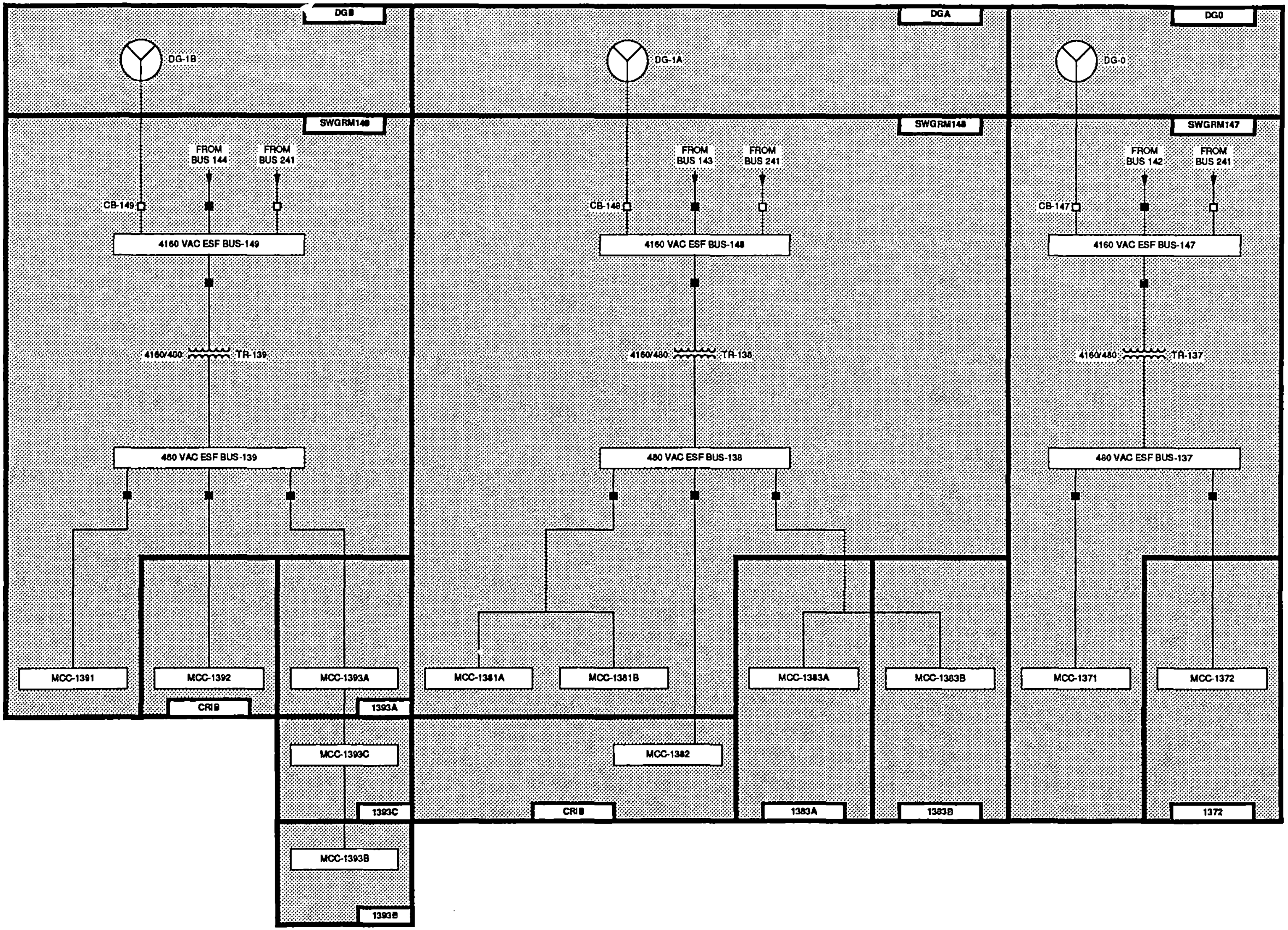


Figure 3.10-5. Zion 1 4160 and 480 VAC Electric Power Systems Showing Component Locations

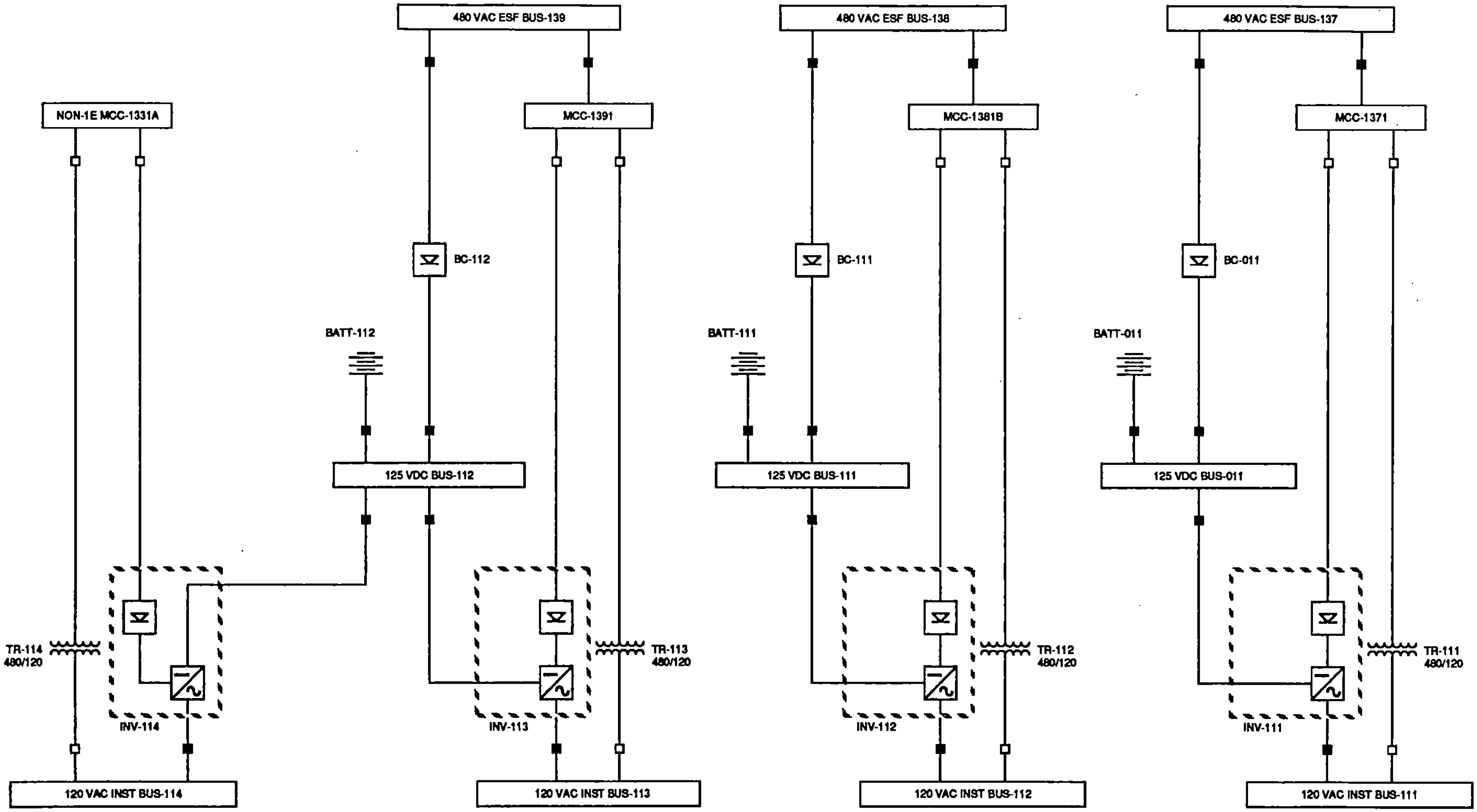


Figure 3.10-6. Zion 1 125 VDC and 120 VAC Electric Power Systems

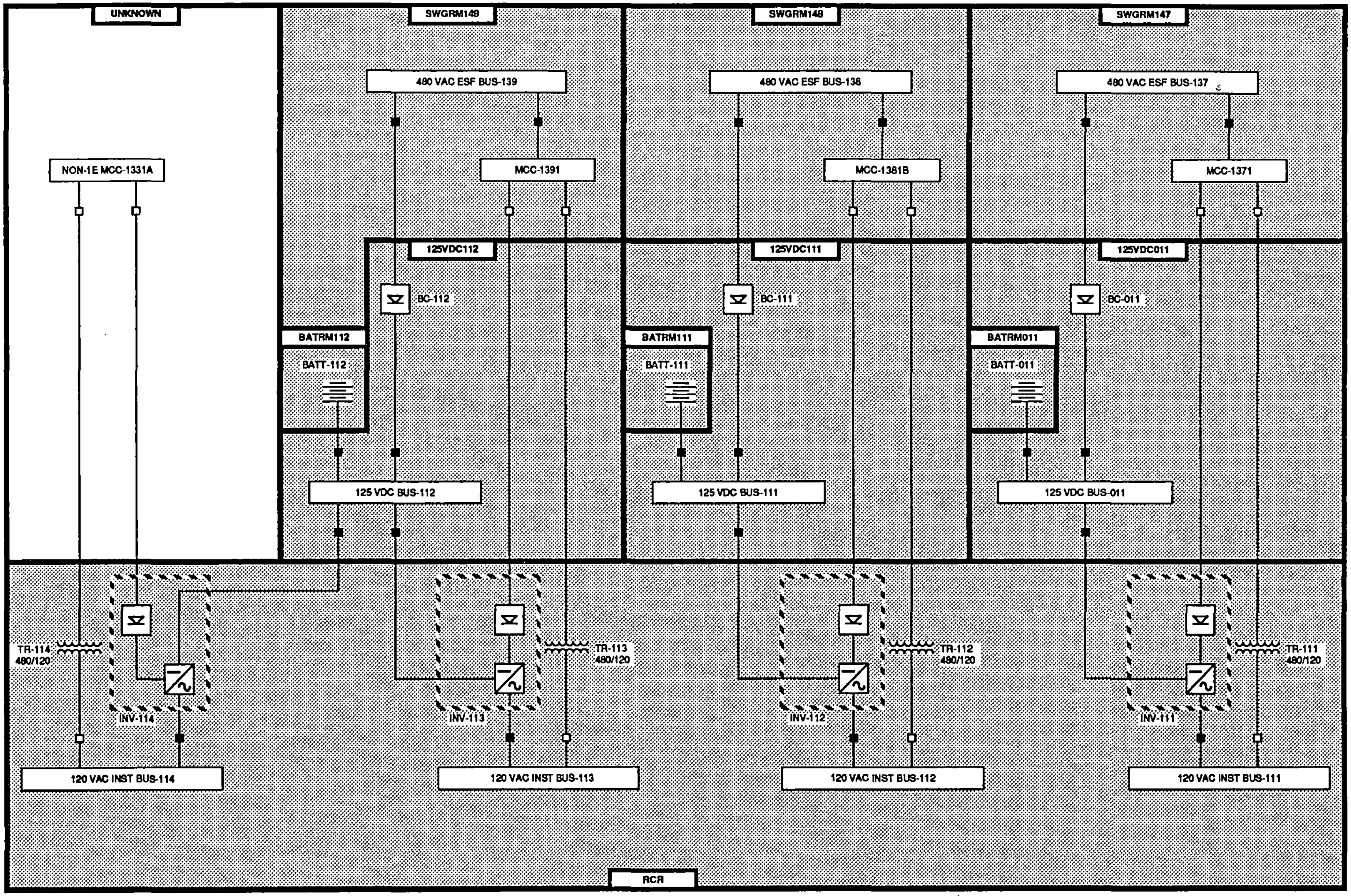


Figure 3.10-7. Zion 1 125 VDC and 120 VAC Electric Power Systems Showing Component Locations

Table 3.10-1. Zion 1 Electric Power System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
BATT-011	BATT	BATRM011		125		DC/0
BATT-111	BATT	BATRM111		125		DC/1
BATT-112	BATT	BATRM112		125		DC/2
BC-011	BC	125VDC011	BUS-137	125	SWGRM147	DC/0
BC-111	BC	125VDC111	BUS-138	125	SWGRM148	DC/1
BC-112	BC	125VDC112	BUS-139	125	SWGRM149	DC/2
BUS-111	BUS	RCR	INV-111	120	RCR	AC/17
BUS-111	BUS	RCR	TR-111	120	RCR	AC/17
BUS-112	BUS	RCR	INV-112	120	RCR	AC/18
BUS-112	BUS	RCR	TR-112	120	RCR	AC/18
BUS-113	BUS	RCR	INV-113	120	RCR	AC/19
BUS-113	BUS	RCR	TR-113	120	RCR	AC/19
BUS-114	BUS	RCR	INV-114	120	RCR	AC/19
BUS-137	BUS	SWGRM147	TR-137	480	SWGRM147	AC/17
BUS-138	BUS	SWGRM148	TR-138	480	SWGRM148	AC/18
BUS-139	BUS	SWGRM149	TR-139	480	SWGRM149	AC/19
BUS-147	BUS	SWGRM147	DG-0	4160	DG0	AC/17
BUS-148	BUS	SWGRM148	DG-1A	4160	DGA	AC/18
BUS-149	BUS	SWGRM149	DG-1B	4160	DGB	AC/19
CB-147	CB	SWGRM147	DG-0	4160	DG0	AC/17
CB-148	CB	SWGRM148	DG-1A	4160	DGA	AC/18
CB-149	CB	SWGRM149	DG-1B	4160	DGB	AC/19
DC-BUS-011	BUS	125VDC011	BATT-011	125	BATRM011	DC/0
DC-BUS-011	BUS	125VDC011	BC-011	125	125VDC011	DC/0
DC-BUS-111	BUS	125VDC111	BATT-111	125	BATRM111	DC/1
DC-BUS-111	BUS	125VDC111	BC-111	125	125VDC111	DC/1
DC-BUS-112	BUS	125VDC112	BATT-112	125	BATRM112	DC/2
DC-BUS-112	BUS	125VDC112	BC-112	125	125VDC112	DC/2
DG-0	DG	DG0		4160		AC/17
DG-1A	DG	DGA		4160		AC/18
DG-1B	DG	DGB		4160		AC/19

Table 3.10-1. Zion 1 Electric Power System Data Summary for Selected Components (Continued)

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
INV-111	INV	RCR	DC-BUS-011	120	125VDC011	DC/0
INV-111	INV	RCR	MCC-1371	120	SWGRM147	DC/0
INV-112	INV	RCR	DC-BUS-111	120	125VDC111	DC/1
INV-112	INV	RCR	MCC-1381B	120	SWGRM148	DC/1
INV-113	INV	RCR	DC-BUS-112	120	125VDC112	DC/2
INV-113	INV	RCR	MCC-1391	120	SWGRM149	DC/2
INV-114	INV	RCR	DC-BUS-112	120	125VDC112	DC2
MCC-1371	MCC	SWGRM147	BUS-137	480	SWGRM147	AC/17
MCC-1372	MCC	1372	BUS-137	480	SWGRM147	AC/17
MCC-1381B	MCC	SWGRM148	BUS-138	480	SWGRM148	AC/18
MCC-1383A	MCC	1383A	BUS-138	480	SWGRM148	AC/18
MCC-1383B	MCC	1383B	BUS-138	480	SWGRM148	AC/18
MCC-1391	MCC	SWGRM149	BUS-139	480	SWGRM149	AC/19
MCC-1393A	MCC	1393A	BUS-139	480	SWGRM149	AC/19
MCC-1393B	MCC	1393B	BUS-139	480	SWGRM149	AC/19
MCC-1393C	MCC	1393C	BUS-139	480	SWGRM149	AC/19
MCC-2393C	MCC	2393C	BUS-239	480	SWGRM249	AC/29
TR-111	TRAN	RCR	MCC-1371	120	SWGRM147	AC/17
TR-112	TRAN	RCR	MCC-1381B	120	SWGRM148	AC/18
TR-113	TRAN	RCR	MCC-1391	120	SWGRM149	AC/19
TR-137	TRAN	SWGRM147	BUS-147	480	SWGRM147	AC/17
TR-138	TRAN	SWGRM148	BUS-148	480	SWGRM148	AC/18
TR-139	TRAN	SWGRM149	BUS-149	480	SWGRM149	AC/19

Table 3.10-2. Partial listing of Electrical Sources and Loads at Zion 1

POWER SOURCE	VOLTAGE	EMERG. LOAD GROUP	POWER SOURCE LOCATION	SYSTEM	COMPONENT ID	COMP TYPE	LOCATION
BATT-011	125	DC/0	BATRM011	EP	DC-BUS-011	BUS	125VDC011
BATT-111	125	DC/1	BATRM111	EP	DC-BUS-111	BUS	125VDC111
BATT-112	125	DC/2	BATRM112	EP	DC-BUS-112	BUS	125VDC112
BC-011	125	DC/0	125VDC011	EP	DC-BUS-011	BUS	125VDC011
BC-111	125	DC/1	125VDC111	EP	DC-BUS-111	BUS	125VDC111
BC-112	125	DC/2	125VDC112	EP	DC-BUS-112	BUS	125VDC112
BUS-137	125	DC/0	SWGRM147	EP	BC-011	BC	125VDC011
BUS-137	480	AC/17	SWGRM147	EP	MCC-1371	MCC	SWGRM147
BUS-137	480	AC/17	SWGRM147	EP	MCC-1372	MCC	1372
BUS-138	480	AC/18	SWGRM148	CVCS	VC-P1C	PDP	CHPMC
BUS-138	125	DC/1	SWGRM148	EP	BC-111	BC	125VDC111
BUS-138	480	AC/18	SWGRM148	EP	MCC-1381B	MCC	SWGRM148
BUS-138	480	AC/18	SWGRM148	EP	MCC-1383A	MCC	1383A
BUS-138	480	AC/18	SWGRM148	EP	MCC-1383B	MCC	1383B
BUS-138	480	AC/18	SWGRM148	FW	FW-P8	MDP	CRIB
BUS-139	125	DC/2	SWGRM149	EP	BC-112	BC	125VDC112
BUS-139	480	AC/19	SWGRM149	EP	MCC-1391	MCC	SWGRM149
BUS-139	480	AC/19	SWGRM149	EP	MCC-1393A	MCC	1393A
BUS-139	480	AC/19	SWGRM149	EP	MCC-1393B	MCC	1393B
BUS-139	480	AC/19	SWGRM149	EP	MCC-1393C	MCC	1393C
BUS-147	4160	AC/17	SWGRM147	CCW	CCW-OE	MDP	560AB
BUS-147	4160	AC/17	SWGRM147	CVCS	VC-P1B	MDP	CHPMB
BUS-147	4160	AC/17	SWGRM147	ECCS	SI-P1A	MDP	SIA
BUS-147	480	AC/17	SWGRM147	EP	TR-137	TRAN	SWGRM147
BUS-147	4160	AC/17	SWGRM147	SW	SW-P1A	MDP	CRIB
BUS-148	4160	AC/18	SWGRM148	AFW	AFW-P1B	MDP	AFWS
BUS-148	4160	AC/18	SWGRM148	CCW	CCW-OD	MDP	560AB
BUS-148	4160	AC/18	SWGRM148	ECCS	RH-P1B	MDP	RHRB
BUS-148	4160	AC/18	SWGRM148	ECCS	SI-P1B	MDP	SIB
BUS-148	480	AC/18	SWGRM148	EP	TR-138	TRAN	SWGRM148
BUS-148	4160	AC/18	SWGRM148	SW	SW-P1B	MDP	CRIB

Table 3.10-2. Partial listing of Electrical Sources and Loads at Zion 1 (Continued)

POWER SOURCE	VOLTAGE	EMERG. LOAD GROUP	POWER SOURCE LOCATION	SYSTEM	COMPONENT ID	COMP TYPE	LOCATION
BUS-149	4160	AC/19	SWGRM149	AFW	AFW-P1C	MDP	AFWS
BUS-149	4160	AC/19	SWGRM149	CCW	CCW-OC	MDP	560AB
BUS-149	4160	AC/19	SWGRM149	CVCS	VC-P1A	MDP	CHPMA
BUS-149	4160	AC/19	SWGRM149	ECCS	RH-P1A	MDP	RHRA
BUS-149	480	AC/19	SWGRM149	EP	TR-139	TRAN	SWGRM149
BUS-149	4160	AC/19	SWGRM149	SW	SW-P1C	MDP	CRIB
BUS-239	480	AC/29	SWGRM249	EP	MCC-2393C	MCC	2393C
DC-BUS-011	120	DC/0	125VDC011	EP	INV-111	INV	RCR
DC-BUS-111	120	DC/1	125VDC111	EP	INV-112	INV	RCR
DC-BUS-112	120	DC/2	125VDC112	EP	INV-113	INV	RCR
DC-BUS-112	120	DC2	125VDC112	EP	INV-114	INV	RCR
DG-0	4160	AC/17	DG0	EP	BUS-147	BUS	SWGRM147
DG-0	4160	AC/17	DG0	EP	CB-147	CB	SWGRM147
DG-1A	4160	AC/18	DGA	EP	BUS-148	BUS	SWGRM148
DG-1A	4160	AC/18	DGA	EP	CB-148	CB	SWGRM148
DG-1B	4160	AC/19	DGB	EP	BUS-149	BUS	SWGRM149
DG-1B	4160	AC/19	DGB	EP	CB-149	CB	SWGRM149
DIESEL			CRIB	FW	FW-P7	DDP	CRIB
INV-111	120	AC/17	RCR	EP	BUS-111	BUS	RCR
INV-112	120	AC/18	RCR	EP	BUS-112	BUS	RCR
INV-113	120	AC/19	RCR	EP	BUS-113	BUS	RCR
INV-114	120	AC/19	RCR	EP	BUS-114	BUS	RCR
MCC-1371	480	AC/17	SWGRM147	AFW	AFW-17	MOV	STMTUN
MCC-1371	480	AC/17	SWGRM147	AFW	AFW-5	MOV	STMTUN
MCC-1371	480	AC/17	SWGRM147	CVCS	SI-8800A	MOV	FC
MCC-1371	480	AC/17	SWGRM147	CVCS	SI-8800C	MOV	FC
MCC-1371	480	AC/17	SWGRM147	CVCS	SI-8801A	MOV	579PP
MCC-1371	480	AC/17	SWGRM147	CVCS	SI-8803A	MOV	579PP
MCC-1371	480	AC/17	SWGRM147	CVCS	VC-8105	MOV	579PP
MCC-1371	480	AC/17	SWGRM147	ECCS	SI-8800A	MOV	FC
MCC-1371	480	AC/17	SWGRM147	ECCS	SI-8800C	MOV	FC

Table 3.10-2. Partial listing of Electrical Sources and Loads at Zion 1 (Continued)

POWER SOURCE	VOLTAGE	EMERG. LOAD GROUP	POWER SOURCE LOCATION	SYSTEM	COMPONENT ID	COMP TYPE	LOCATION
MCC-1371	480	AC/17	SWGRM147	ECCS	SI-8801A	MOV	579PP
MCC-1371	480	AC/17	SWGRM147	ECCS	SI-8803A	MOV	579PP
MCC-1371	480	AC/17	SWGRM147	ECCS	VC-8105	MOV	579PP
MCC-1371	120	DC/0	SWGRM147	EP	INV-111	INV	RCR
MCC-1371	120	AC/17	SWGRM147	EP	TR-111	TRAN	RCR
MCC-1371	480	AC/17	SWGRM147	FW	SW-110	MOV	DG0
MCC-1371	480	AC/17	SWGRM147	SW	SW-17	MOV	DGLOB
MCC-1371	480	AC/17	SWGRM147	SW	SW-19	MOV	DGLOA
MCC-1372	480	AC/17	1372	CVCS	SI-8800D	MOV	RC
MCC-1372	480	AC/17	1372	CVCS	SI-8923	MOV	SIA
MCC-1372	480	AC/17	1372	CVCS	VC-112D	MOV	RWST
MCC-1372	480	AC/17	1372	ECCS	SI-8800D	MOV	RC
MCC-1372	480	AC/17	1372	ECCS	SI-8923A	MOV	SIA
MCC-1372	480	AC/17	1372	ECCS	SI-9010A	MOV	SIA
MCC-1372	480	AC/17	1372	ECCS	SI-9011A	MOV	579PP
MCC-1381A	480	AC/18	SWGRM148	AFW	AFW-6	MOV	579PP
MCC-1381A	480	AC/18	SWGRM148	FW	SW-108	MOV	DGA
MCC-1381A	480	AC/18	SWGRM148	RCS	RH-8702	MOV	RC
MCC-1381A	480	AC/18	SWGRM148	SW	SW-16	MOV	DGLOB
MCC-1381B	480	AC/18	SWGRM148	AFW	AFW-18	MOV	STMTUN
MCC-1381B	480	AC/18	SWGRM148	ECCS	CCW-9412B	MOV	RHRHXB
MCC-1381B	120	DC/1	SWGRM148	EP	INV-112	INV	RCR
MCC-1381B	120	AC/18	SWGRM148	EP	TR-112	TRAN	RCR
MCC-1383A	480	AC/18	1383A	AFW	AFW-50	MOV	579PP
MCC-1383A	480	AC/18	1383A	AFW	AFW-53	MOV	579PP
MCC-1383A	480	AC/18	1383A	AFW	AFW-55	MOV	579PP
MCC-1383A	480	AC/18	1383A	AFW	AFW-56	MOV	579PP
MCC-1383A	480	AC/18	1383A	AFW	AFW-74	MOV	AFWS
MCC-1383A	480	AC/18	1383A	AFW	SW-101	MOV	AFWS
MCC-1383A	480	AC/18	1383A	AFW	SW-104	MOV	AFWS
MCC-1383A	480	AC/18	1383A	AFW	SW-106	MOV	AFWS

Table 3.10-2. Partial listing of Electrical Sources and Loads at Zion 1 (Continued)

POWER SOURCE	VOLTAGE	EMERG. LOAD GROUP	POWER SOURCE LOCATION	SYSTEM	COMPONENT ID	COMP TYPE	LOCATION
MCC-1383A	480	AC/18	1383A	AFW	SW-107	MOV	AFWS
MCC-1383A	480	AC/18	1383A	CVCS	SI-8806	MOV	RWST
MCC-1383A	480	AC/18	1383A	ECCS	SI-8802	MOV	579PP
MCC-1383A	480	AC/18	1383A	ECCS	SI-8804B	MOV	SIB
MCC-1383A	480	AC/18	1383A	ECCS	SI-8804B	MOV	RWST
MCC-1383A	480	AC/18	1383A	ECCS	SI-8806	MOV	RWST
MCC-1383A	480	AC/18	1383A	ECCS	SI-8811B	MOV	RWST
MCC-1383A	480	AC/18	1383A	ECCS	SI-8923B	MOV	SIB
MCC-1383A	480	AC/18	1383A	SW	SW-3	MOV	CRIB
MCC-1383A	480	AC/18	1383A	SW	SW-3	MOV	CRIB
MCC-1383A	480	AC/18	1383A	SW	SW-7	MOV	542AB
MCC-1383B	480	AC/18	1383B	CVCS	SI-8807B	MOV	RWST
MCC-1383B	480	AC/18	1383B	ECCS	SI-8807B	MOV	RWST
MCC-1383B	480	AC/18	1383B	ECCS	SI-9010B	MOV	SIB
MCC-1383B	480	AC/18	1383B	ECCS	SI-9011B	MOV	579PP
MCC-1391	480	AC/19	SWGRM149	AFW	AFW-11	MOV	STMTUN
MCC-1391	480	AC/19	SWGRM149	AFW	AFW-19	MOV	STMTUN
MCC-1391	480	AC/19	SWGRM149	AFW	AFW-20	MOV	STMTUN
MCC-1391	480	AC/19	SWGRM149	ECCS	CCW-9412A	MOV	RHRHXA
MCC-1391	120	DC/2	SWGRM149	EP	INV-113	INV	RCR
MCC-1391	120	AC/19	SWGRM149	EP	TR-113	TRAN	RCR
MCC-1391	480	AC/19	SWGRM149	FW	SW-109	MOV	DGB
MCC-1391	480	AC/19	SWGRM149	RCS	RH-8701	MOV	RC
MCC-1391	480	AC/19	SWGRM149	SW	SW-18	MOV	DGLOA
MCC-1393A	480	AC/19	1393A	AFW	AFW-51	MOV	579PP
MCC-1393A	480	AC/19	1393A	AFW	AFW-54	MOV	579PP
MCC-1393A	480	AC/19	1393A	AFW	AFW-76	MOV	AFWS
MCC-1393A	480	AC/19	1393A	AFW	SW-102	MOV	AFWS
MCC-1393A	480	AC/19	1393A	AFW	SW-103	MOV	AFWS
MCC-1393A	480	AC/19	1393A	CVCS	SI-8800B	MOV	RC
MCC-1393A	480	AC/19	1393A	CVCS	SI-8807A	MOV	RWST

Table 3.10-2. Partial listing of Electrical Sources and Loads at Zion 1 (Continued)

POWER SOURCE	VOLTAGE	EMERG. LOAD GROUP	POWER SOURCE LOCATION	SYSTEM	COMPONENT ID	COMP TYPE	LOCATION
MCC-1393A	480	AC/19	1393A	CVCS	VC-112E	MOV	RWST
MCC-1393A	480	AC/19	1393A	ECCS	SI-8800B	MOV	RC
MCC-1393A	480	AC/19	1393A	ECCS	SI-8804A	MOV	MAZE
MCC-1393A	480	AC/19	1393A	ECCS	SI-8804A	MOV	MAZE
MCC-1393A	480	AC/19	1393A	ECCS	SI-8807A	MOV	RWST
MCC-1393A	480	AC/19	1393A	ECCS	SI-8811A	MOV	RWST
MCC-1393A	480	AC/19	1393A	RCS	RCS-8000A	MOV	RC
MCC-1393A	480	AC/19	1393A	RCS	RCS-8000B	MOV	RC
MCC-1393A	480	AC/19	1393A	SW	SW-12	MOV	560AB
MCC-1393A	480	AC/19	1393A	SW	SW-14	MOV	560AB
MCC-1393A	480	AC/19	1393A	SW	SW-2	MOV	560AB
MCC-1393A	480	AC/19	1393A	SW	SW-8	MOV	542AB
MCC-1393B	480	AC/18	1393B	AFW	AFW-75	MOV	AFWS
MCC-1393B	480	AC/19	1393B	CVCS	SI-8801B	MOV	579PP
MCC-1393B	480	AC/19	1393B	CVCS	SI-8803B	MOV	579PP
MCC-1393B	480	AC/19	1393B	ECCS	SI-8801B	MOV	579PP
MCC-1393B	480	AC/19	1393B	ECCS	SI-8803B	MOV	579PP
MCC-1393C	480	AC/19	1393C	AFW	AFW-52	MOV	579PP
MCC-1393C	480	AC/19	1393C	AFW	AFW-57	MOV	579PP
MCC-1393C	480	AC/19	1393C	AFW	SW-105	MOV	AFWS
MCC-1393C	480	AC/19	1393C	CVCS	VC-8106	MOV	579PP
MCC-1393C	480	AC/19	1393C	ECCS	VC-8106	MOV	579PP
MCC-1393C	480	AC/19	1393C	SW	SW-4	MOV	CRIB
MCC-1393C	480	AC/19	1393C	SW	SW-4	MOV	CRIB
MCC-2393C	480	AC/29	2393C	SW	SW-13	MOV	560AB
MCC-2393C	480	AC/29	2393C	SW	SW-15	MOV	560AB
TR-111	120	AC/17	RCR	EP	BUS-111	BUS	RCR
TR-112	120	AC/18	RCR	EP	BUS-112	BUS	RCR
TR-113	120	AC/19	RCR	EP	BUS-113	BUS	RCR
TR-137	480	AC/17	SWGRM147	EP	BUS-137	BUS	SWGRM147
TR-138	480	AC/18	SWGRM148	EP	BUS-138	BUS	SWGRM148

Table 3.10-2. Partial listing of Electrical Sources and Loads at Zion 1 (Continued)

POWER SOURCE	VOLTAGE	EMERG. LOAD GROUP	POWER SOURCE LOCATION	SYSTEM	COMPONENT ID	COMP TYPE	LOCATION
TR-139	480	AC/19	SWGRM149	EP	BUS-139	BUS	SWGRM149
UNKNOWN	UNKNOWN	NON-CLASS 1E	UNKNOWN	RCS	P1A	MDP	RC
UNKNOWN	UNKNOWN	NON-CLASS 1E	UNKNOWN	RCS	P1B	MDP	RC
UNKNOWN	UNKNOWN	NON-CLASS 1E	UNKNOWN	RCS	P1C	MDP	RC
UNKNOWN	UNKNOWN	NON-CLASS 1E	UNKNOWN	RCS	P1D	MDP	RC

3.11 COMPONENT COOLING WATER SYSTEM (CCWS)

3.11.1 System Function

The CCWS serves to remove heat from the reactor auxiliaries and RHR heat exchangers and to transfer it to the Service Water System for rejection to the ultimate heat sink. The CCWS ensures continuous operation or safe shutdown of the plant under all modes of operation. The CCWS serves as an intermediate system between the RCS and SWS, thereby reducing the probability of leakage of potentially radioactive coolant.

3.11.2 System Definition

The CCWS is a closed loop cooling water system designed to remove heat from safety-related ECCS components and various other non-essential components. The system is shared by the two units. The system consists of five pumps, three heat exchangers, and two surge tanks. Flow to the cooled components is arranged in parallel flow circuits. Heat is rejected in the CCWS heat exchangers to the Service Water System. There are three main loops for each unit, loop A serves train A ECCS components, loop B serves train B ECCS components, and loop C serves non-essential components as follows:

<u>Loop A</u>
Charging Pump 1C
Charging Pump 1B
SI Pump 1A
RHR Pump 1A
RHR HX1A

<u>Loop B</u>
Charging Pump 1A
SI Pump 1B
RHR Pump 1B
RHR HX1B

<u>Loop C</u>
RCS reciculation pumps
Other non-essential heat loads

Simplified drawings of the CCWS are shown in Figures 3.11-1 and 3.11-2. A summary of data on selected CCWS components is presented in Table 3.11-1.

3.11.3 System Operation

During normal operation two pumps and two heat exchangers are capable of serving all operating components in both units. Three pumps and two heat exchangers are required for the removal of residual and sensible heat from the RCS via the RHR system during cooldown of one unit with the other unit remaining at full power operation.

In the event of LOCA in one plant, one pump and one heat exchanger are capable of fulfilling system requirements. The remaining components serve as backup and/or additional capacity.

CCW pumps A and B and heat exchanger 2 are normally aligned to serve Unit 2 components. Pumps D and E and heat exchanger 1 normally serve Unit 1 components. Pump C and heat exchanger 0 serve either unit. However, all five pumps supply a common header to the heat exchangers, which in turn supply a common header to the cooling loops, so any pump and heat exchanger can cool any component in either unit.

The CCW heat exchangers transfer heat to the Service Water System. The CCW surge tanks are connected to the suction side of the pumps, and accommodate fluid expansion and contraction in the system (Ref. 1).

3.11.4 System Success Criteria

Following a LOCA in one unit, one CCW pump and one heat exchanger are capable of fulfilling system requirements (Ref.1, Section 9.3.2). The Service Water System (see Section 3.12) is required to remove heat from the CCWS.

3.11.5 Component Information

A. Component Cooling Water pumps A, B, C, D, E
   1. Rated flow: 4600 gpm @ 200 ft head (87 psid)
   2. Rated capacity: 100%
   3. Type: Horizontal centrifugal

B. Component Cooling Water heat exchangers 0, 1, 2
   1. Heat transferred: 53×10^6 Btu/hr
   2. Type: Shell and U-tube

C. Surge tanks (2)
   1. Total Volume: 2000 gallons
   2. Normal water volume: 1000 gallons

3.11.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      CCWS lines into containment are automatically isolated following a LOCA. The CCWS pumps are not automatically actuated.
   2. Remote manual
      The CCWS can be operated from the control room.

B. Motive Power
   The motor driven CCWS pumps and motor operated valves are Class 1E loads that can be supplied from the standby diesel generators as described in Section 3.10.

C. Other
   Lubrication, cooling, and ventilation are assumed to be provided locally for the CCWS pumps.

3.11.7 Section 3.11 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 9.3.

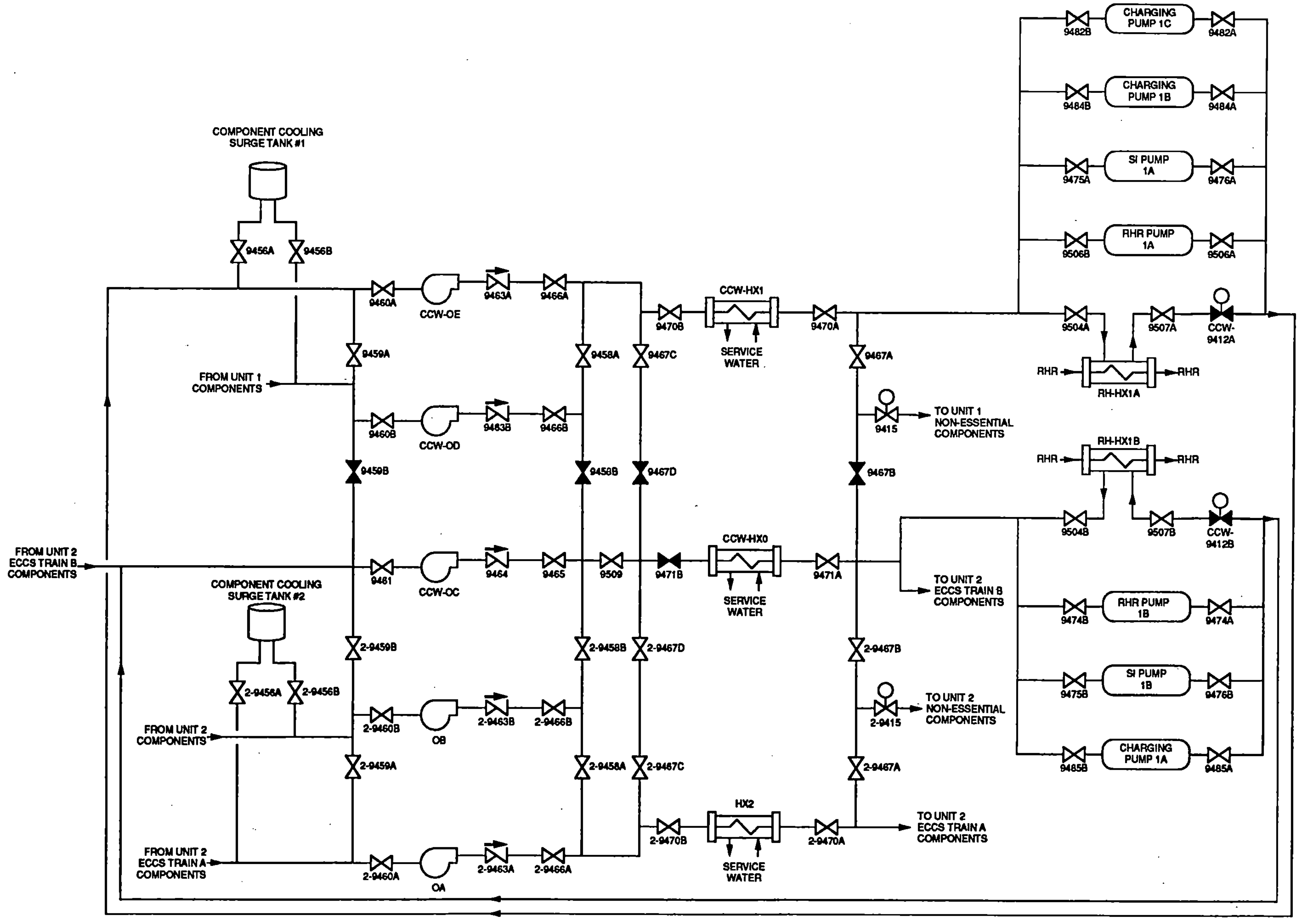


Figure 3.11-1. Zion 1 and 2 Component Cooling Water System

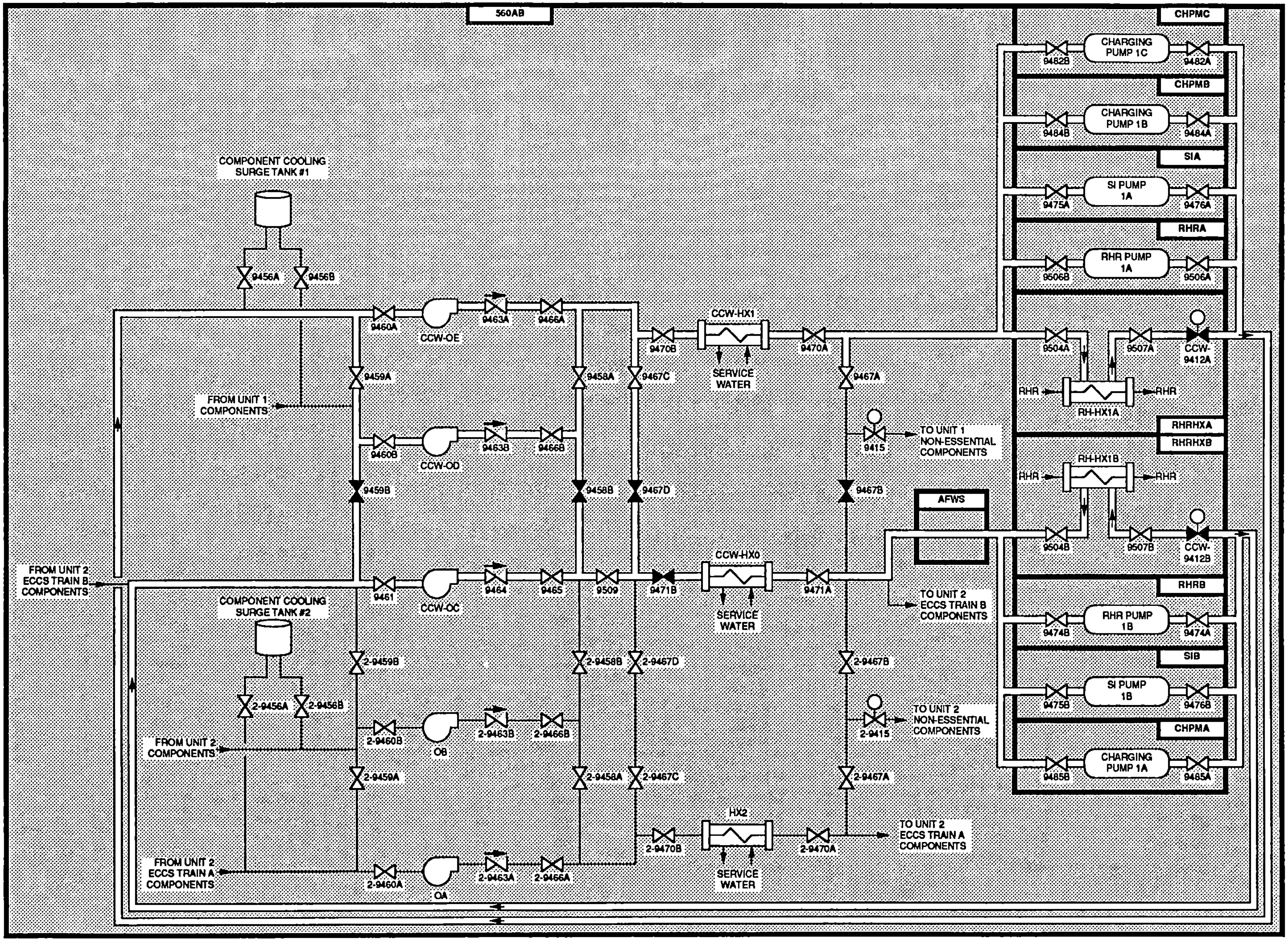


Figure 3.11-2. Zion 1 and 2 Component Cooling Water System Showing Component Locations

Table 3.11-1. Zion 1 Component Cooling Water System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
CCW-HX0	HX	560AB				
CCW-HX1	HX	560AB				
CCW-OC	MDP	560AB	BUS-149	4160	SWGRM149	AC/19
CCW-OD	MDP	560AB	BUS-148	4160	SWGRM148	AC/18
CCW-OE	MDP	560AB	BUS-147	4160	SWGRM147	AC/17

3.12 SERVICE WATER SYSTEM (SWS)

3.12.1 System Function

The SWS supplies all the equipment cooling water for the plant, including the emergency shutdown requirements and transfers the heat removed from the plant components to Lake Michigan (the ultimate heat sink). The SWS can also deliver water to the suction of the auxiliary feedwater pumps, thereby serving as a backup water source to the condensate storage tank.

3.12.2 System Definition

The SWS is an open loop system that serves both units. The system consists of six pumps that feed two separate main supply headers, one header for each unit and three pumps on each header. The headers are crosstied so that any combination of pumps can serve both units during normal operating conditions. The pumps take suction from the crib house forebay. A listing of safety-related SWS heat loads is provided below (Ref. 1).

- Diesel generators 0, 1A, 1B, 2A, and 2B
- Containment coolers for units 1 and 2
- Component cooling water heat exchangers 0, 1 and 2
- Various air conditioning and ventilation coolers and condensers

Simplified drawings of the SWS are shown in Figures 3.12-1 and 3.12-2. A summary of data on selected SWS components is presented in Table 3.12-1.

3.12.3 System Operation

During normal operation two pumps on each unit are running with the third pump serving as a standby. The system pressure is maintained at 55-75 psig in the main supply header. The third pump will automatically start if header pressure decreases to 50 psig. Under emergency shutdown and accident conditions, one pump is required for each unit.

Each service water pump is powered by a separate 4160 VAC bus. The five diesel generators are sized to accommodate one service water pump in addition to the other engineered safeguards loads.

3.12.4 System Success Criteria

Under emergency shutdown and accident conditions, system success can be achieved by one service water pump in each unit (Ref.1, Section 9.6.3).

3.12.5 Component Information

A. Service Water pumps 1A, 1B, 1C
   1. Rated flow: 22,000 gpm @ 210 ft head (91 psid)
   2. Rated capacity: 100%

3.12.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      During normal operation with two SWS pumps running per unit, the third pump will be automatically started if system pressure decreases to 50 psig.
   2. Remote Manual
      The SWS pumps can be operated from the control room.

B. Motive Power
The motor driven SWS pumps and motor-operated valves are Class 1E loads that can be supplied from the standby diesel generators as described in Section 3.10.

C. Other
Lubrication, cooling, and ventilation are assumed to be provided locally for the SWS pumps.

3.12.7 Section 3.12 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 9.6.

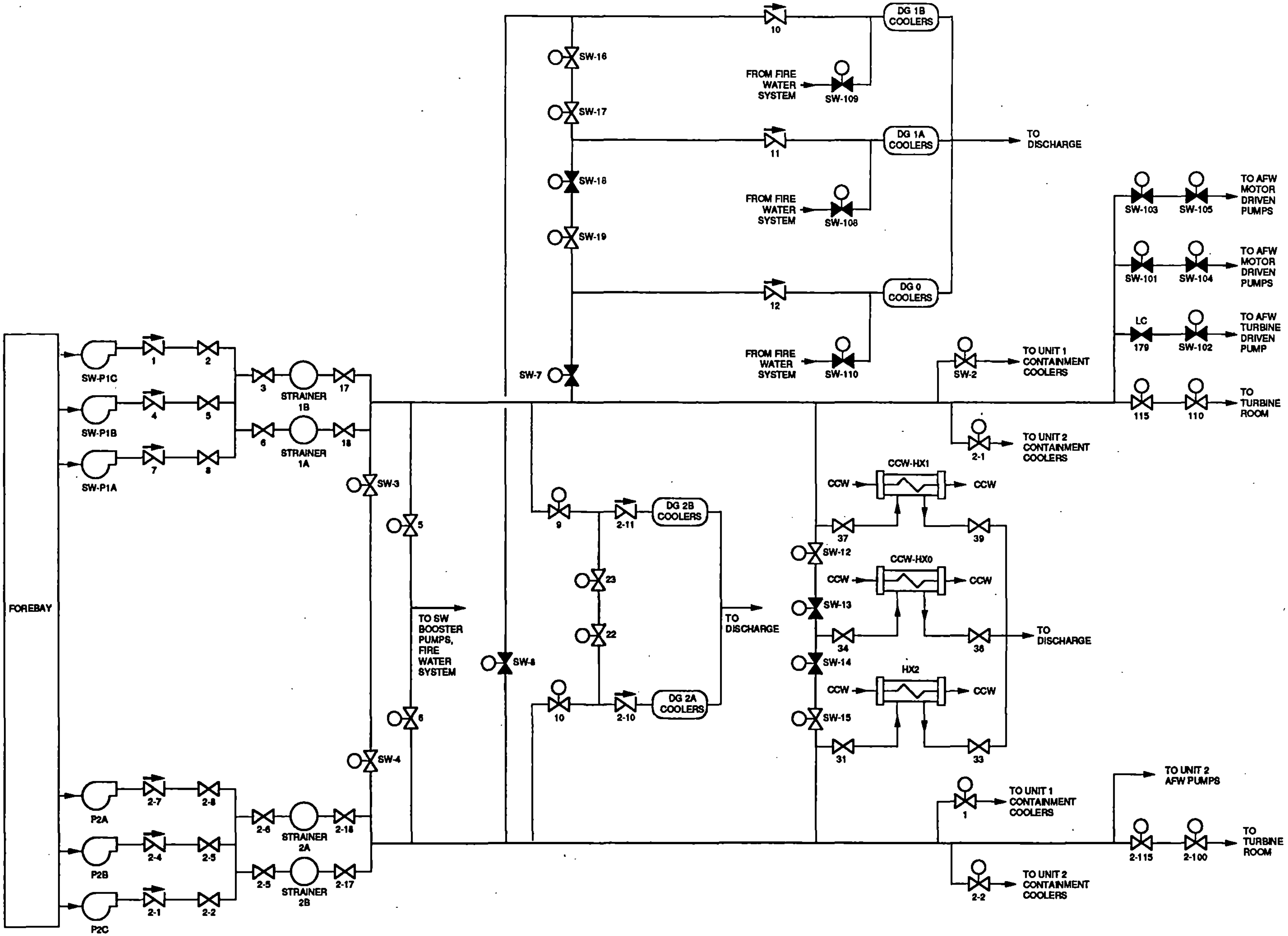


Figure 3.12-1. Zion 1 and 2 Service Water System

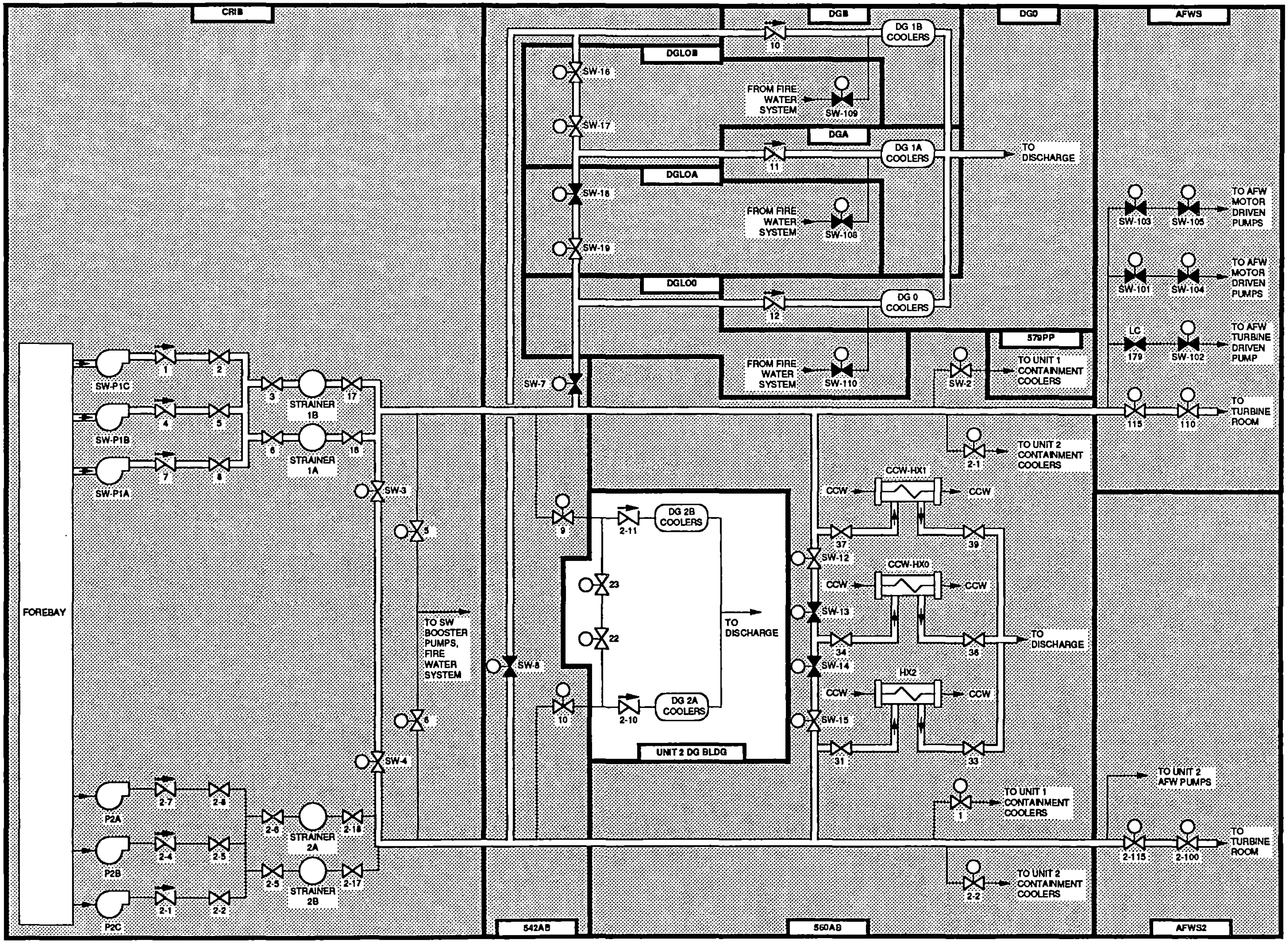


Figure 3.12-2. Zion 1 and 2 Service Water System Showing Component Locations

Table 3.12-1. Zion 1 Service Water System Data Summary
for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
SW-12	MOV	560AB	MCC-1393A	480	1393A	AC/19
SW-13	MOV	560AB	MCC-2393C	480	2393C	AC/29
SW-14	MOV	560AB	MCC-1393A	480	1393A	AC/19
SW-15	MOV	560AB	MCC-2393C	480	2393C	AC/29
SW-16	MOV	DGLOB	MCC-1381A	480	SWGRM148	AC/18
SW-17	MOV	DGLOB	MCC-1371	480	SWGRM147	AC/17
SW-18	MOV	DGLOA	MCC-1391	480	SWGRM149	AC/19
SW-19	MOV	DGLOA	MCC-1371	480	SWGRM147	AC/17
SW-2	MOV	560AB	MCC-1393A	480	1393A	AC/19
SW-3	MOV	CRIB	MCC-1383A	480	1383A	AC/18
SW-3	MOV	CRIB	MCC-1383A	480	1383A	AC/18
SW-4	MOV	CRIB	MCC-1393C	480	1393C	AC/19
SW-4	MOV	CRIB	MCC-1393C	480	1393C	AC/19
SW-7	MOV	542AB	MCC-1383A	480	1383A	AC/18
SW-8	MOV	542AB	MCC-1393A	480	1393A	AC/19
SW-P1A	MDP	CRIB	BUS-147	4160	SWGRM147	AC/17
SW-P1B	MDP	CRIB	BUS-148	4160	SWGRM148	AC/18
SW-P1C	MDP	CRIB	BUS-149	4160	SWGRM149	AC/19

3.13 FIRE WATER SYSTEM (FWS)

3.13.1 System Function

The fire water system provides fire protection throughout the plant. Plant fire protection is provided by a loop fire header distribution system utilizing fire hydrants, fire hose reels, fixed water sprinkler spray systems, and water deluge systems. The fire water system can also provide cooling water to the emergency diesel generators when normal cooling from the service water system is unavailable.

3.13.2 System Definition

The fire system consists of two pumps, one-diesel-driven and one motor-driven. The pumps supply water to the plant fire header distribution loop. The fire protection system is normally supplied with water by the service water booster pumps, which take their suction from the service water system.

Simplified drawings of the portion of the fire water system that provides backup diesel generator cooling are shown in Figures 3.13-1 and 3.13-2. A summary of data on selected fire water system components is presented in Table 3.13-1.

3.13.3 System Operation

A looped 10 inch yard main encircles the entire plant with fire hydrants spaced at approximately 250 foot intervals. The various buildings are supplied from headers off of the main sprinklers and deluge systems are actuated by heat detecting devices. Alarms and interlocks are provided to indicate operation of the system.

The fire system is normally supplied with water and maintained at a pressure of 125 to 140 psig by the service water booster pumps. Under LOCA conditions the suction lines to these pumps are isolated from the service water header by motor-operated valves.

Whenever the fire protection system header falls to 110 psig, the motor-driven fire pump will automatically start. If this pump fails to start or is unable to satisfy the demands of the fire system the diesel-driven fire pump will automatically start at a header pressure of 100 psig. The diesel-driven pump is battery started and does not require any external electrical power for operation. Both pumps take their suction from the crib house forebay.

If both fire pumps and both service water booster pumps are unavailable, water can be supplied to the fire system headers through a bypass around the service water booster pumps.

3.13.4 System Success Criteria

The Zion 1 and 2 FSAR (Ref. 1, Section 9.9.3) implies that either the motor-driven or the diesel-driven fire water pump can successfully supply the needs of the fire system, including providing cooling water to the diesel generators.

3.13.5 Component Information

A. Fire water pumps P7, P8
   1. Rated flow: 2000 gpm @ 141 ft head (61 psid)
   2. Rated capacity: 100%

3.13.6 Support Systems and Interfaces

A. Control Signals
   1. Automatic
      The motor-driven fire pump is automatically started when system pressure decreases to 110 psig. The diesel-driven fire pump is automatically started when system pressure decreases to 100 psig.

2. Remote Manual
   The fire pumps can be operated from the control room.

B. Motive Power
1. The motor-driven fire pump is a Class 1E load that can be supplied from the standby diesel generators as described in Section 3.10.
2. The diesel-driven fire pump is powered by its own diesel engine.

C. Other
Lubrication, cooling, and ventilation are assumed to be provided locally for the fire pumps.

3.13.7 Section 3.13 References

1. Zion 1 and 2 Final Safety Analysis Report, Section 9.9.

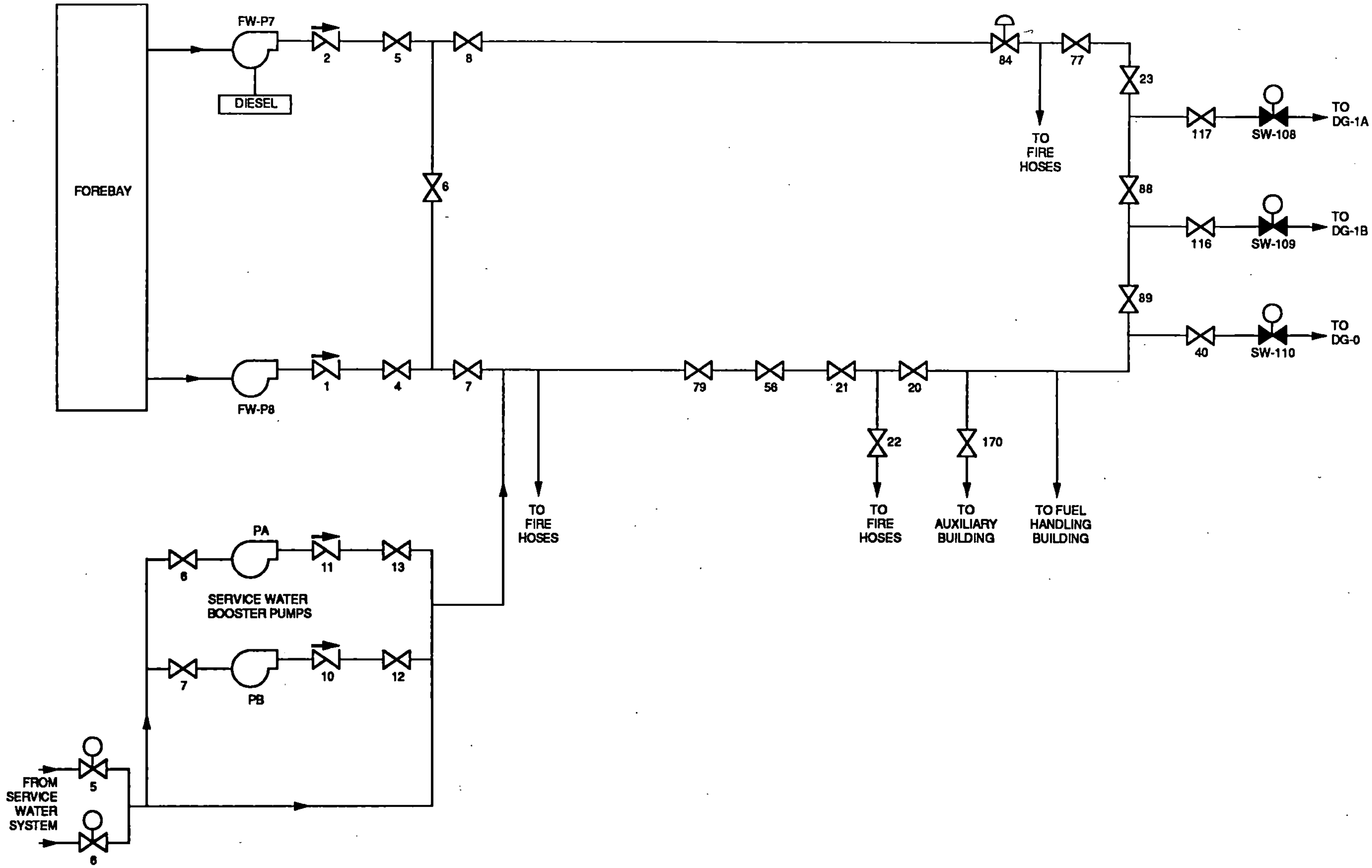


Figure 3.13-1. Zion 1 and 2 Fire Water System Flow Paths For Backup Diesel Generator Cooling

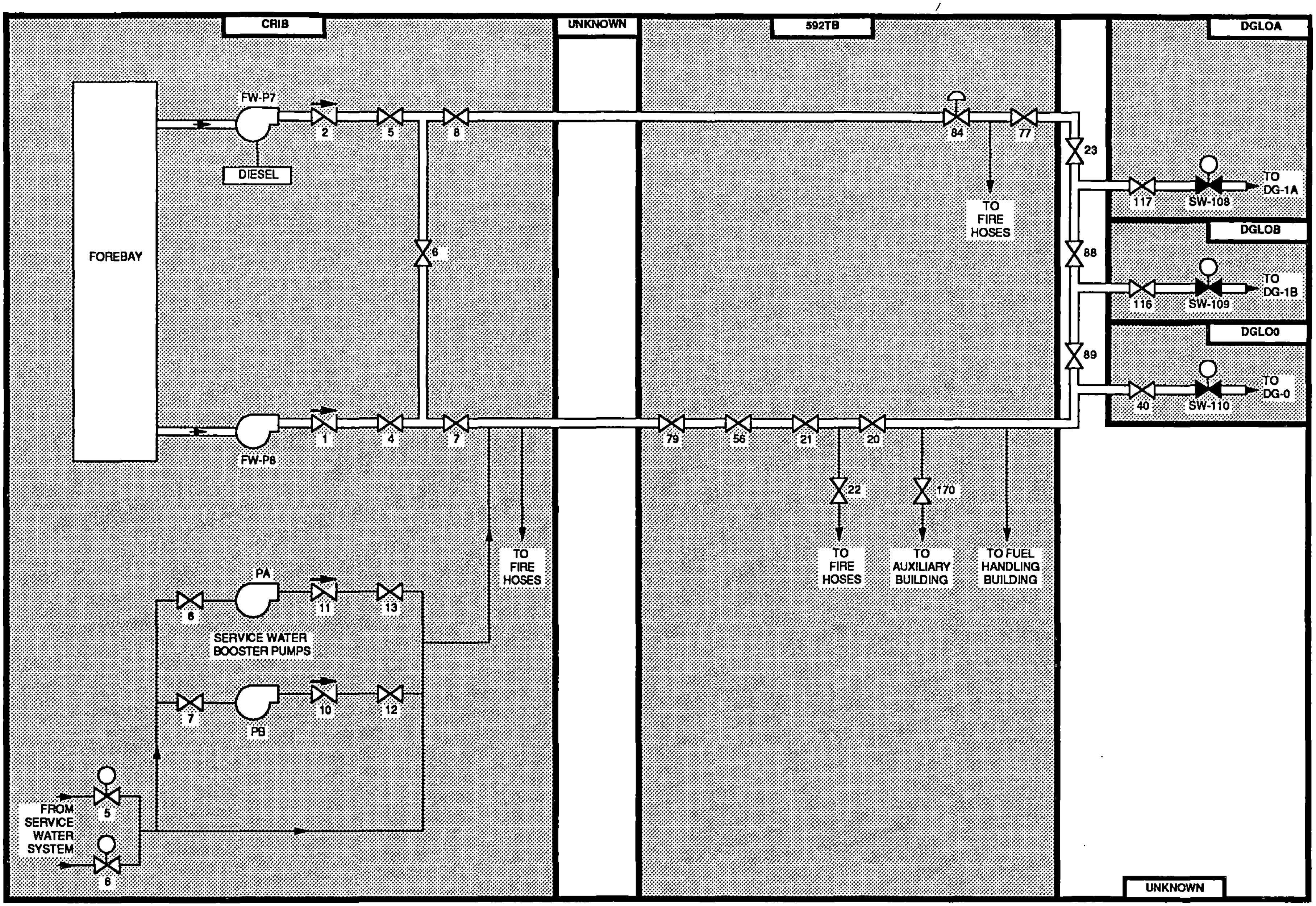


Figure 3.13-2. Zion 1 and 2 Fire Water System Flow Paths For Backup Diesel Generator Cooling Showing Component Locations

Table 3.13-1. Zion 1 Fire Water System Data Summary for Selected Components

COMPONENT ID	COMP TYPE	LOCATION	POWER SOURCE	VOLTAGE	POWER SOURCE LOCATION	EMERG. LOAD GROUP
FW-P7	DDP	CRIB	DIESEL		CRIB	
FW-P8	MDP	CRIB	BUS-138	480	SWGRM148	AC/18
SW-108	MOV	DGA	MCC-1381A	480	SWGRM148	AC/18
SW-109	MOV	DGB	MCC-1391	480	SWGRM149	AC/19
SW-110	MOV	DG0	MCC-1371	480	SWGRM147	AC/17

4. PLANT INFORMATION

4.1 SITE AND BUILDING SUMMARY

The Zion 1 and 2 site is located in the city of Zion, Illinois, on the west shore of Lake Michigan, approximately 6 miles north-northeast of the center of the city of Waukegan, Illinois, and 8 miles south of the center of the city of Kenosha, Wisconsin. The site is about 40 miles north of Chicago and about 42 miles south of Milwaukee. Figure 4-1 (from Ref. 1) shows a general view of the site, while Figure 4-2 shows a simplified plot plan.

The major structures include a separate and independent containment for each reactor, a common auxiliary building, a common fuel handling building, a common turbine building, and a common administrative and service building.

The reactor containments contain the RCS and portions of the AFWS, ECCS, and CVCS for each unit. The Unit 2 containment is located north of the Unit 1 containment.

The auxiliary building, located east of the containments, contains the major engineered safety features components. Components of the AFWS, ECCS, CVCS, CCWS, and electric power system are located in the auxiliary building. The control room is also located in the auxiliary building.

The fuel handling building is located between the two containments and contains the spent fuel pool. The turbine building is located east of the auxiliary building and contains components of the power conversion system.

The crib house is located on Lake Michigan and contains the service water pumps for both units, as well as the fire water pumps.

4.2 FACILITY LAYOUT DRAWINGS

Section views of the Zion plant are shown in Figure 4-3. Figures 4-4 through 4-10 are simplified building layout drawings for the Zion 1 and 2 containment, auxiliary building, fuel handling building and control building. The intake structure is shown in Figure 4-11. Major rooms, stairways, elevators, and doorways are shown in the simplified layout drawings, however, many interior walls have been omitted for clarity. Labels printed in uppercase correspond to the location codes listed in Table 4-1 and used in the component data listings and system drawings in Section 3. Some additional labels are included for information and are printed in lowercase type.

A listing of components by location is presented in Table 4-2. Components included in Table 4-2 are those found in the system data tables in Section 3, therefore this table is only a partial listing of the components and equipment that are located in a particular room or area of the plant.

4.3 SECTION 4.0 REFERENCES

1. Heddleson, F.A., "Design Data and Safety Features of Commercial Nuclear Power Plants.", ORNL-NSIC-55, Volume I, Oak Ridge National Laboratory, Nuclear Safety Information Center, December 1973.

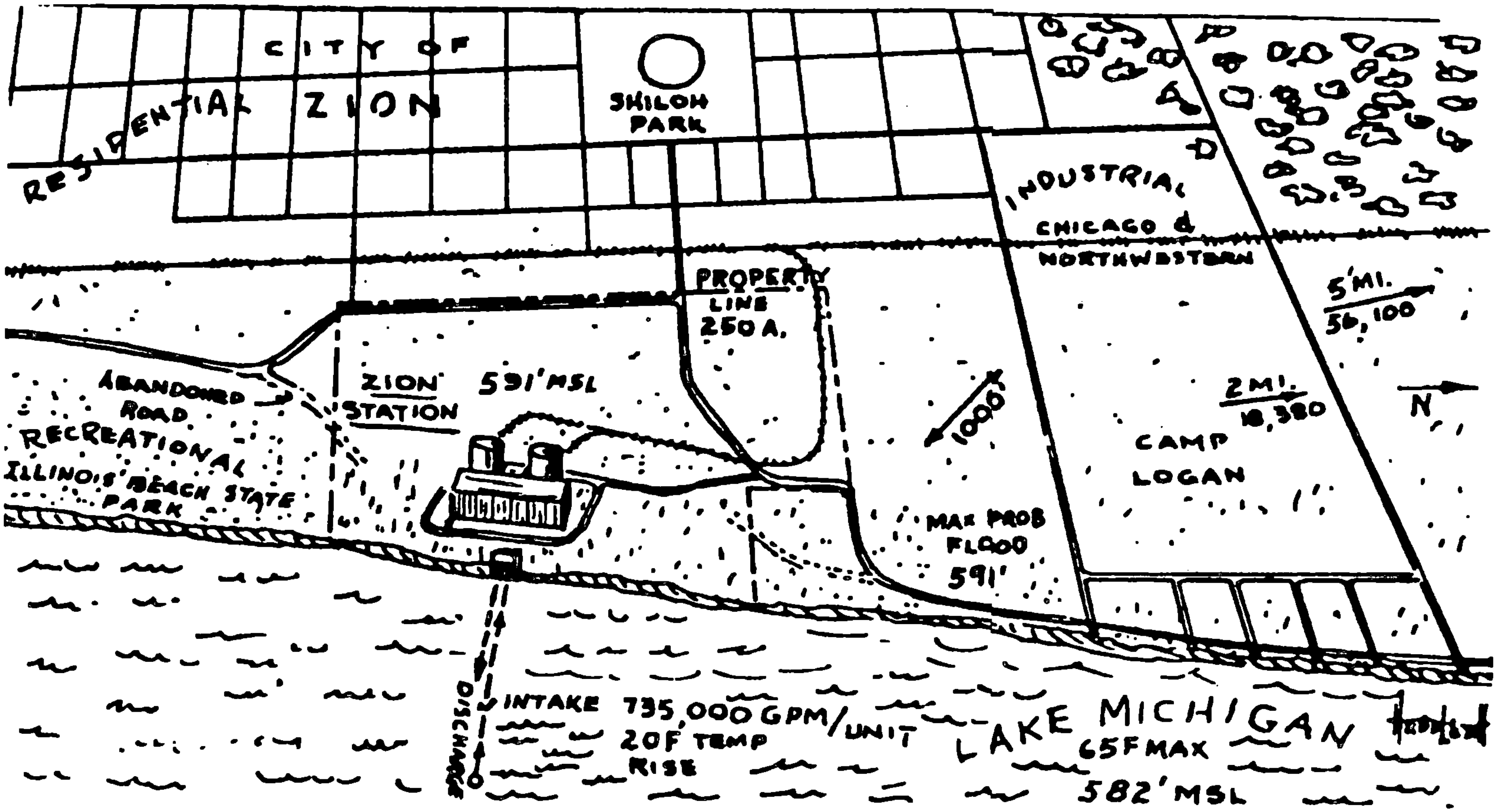


Figure 4-1. General View of Zion 1 and 2 Site and Vicinity

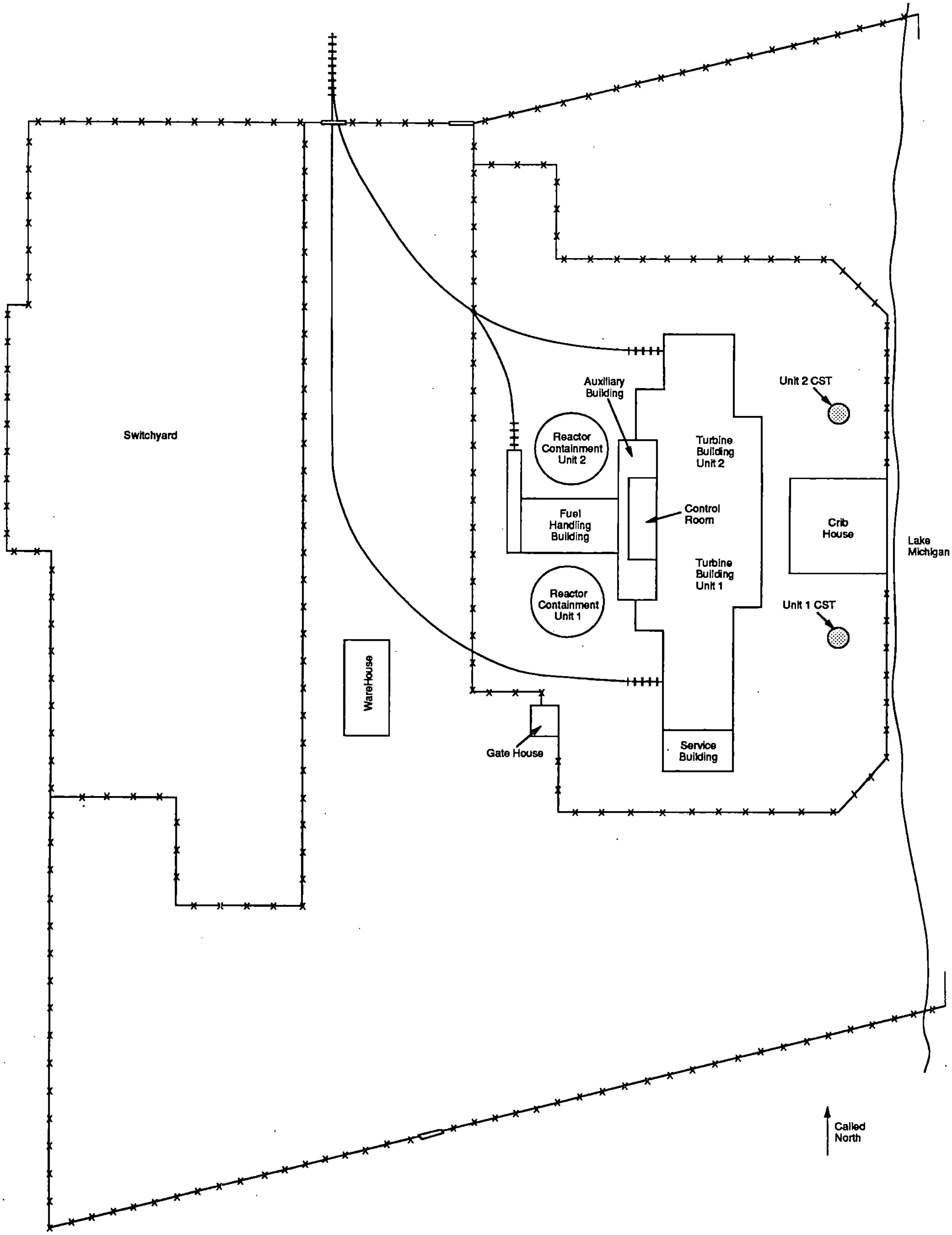


Figure 4-2. Zion 1 and 2 Plot Plan

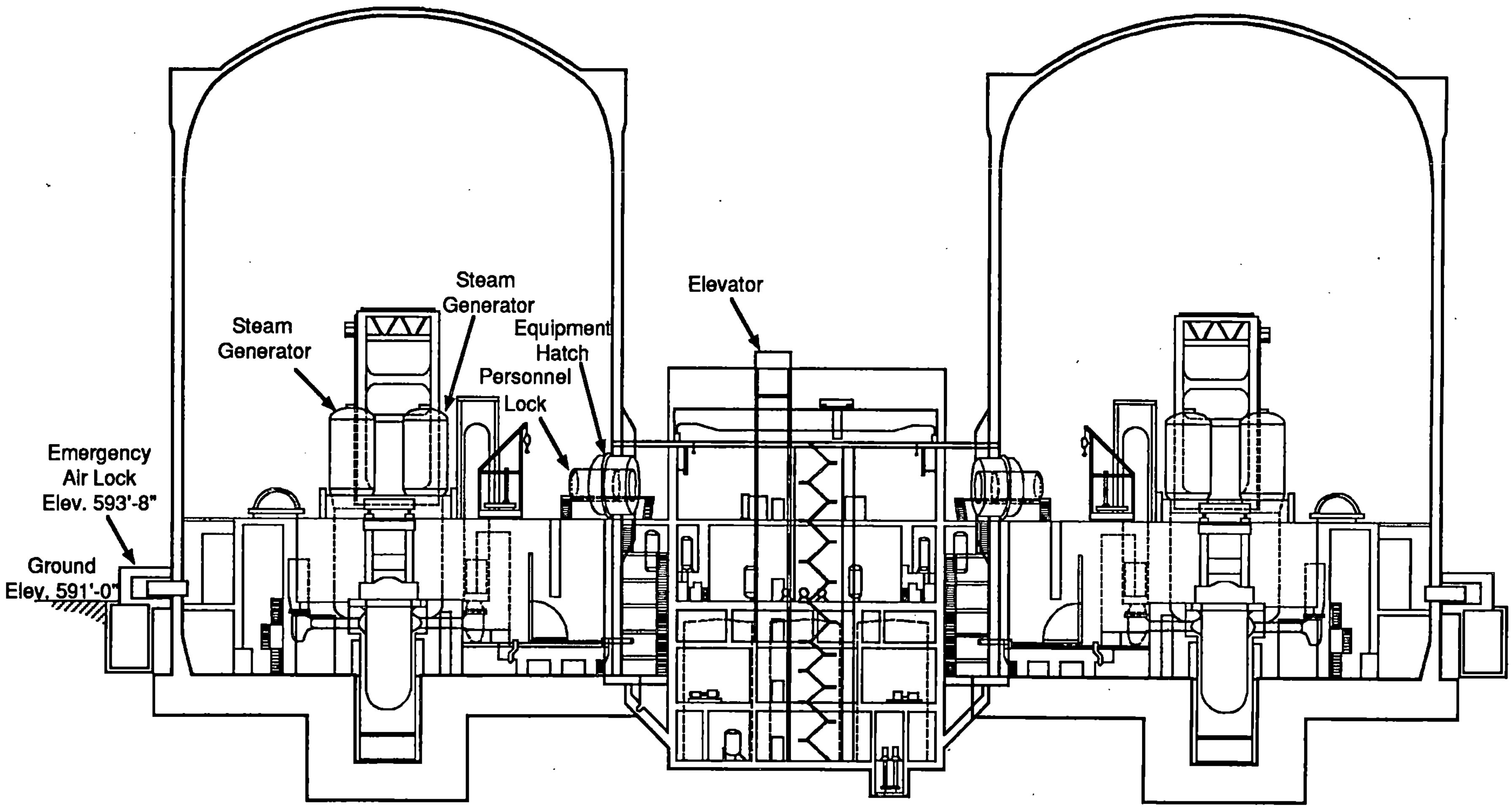


Figure 4-3. Zion 1 and 2 Section Drawings (Page 1 of 2)

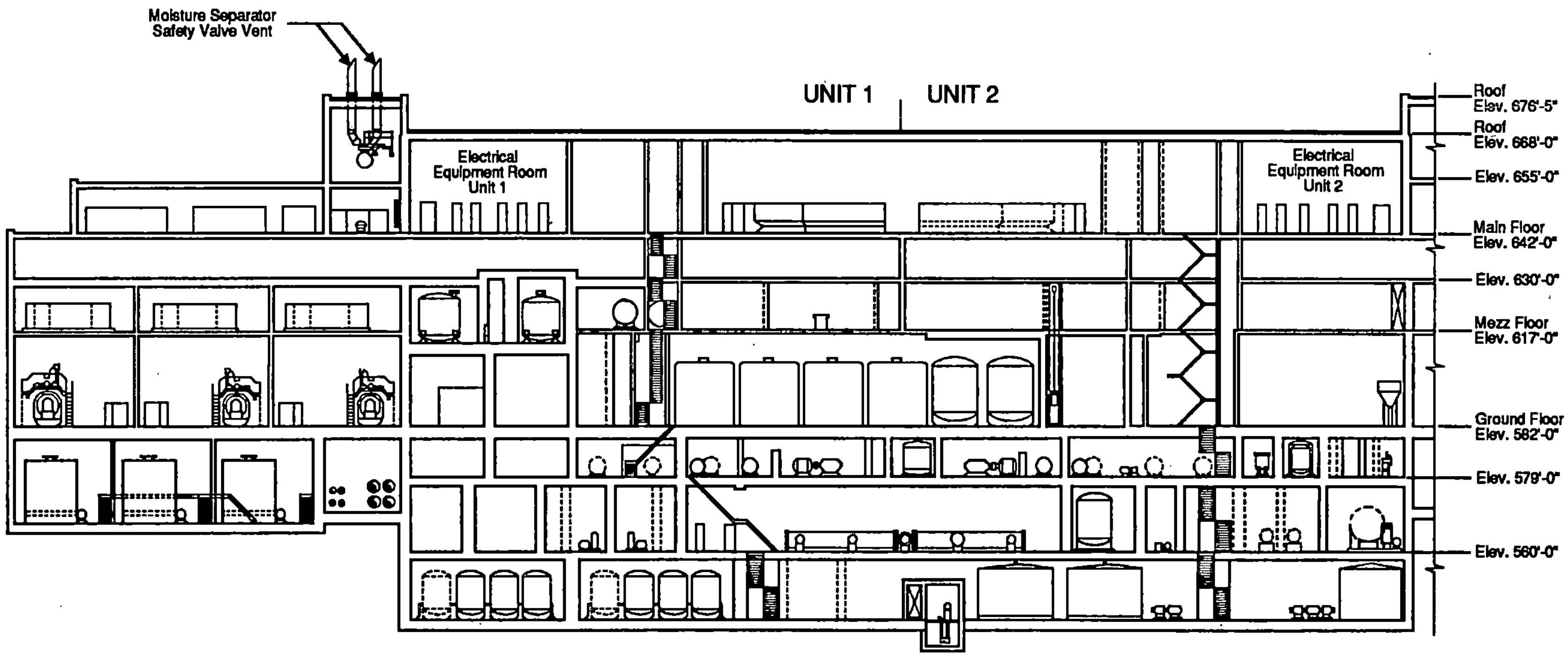


Figure 4-3. Zion 1 and 2 Section Drawings (Page 2 of 2)

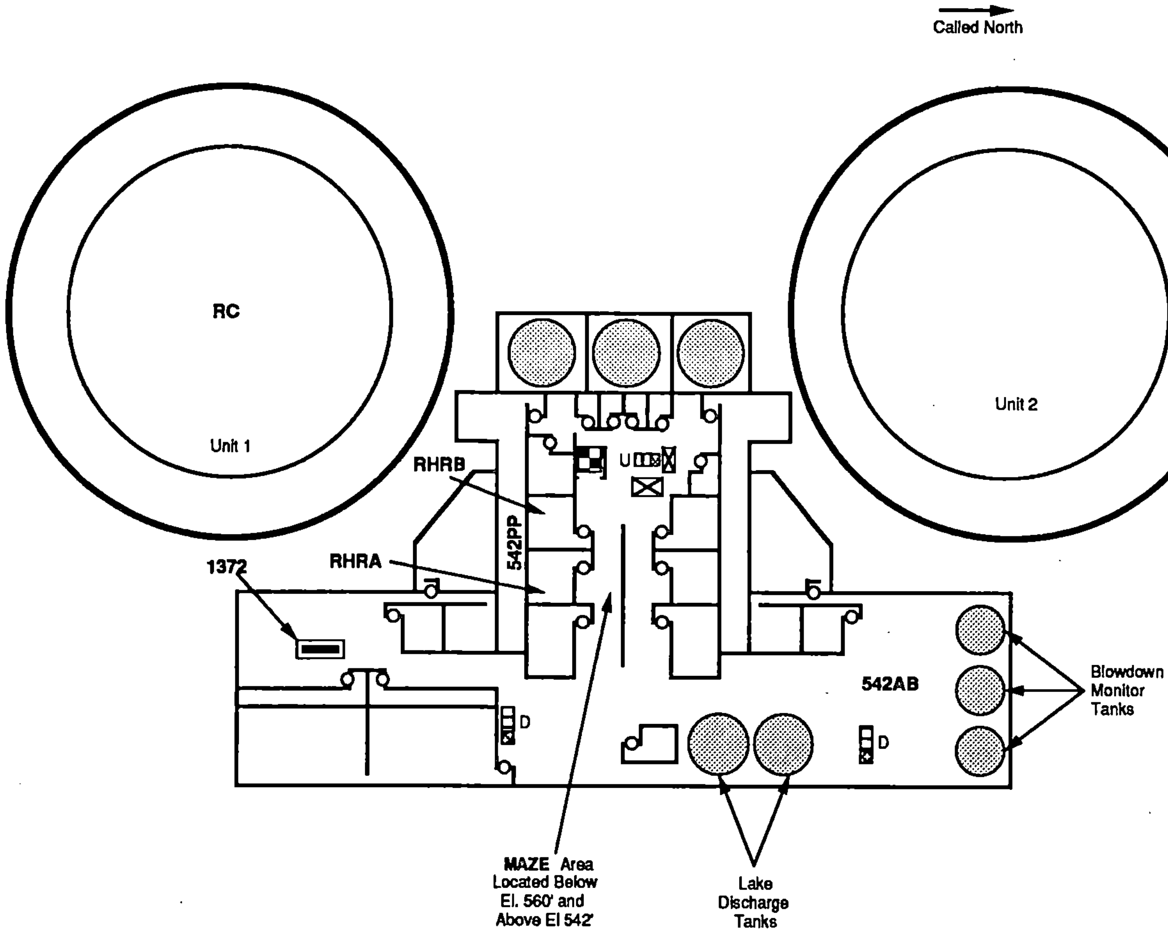


Figure 4-4. Zion 1 and 2 General Arrangement, Elevation 542'

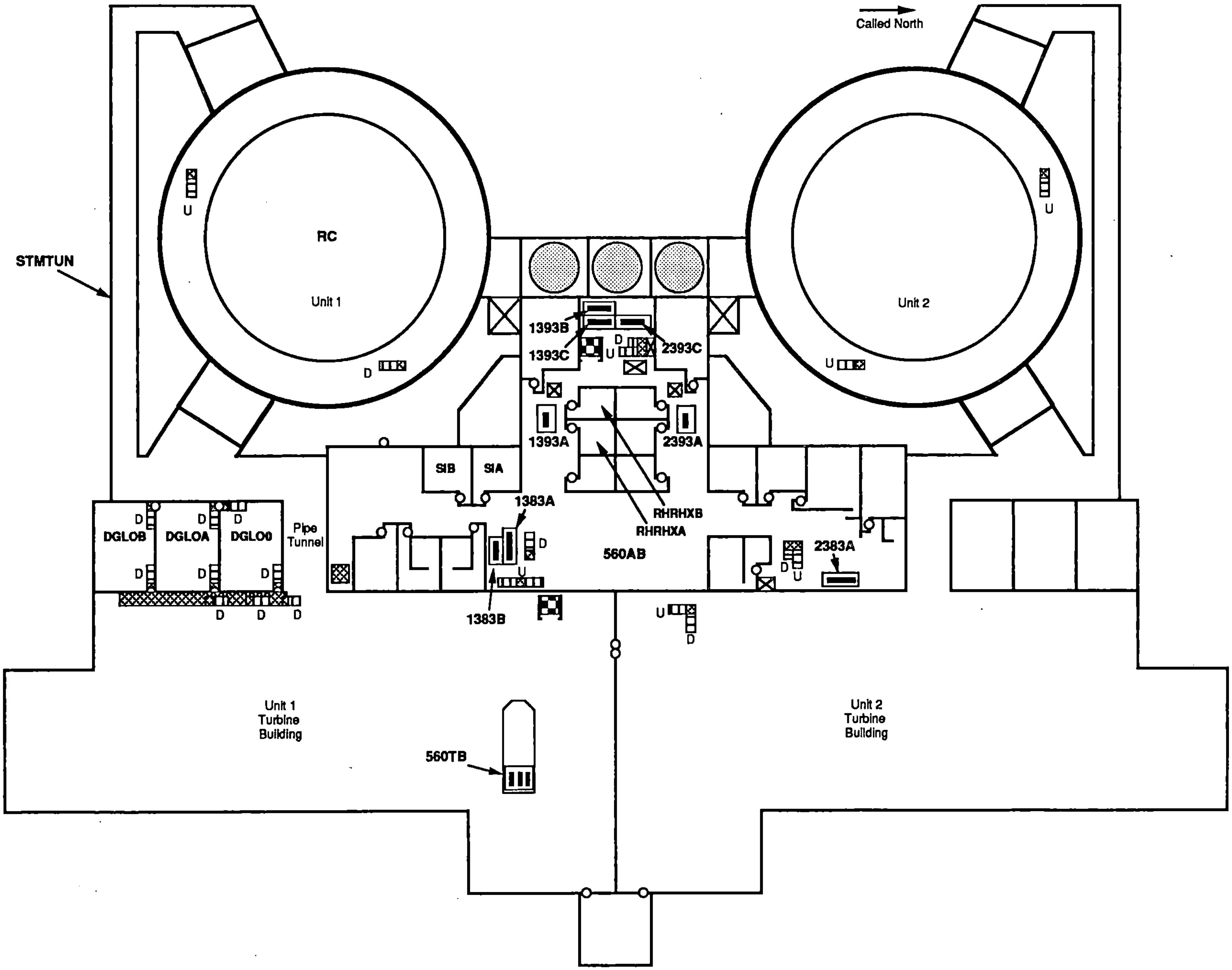


Figure 4-5. Zion 1 and 2 General Arrangement, Elevation 560'

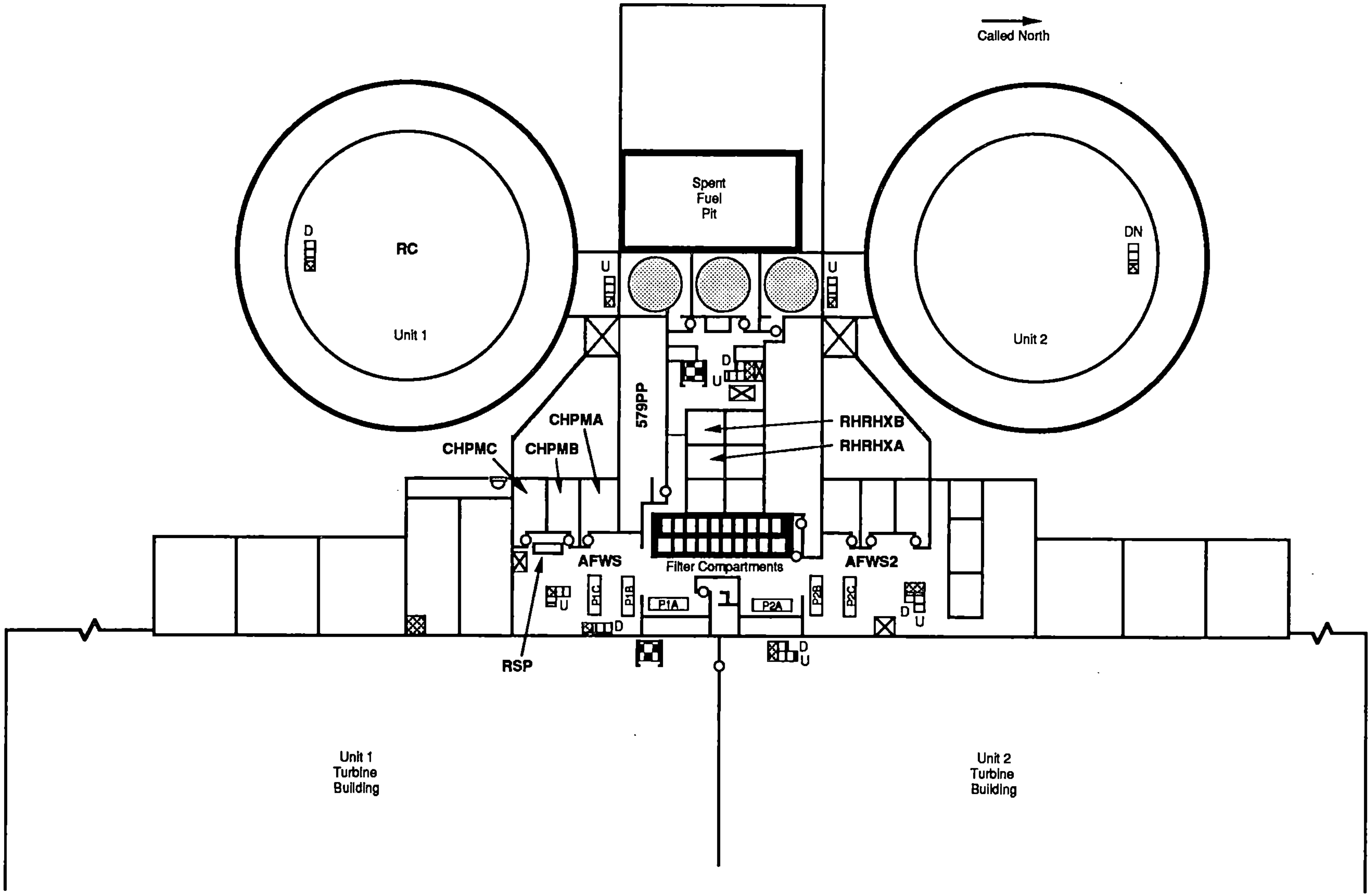


Figure 4-6. Zion 1 and 2 General Arrangement, Elevation 579'

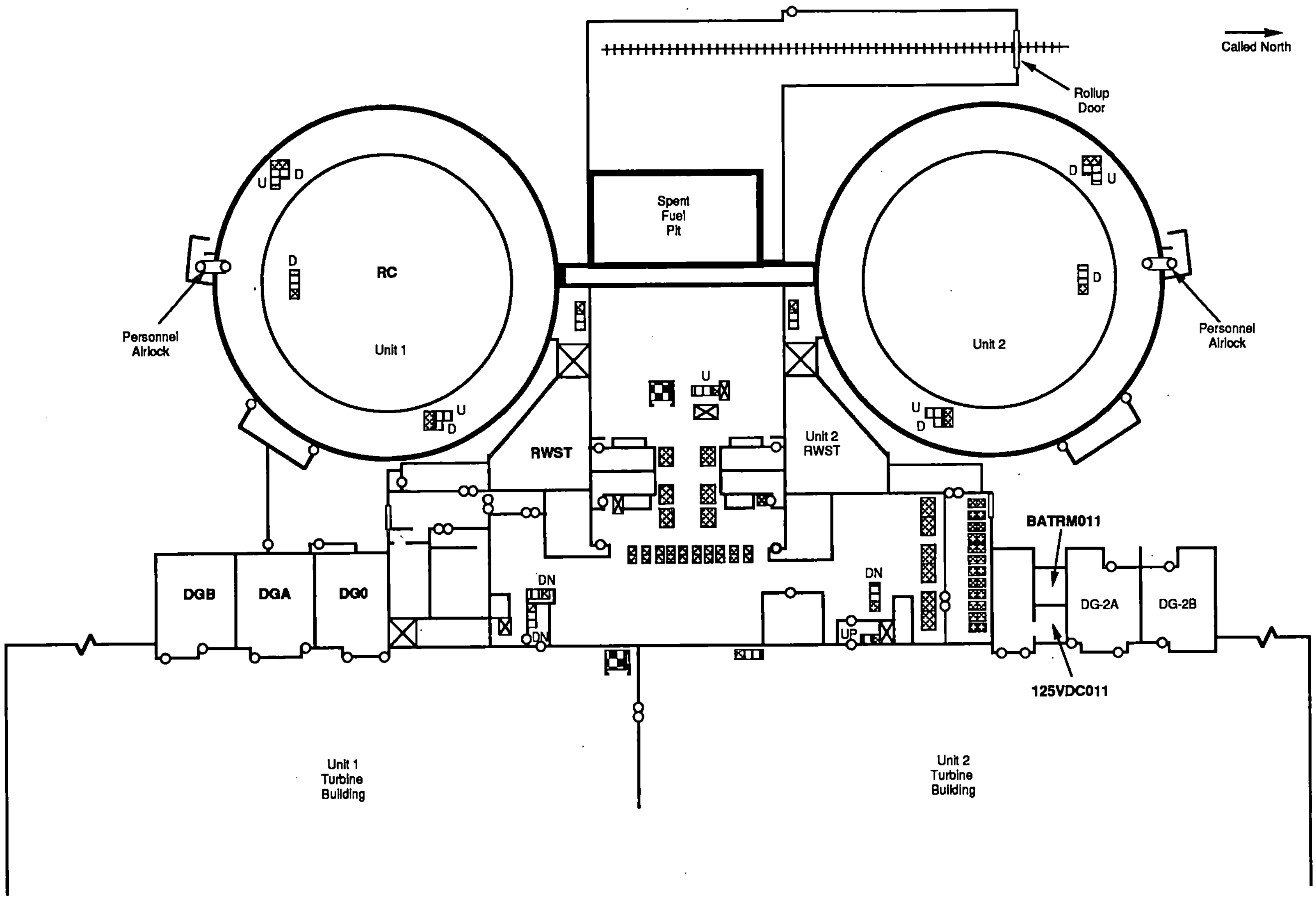


Figure 4-7. Zion 1 and 2 General Arrangement, Elevation 592'

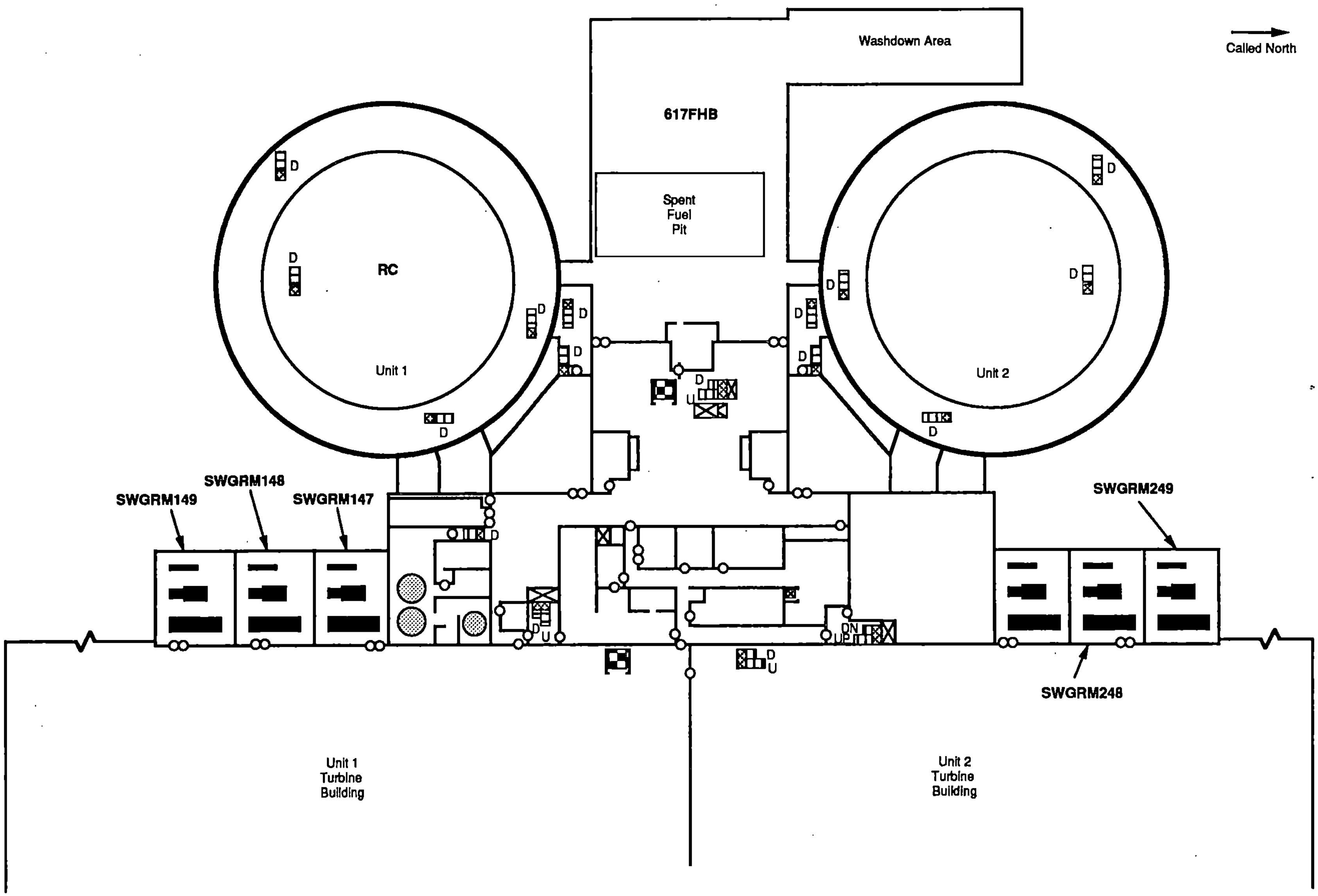


Figure 4-8. Zion 1 and 2 General Arrangement, Elevation 617'

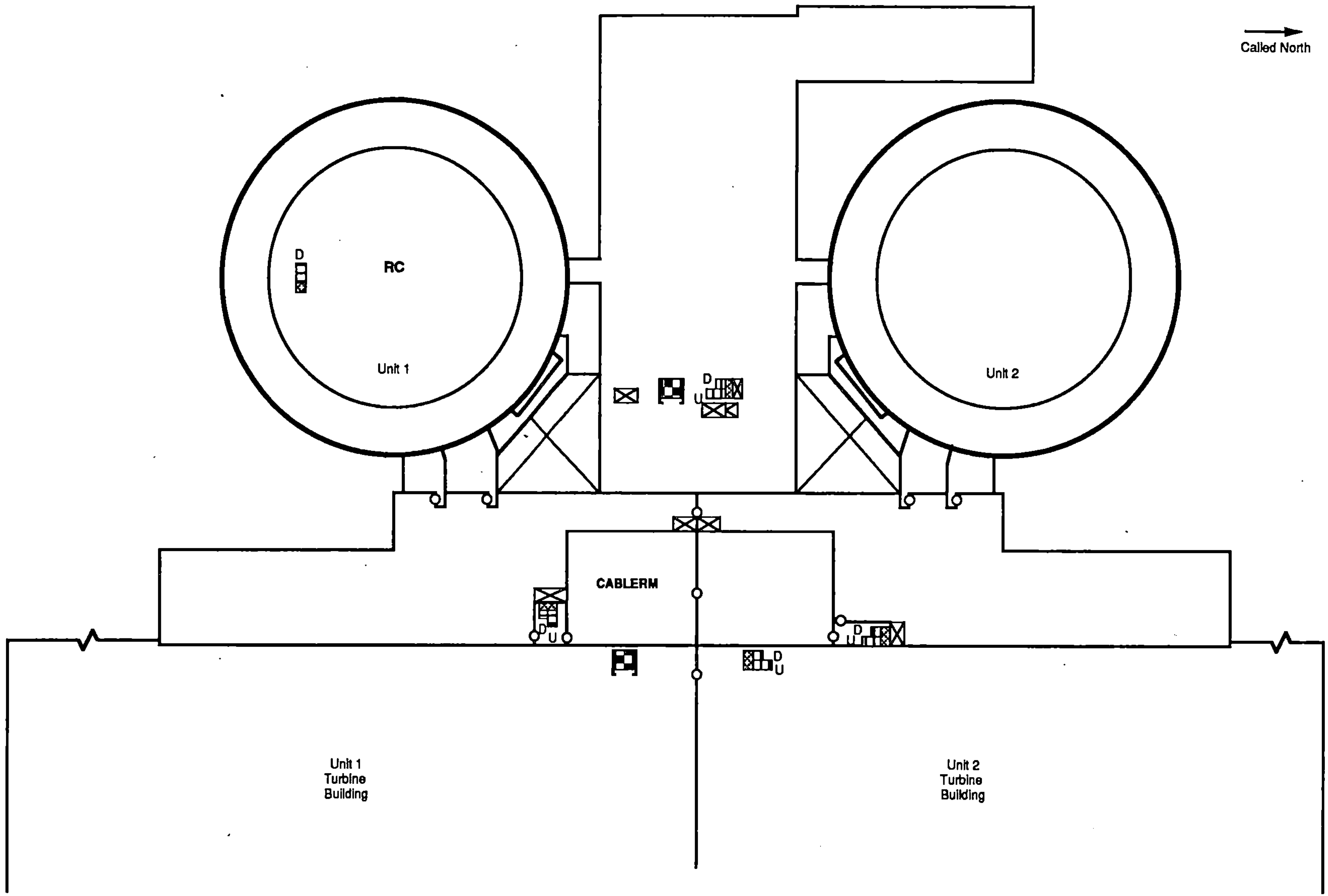


Figure 4-9. Zion 1 and 2 General Arrangement, Elevation 630'

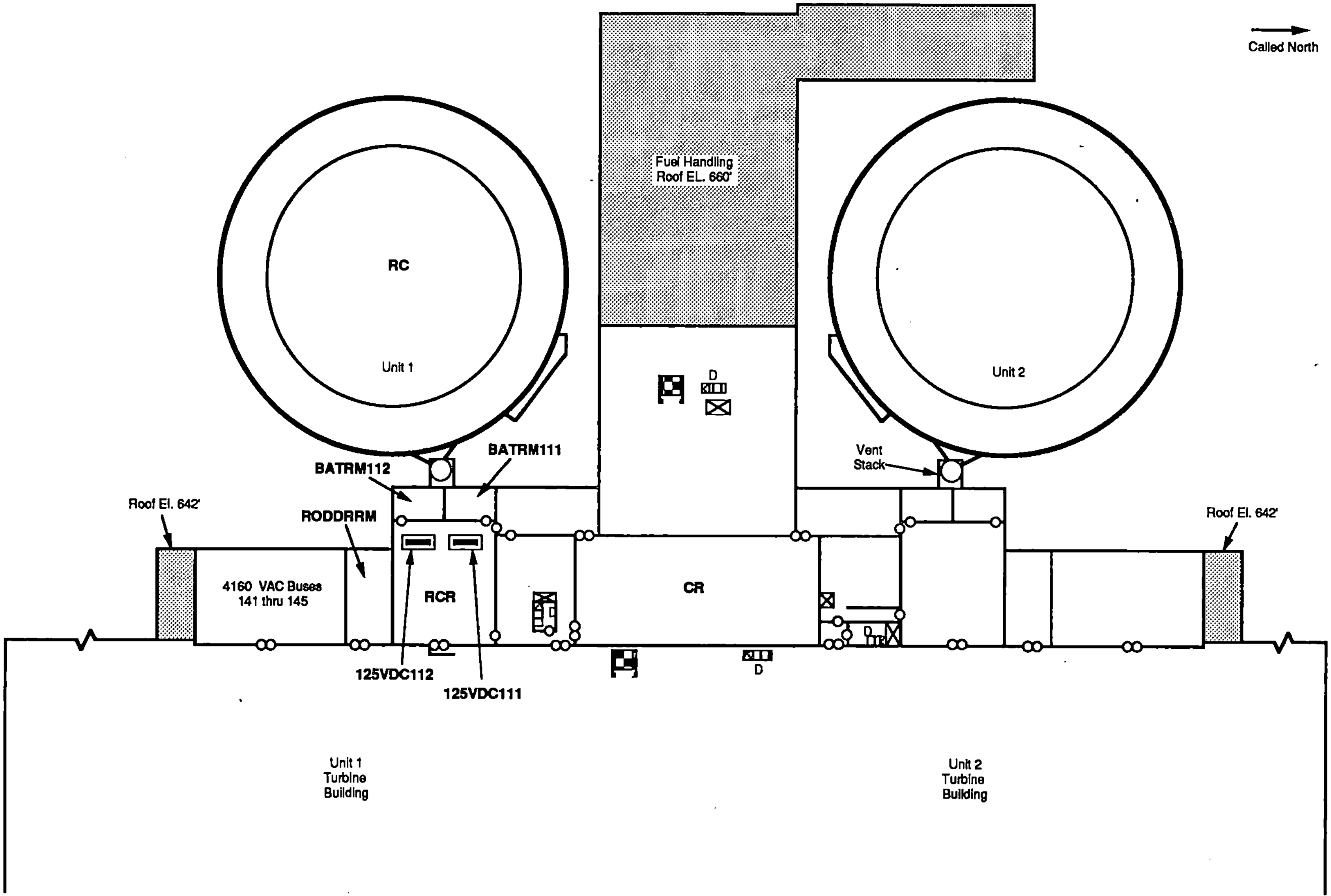


Figure 4-10. Zion 1 and 2 General Arrangement, Elevation 642'

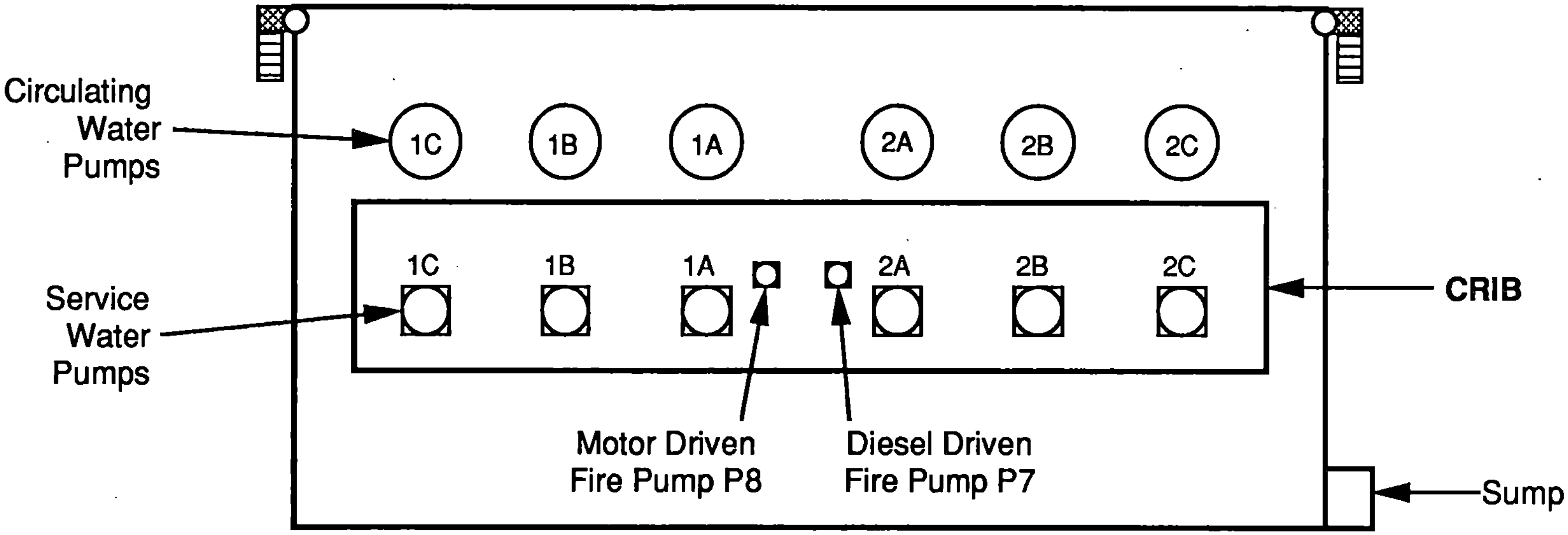


Figure 4-11. Zion 1 and 2 General Arrangement, Crib House

Table 4-1. Definition of Zion 1 Building and Location Codes

	Codes	Descriptions
1.	AFWS	Auxiliary Feedwater System room, located in the Auxiliary Building at elevation 579'. Contains auxiliary feedwater pumps 1A, 1B, and 1C.
2.	AFWS2	Auxiliary Feedwater System room, located in the Auxiliary Building at elevation 579', Unit 2.
3.	BATRM011	Battery Room 011, located in the Auxiliary Building at elevation 592' (Swing Battery).
4.	BATRM111	Battery Room 111, located in the Auxiliary Building at elevation 642'. Contains the battery set for 125 VDC Bus 111.
5.	BATRM112	Battery Room 112, located in the Auxiliary Building at elevation 642'. Contains the battery set for 125 VDC Bus 112.
6.	CABLERM	Cable Room, located in the Auxiliary Building at elevation 630' directly below Control Room.
7.	CHPMA	Charging Pump Room A located in the Auxiliary Building at elevation 579'. Contains charging pump A.
8.	CHPMB	Charging Pump Room B located in the Auxiliary Building at elevation 579'. Contains charging pump B.
9.	CHPMC	Charging Pump Room C located in the Auxiliary Building at elevation 579'. Contains charging pump C.
10.	CR	Control Room, located in the Auxiliary Building at elevation 642'.
11.	CRIB	Crib House. Contains the service water pumps.
12.	CST	Condensate Storage Tank, located south of the Crib House.
13.	DGA	Diesel Generator Room A, located in the Auxiliary Building at elevation 592'. Contains diesel generator unit 1A.
14.	DGB	Diesel Generator Room B, located in the Auxiliary Building at elevation 592'. Contains diesel generator unit 1B.
15.	DG0	Diesel Generator Room 0, located in the Auxiliary Building at elevation 592'. Contains diesel generator unit 0.

Table 4-1. Definition of Zion 1 Building and Location Codes (Continued)

16.	DGLOA	Diesel Generator Oil Storage Tank Room A, located in the Auxiliary Building at elevation 560'. Contains the oil supply for diesel generator 1A.
17.	DGLOB	Diesel Generator Oil Storage Tank Room B, located in the Auxiliary Building at elevation 560'. Contains the oil supply for diesel generator 1B.
18.	DGLO0	Diesel Generator Oil Storage Tank Room 0, located in the Auxiliary Building at elevation 560'. Contains the oil supply for diesel generator 0.
19.	MAZE	Maze of piping between the 542' and 579' elevations of the Auxiliary Building.
20.	RC	Reactor Containment
21.	RCR	Rod Control Room, located in the Auxiliary Building at elevation 642'.
22.	RHRA	Residual Heat Removal Room A, located in the Auxiliary Building at elevation 542'. Contains RHR pump 1A.
23.	RHRB	Residual Heat Removal Room B, located in the Auxiliary Building at elevation 542'. Contains RHR pump 1B.
24.	RHRHXA	Residual Heat Removal Heat Exchanger Room A, located in the Auxiliary Building at elevation 579'. Contains RHR heat exchanger 1A.
25.	RHRHXB	Residual Heat Removal Heat Exchanger Room B, located in the Auxiliary Building at elevation 579'. Contains RHR heat exchanger 1B.
26.	RODDRRM	Rod Drive Room, located in the Auxiliary Building at elevation 642'.
27.	RSP	Remote Shutdown Panel, located in the Auxiliary Building at elevation 579'.
28.	RWST	Refueling Water Storage Tank Vault, located directly northeast of the containment building. Contains the refueling water storage tank.
29.	SIA	Safety Injection Room A, located in the Auxiliary Building at elevation 560'. Contains safety injection pump 1A.
30.	SIB	Safety Injection Room B, located in the Auxiliary Building at elevation 560'. Contains safety injection pump 1B.

Table 4-1. Definition of Zion 1 Building and Location Codes (Continued)

31.	STMTUN	Steam Tunnel, located south of the Reactor Containment at elevation 560'. Contains main steam and feedwater lines.
32.	SWGRM147	Switchgear Room 147, located in the Auxiliary Building at elevation 617'. Contains the switchgear for buses 137 and 147 and MCC 1371.
33.	SWGRM148	Switchgear Room 148, located in the Auxiliary Building at elevation 617'. Contains the switchgear for buses 138 and 148 and MCC 1381.
34.	SWGRM149	Switchgear Room 149, located in the Auxiliary Building at elevation 617'. Contains the switchgear for buses 139 and 149 and MCC 1391.
35.	SWGRM248	Switchgear Room 248, located in the Auxiliary Building at elevation 617', Unit 2.
36.	SWGRM249	Switchgear Room 249, located in the Auxiliary Building at elevation 617', Unit 2.
37.	125VDC011	125 DC Bus 011, located in the Auxiliary Building at elevation 642'.
38.	125VDC111	125 DC Bus 111, located in the Auxiliary Building at elevation 642'.
39.	125VDC112	125 DC Bus 112, located in the Auxiliary Building at elevation 642'.
40.	1372	Motor Control Center 1372, located in the Auxiliary Building at elevation 542', south end.
41.	1383A	Motor Control Center 1383A, located in the Auxiliary Building at elevation 560', east side.
42.	1383B	Motor Control Center 1383B, located in the Auxiliary Building at elevation 560', east side.
43.	1393A	Motor Control Center 1393A, located in the Auxiliary Building at elevation 560', northwest of Safety Injection Pump Room 1A.
44.	1393B	Motor Control Center 1393B, located in the Auxiliary Building at elevation 560', west end.
45.	1393C	Motor Control Center 1393C, located in the Auxiliary Building at elevation 560', west end.

Table 4-1. Definition of Zion 1 Building and Location Codes (Continued)

46.	2383A	Motor Control Center 2383A, located in the Auxiliary Building at elevation 560', Unit 2.
47.	2393A	Motor Control Center 2393A, located in the Auxiliary Building at elevation 560', Unit 2.
48.	2393C	Motor Control Center 2393C, located in the Auxiliary Building at elevation 560', Unit 2.
49.	542AB	542' elevation of the Auxiliary Building.
50.	542PP	Pipe Tunnel at elevation 542', located in the Auxiliary Building at elevation 542'. Contains piping from containment building to the RHR pump rooms.
51.	560AB	560' elevation of the Auxiliary Building.
52.	560TB	560' elevation of the Turbine Building.
53.	592TB	592' elevation of the Turbine Building
54.	579PP	Pipe Penetration Area, located in the Auxiliary Building at elevation 579'.
55.	617FHB	617' elevation of the Fuel Handling Building.

Table 4-2. Partial Listing of Components by Location at Zion 1

LOCATION	SYSTEM	COMPONENT ID	COMP TYPE
1372	EP	MCC-1372	MCC
125VDC011	EP	BC-011	BC
125VDC011	EP	DC-BUS-011	BUS
125VDC011	EP	DC-BUS-011	BUS
125VDC111	EP	BC-111	BC
125VDC111	EP	DC-BUS-111	BUS
125VDC111	EP	DC-BUS-111	BUS
125VDC112	EP	BC-112	BC
125VDC112	EP	DC-BUS-112	BUS
125VDC112	EP	DC-BUS-112	BUS
1383A	EP	MCC-1383A	MCC
1383B	EP	MCC-1383B	MCC
1393A	EP	MCC-1393A	MCC
1393B	EP	MCC-1393B	MCC
1393C	EP	MCC-1393C	MCC
2393C	EP	MCC-2393C	MCC
542AB	SW	SW-7	MOV
542AB	SW	SW-8	MOV
560AB	CCW	CCW-HX0	HX
560AB	CCW	CCW-HX1	HX
560AB	CCW	CCW-OC	MDP
560AB	CCW	CCW-OD	MDP
560AB	CCW	CCW-OE	MDP
560AB	SW	SW-12	MOV
560AB	SW	SW-13	MOV
560AB	SW	SW-14	MOV
560AB	SW	SW-15	MOV
560AB	SW	SW-2	MOV
579PP	AFW	AFW-50	MOV
579PP	AFW	AFW-51	MOV
579PP	AFW	AFW-52	MOV
579PP	AFW	AFW-53	MOV
579PP	AFW	AFW-54	MOV
579PP	AFW	AFW-55	MOV
579PP	AFW	AFW-56	MOV
579PP	AFW	AFW-57	MOV
579PP	AFW	AFW-6	MOV
579PP	CVCS	SI-8801A	MOV
579PP	CVCS	SI-8801B	MOV
579PP	CVCS	SI-8803A	MOV

Table 4-2. Partial Listing of Components by Location at Zion 1 (Continued)

LOCATION	SYSTEM	COMPONENT ID	COMP TYPE
579PP	CVCS	SI-8803B	MOV
579PP	CVCS	VC-8105	MOV
579PP	CVCS	VC-8106	MOV
579PP	ECCS	SI-8801A	MOV
579PP	ECCS	SI-8801B	MOV
579PP	ECCS	SI-8802	MOV
579PP	ECCS	SI-8803A	MOV
579PP	ECCS	SI-8803B	MOV
579PP	ECCS	SI-9011A	MOV
579PP	ECCS	SI-9011B	MOV
579PP	ECCS	VC-8105	MOV
579PP	ECCS	VC-8106	MOV
AFWS	AFW	AFW-74	MOV
AFWS	AFW	AFW-75	MOV
AFWS	AFW	AFW-76	MOV
AFWS	AFW	AFW-P1A	TDP
AFWS	AFW	AFW-P1B	MDP
AFWS	AFW	AFW-P1C	MDP
AFWS	AFW	SW-101	MOV
AFWS	AFW	SW-102	MOV
AFWS	AFW	SW-103	MOV
AFWS	AFW	SW-104	MOV
AFWS	AFW	SW-105	MOV
AFWS	AFW	SW-106	MOV
AFWS	AFW	SW-107	MOV
BATRM011	EP	BATT-011	BATT
BATRM111	EP	BATT-111	BATT
BATRM112	EP	BATT-112	BATT
CHPMA	CVCS	VC-P1A	MDP
CHPMB	CVCS	VC-P1B	MDP
CHPMC	CVCS	VC-P1C	PDP
CRIB	FW	FW-P7	DDP
CRIB	FW	FW-P8	MDP
CRIB	SW	SW-3	MOV
CRIB	SW	SW-3	MOV
CRIB	SW	SW-4	MOV
CRIB	SW	SW-4	MOV
CRIB	SW	SW-P1A	MDP
CRIB	SW	SW-P1B	MDP
CRIB	SW	SW-P1C	MDP

Table 4-2. Partial Listing of Components by Location at Zion 1 (Continued)

LOCATION	SYSTEM	COMPONENT ID	COMP TYPE
CST	AFW	AFW-CST	TANK
DG0	EP	DG-0	DG
DG0	FW	SW-110	MOV
DGA	EP	DG-1A	DG
DGA	FW	SW-108	MOV
DGB	EP	DG-1B	DG
DGB	FW	SW-109	MOV
DGLOA	SW	SW-18	MOV
DGLOA	SW	SW-19	MOV
DGLOB	SW	SW-16	MOV
DGLOB	SW	SW-17	MOV
MAZE	ECCS	RH-8724A	XV
MAZE	ECCS	RH-8724B	XV
MAZE	ECCS	RH-8728A	XV
MAZE	ECCS	RH-8728B	XV
MAZE	ECCS	SI-8804A	MOV
MAZE	ECCS	SI-8804A	MOV
RC	AFW	SG-A	SG
RC	AFW	SG-B	SG
RC	AFW	SG-C	SG
RC	AFW	SG-D	SG
RC	CVCS	SI-8800A	MOV
RC	CVCS	SI-8800B	MOV
RC	CVCS	SI-8800C	MOV
RC	CVCS	SI-8800D	MOV
RC	ECCS	SI-8800A	MOV
RC	ECCS	SI-8800B	MOV
RC	ECCS	SI-8800C	MOV
RC	ECCS	SI-8800D	MOV
RC	ECCS	SI-SUMP	TANK
RC	RCS	P1A	MDP
RC	RCS	P1B	MDP
RC	RCS	P1C	MDP
RC	RCS	P1D	MDP
RC	RCS	RCS-455C	NV
RC	RCS	RCS-456	NV
RC	RCS	RCS-8000A	MOV
RC	RCS	RCS-8000B	MOV
RC	RCS	RCS-VESSEL	RV
RC	RCS	RH-8701	MOV

Table 4-2. Partial Listing of Components by Location at Zion 1 (Continued)

LOCATION	SYSTEM	COMPONENT ID	COMP TYPE
RC	RCS	RH-8702	MOV
RCR	EP	BUS-111	BUS
RCR	EP	BUS-111	BUS
RCR	EP	BUS-112	BUS
RCR	EP	BUS-112	BUS
RCR	EP	BUS-113	BUS
RCR	EP	BUS-113	BUS
RCR	EP	BUS-114	BUS
RCR	EP	INV-111	INV
RCR	EP	INV-111	INV
RCR	EP	INV-112	INV
RCR	EP	INV-112	INV
RCR	EP	INV-113	INV
RCR	EP	INV-113	INV
RCR	EP	INV-114	INV
RCR	EP	TR-111	TRAN
RCR	EP	TR-112	TRAN
RCR	EP	TR-113	TRAN
RHRA	ECCS	RH-P1A	MDP
RHRB	ECCS	RH-P1B	MDP
RHRHXA	ECCS	CCW-9412A	MOV
RHRHXA	ECCS	RH-HX1A	HX
RHRHXB	ECCS	CCW-9412B	MOV
RHRHXB	ECCS	RH-HX1B	HX
RWST	CVCS	SI-8806	MOV
RWST	CVCS	SI-8807A	MOV
RWST	CVCS	SI-8807B	MOV
RWST	CVCS	SI-RWST	TANK
RWST	CVCS	VC-112D	MOV
RWST	CVCS	VC-112E	MOV
RWST	ECCS	SI-8804B	MOV
RWST	ECCS	SI-8806	MOV
RWST	ECCS	SI-8807A	MOV
RWST	ECCS	SI-8807B	MOV
RWST	ECCS	SI-8811A	MOV
RWST	ECCS	SI-8811B	MOV
SIA	CVCS	SI-8923	MOV
SIA	ECCS	SI-8923A	MOV
SIA	ECCS	SI-9010A	MOV
SIA	ECCS	SI-P1A	MDP

Table 4-2. Partial Listing of Components by Location at Zion 1 (Continued)

LOCATION	SYSTEM	COMPONENT ID	COMP TYPE
SIB	ECCS	SI-8804B	MOV
SIB	ECCS	SI-8923B	MOV
SIB	ECCS	SI-9010B	MOV
SIB	ECCS	SI-P1B	MDP
STMTUN	AFW	AFW-11	MOV
STMTUN	AFW	AFW-17	MOV
STMTUN	AFW	AFW-18	MOV
STMTUN	AFW	AFW-19	MOV
STMTUN	AFW	AFW-20	MOV
STMTUN	AFW	AFW-5	MOV
SWGRM147	EP	BUS-137	BUS
SWGRM147	EP	BUS-147	BUS
SWGRM147	EP	CB-147	CB
SWGRM147	EP	MCC-1371	MCC
SWGRM147	EP	TR-137	TRAN
SWGRM148	EP	BUS-138	BUS
SWGRM148	EP	BUS-148	BUS
SWGRM148	EP	CB-148	CB
SWGRM148	EP	MCC-1381B	MCC
SWGRM148	EP	TR-138	TRAN
SWGRM149	EP	BUS-139	BUS
SWGRM149	EP	BUS-149	BUS
SWGRM149	EP	CB-149	CB
SWGRM149	EP	MCC-1391	MCC
SWGRM149	EP	TR-139	TRAN

5. BIBLIOGRAPHY FOR ZION 1 AND 2

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APPENDIX A
DEFINITION OF SYMBOLS USED IN THE SYSTEM AND LAYOUT DRAWINGS

A1. SYSTEM DRAWINGS

A1.1 Fluid and Ventilation System Drawings

The simplified system drawings are accurate representations of the major flow paths in a system and the important interfaces with other fluid systems. As a general rule, small fluid lines that are not essential to the basic operation of the system are not shown in these drawings. Lines of this type include instrumentation lines, vent lines, drain lines, and other lines that are less than 1/3 the diameter of the connecting major flow path. There usually are two versions of each fluid system drawing; a simplified system drawing, and a comparable drawing showing component locations. The drawing conventions used in the fluid system drawings are the following:

- Flow generally is left to right.
  - Water sources and air intakes are located on the left and water "users" (i.e., heat loads) or discharge paths are located on the right.
  - One exception is the return flow path in closed loop systems which is right to left.
  - Another exception is the Reactor Coolant System (RCS) drawing which is "vessel-centered", with the primary loops on both sides of the vessel.
  - Horizontal lines always dominate and break vertical lines.

- Component symbols used in the fluid system drawings are defined in Figure A-1 and unique ventilation system components are defined in Figure A-2.
  - Most valve, damper, and pump symbols are designed to allow the reader to distinguish among similar components based on their support system requirements (i.e., electric power for a motor or solenoid, steam to drive a turbine, pneumatic or hydraulic source for valve operation, etc.)
  - Valve and damper symbols allow the reader to distinguish among valves that allow flow in either direction, check (non-return) valves, and valves that perform an overpressure protection function. No attempt has been made to define the specific type of valve (i.e., as a globe, gate, butterfly, or other specific type of valve).
  - Pump symbols distinguish between centrifugal and positive displacement pumps and between types of pump drives (i.e., motor, turbine, or engine).

- Locations are identified in terms of plant location codes defined in Section 4 of this Sourcebook.
  - Location is indicated by shaded "zones" that are not intended to represent the actual room geometry.
  - Locations of discrete components represent the actual physical location of the component.
  - Piping locations between discrete components represent the plant areas through which the piping passes (i.e. including pipe tunnels and underground pipe runs).
  - Component locations that are not known are indicated by placing the components in an unshaded (white) zone.
  - The primary flow path in the system is highlighted (i.e., bold white line) in the location version of the fluid system drawings.

A1.2 Electrical System Drawings

The electric power system drawings focus on the Class 1E portions of the plant's electric power system. Separate drawings are provided for the AC and DC portions of the Class 1E system. There often are two versions of each electrical system drawing; a simplified system drawing, and a comparable drawing showing component locations. The drawing conventions used in the electrical system drawings are the following:

- Flow generally is top to bottom
  - In the AC power drawings, the interface with the switchyard and/or offsite grid is shown at the top of the drawing.
  - In the DC power drawings, the batteries and the interface with the AC power system are shown at the top of the drawing.
  - Vertical lines dominate and break horizontal lines.

- Component symbols used in the electrical system drawings are defined in Figure A-3.

- Locations are identified in terms of plant location codes defined in Section 4 of this Sourcebook.
  - Locations are indicated by shaded "zones" that are not intended to represent the actual room geometry.
  - Locations of discrete components represent the actual physical location of the component.
  - The electrical connections (i.e., cable runs) between discrete components, as shown on the electrical system drawings, DO NOT represent the actual cable routing in the plant.
  - Component locations that are not known are indicated by placing the discrete components in an unshaded (white) zone.

A2. SITE AND LAYOUT DRAWINGS

A2.1 Site Drawings

A general view of each reactor site and vicinity is presented along with a simplified site plan showing the arrangement of the major buildings, tanks, and other features of the site. The general view of the reactor site is obtained from ORNL-NSIC-55 (Ref. 1). The site drawings are approximately to scale, but should not be used to estimate distances on the site. As-built scale drawings should be consulted for this purpose.

Labels printed in bold uppercase correspond to the location codes defined in Section 4 and used in the component data listings and system drawings in Section 3. Some additional labels are included for information and are printed in lowercase type.

A2.2 Layout Drawings

Simplified building layout drawings are developed for the portions of the plant that contain components and systems that are described in Section 3 of this Sourcebook. Generally, the following buildings are included: reactor building, auxiliary building, fuel building, diesel building, and the intake structure or pumphouse. Layout drawings generally are not developed for other buildings.

Symbols used in the simplified layout drawings are defined in Figure A-4. Major rooms, stairways, elevators, and doorways are shown in the simplified layout drawings however, many interior walls have been omitted for clarity. The building layout drawings, are approximately to scale, should not be used to estimate room size or distances. As-built scale drawings for should be consulted his purpose.

Labels printed in uppercase bolded also correspond to the location codes defined in Section 4 and used in the component data listings and system drawings in Section 3. Some additional labels are included for information and are printed in lowercase type.

A3. APPENDIX A REFERENCES

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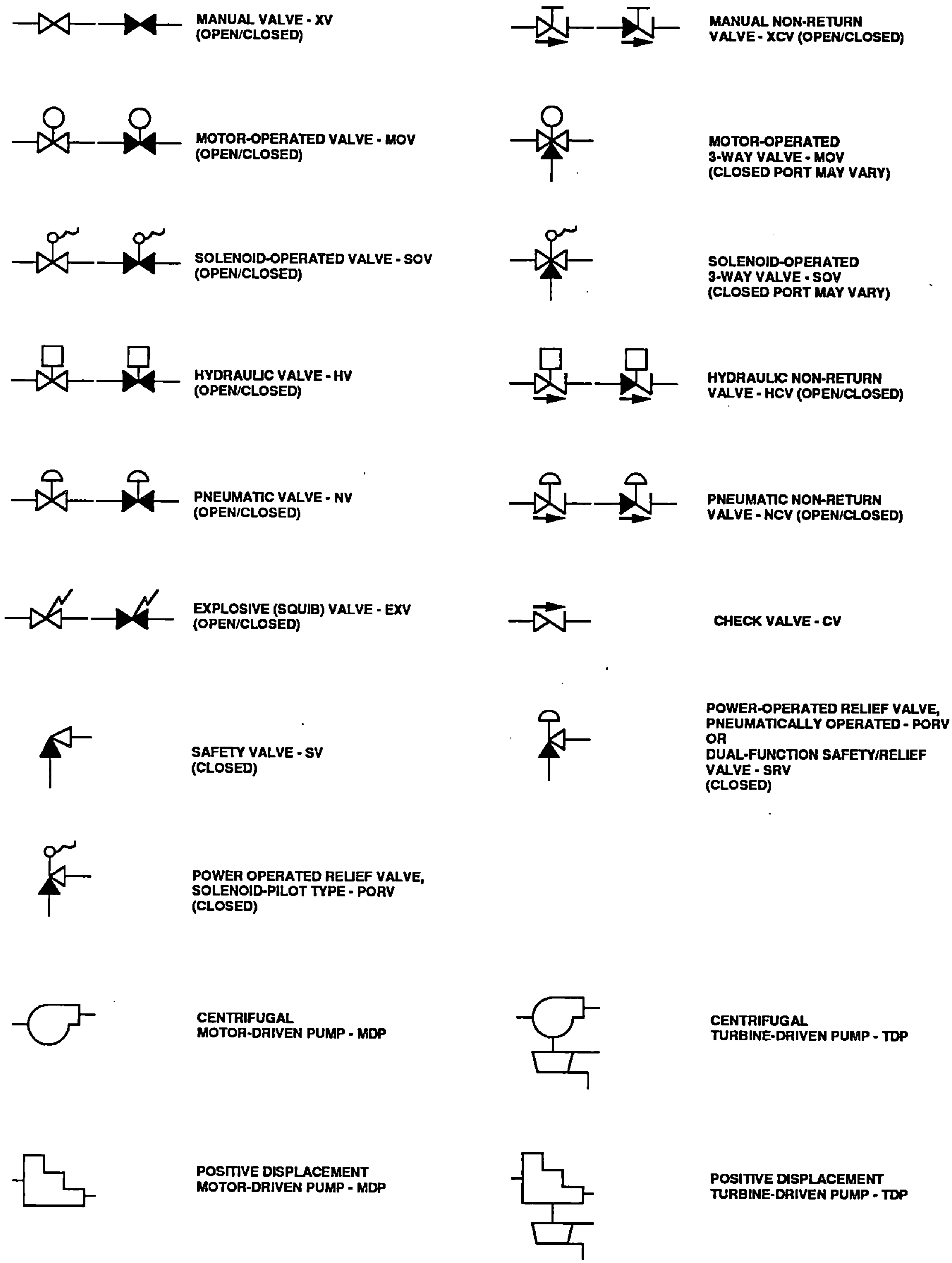

Figure A-1. Key To Symbols In Fluid System Drawings

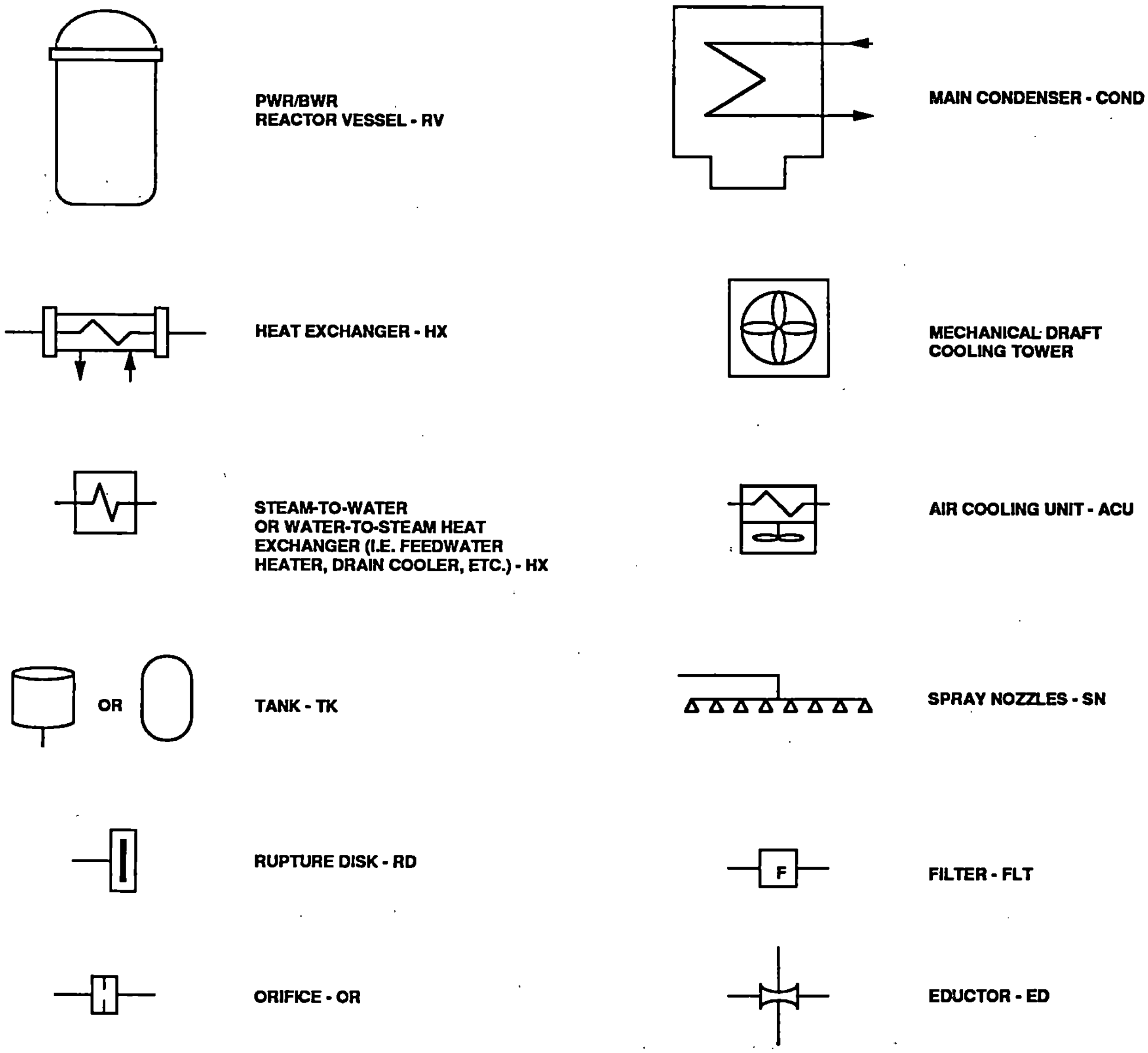

Figure A-1. Key To Symbols In Fluid System Drawings (Continued)

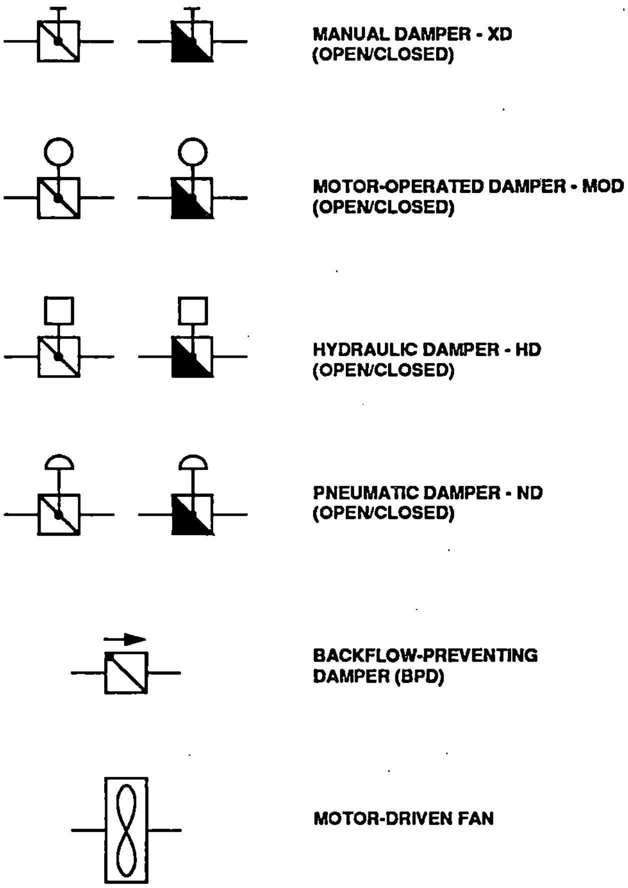

Figure A-2. Key To Symbols In Ventilation System Drawings

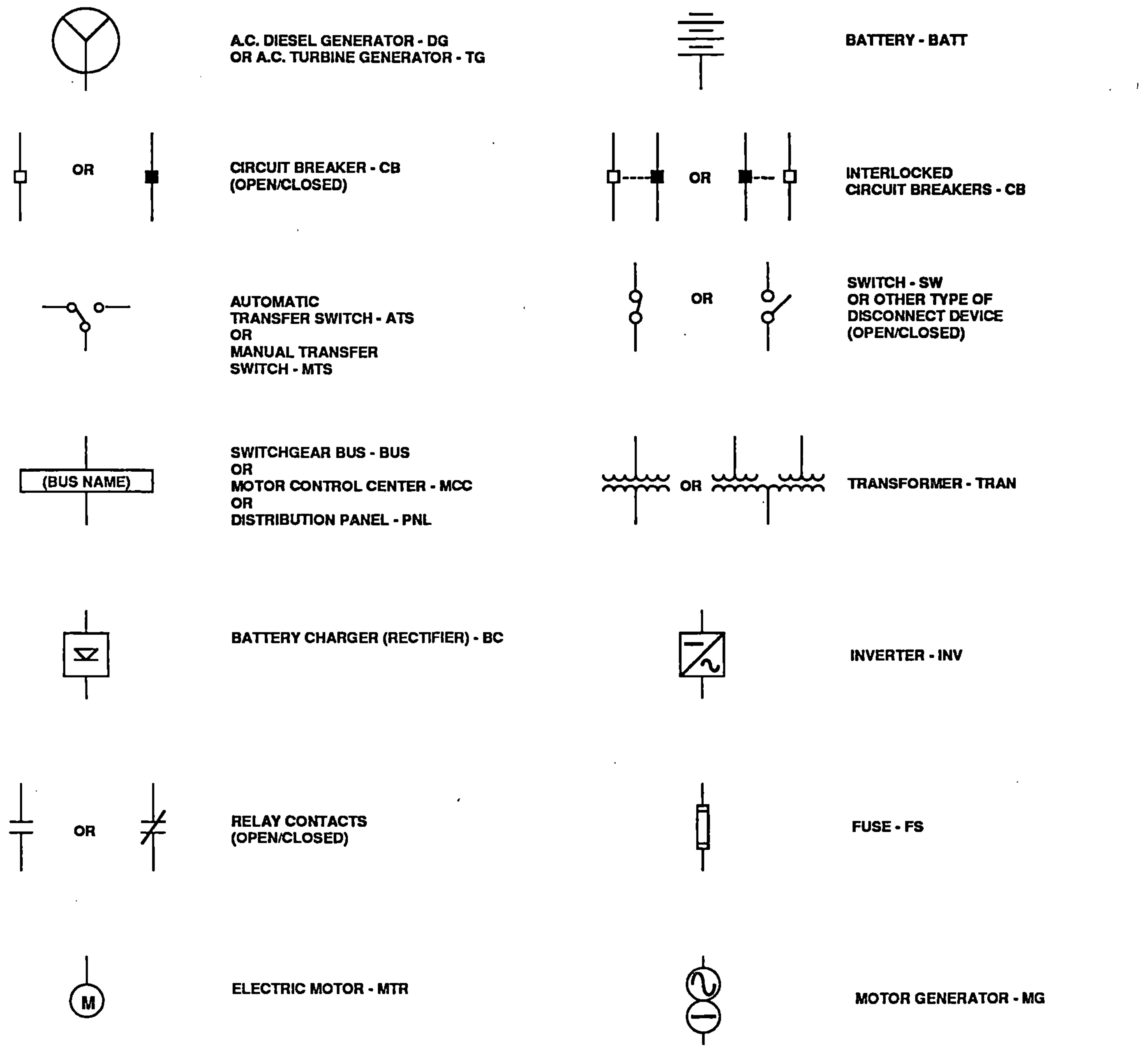

Figure A-3. Key To Symbols In Electrical System Drawings

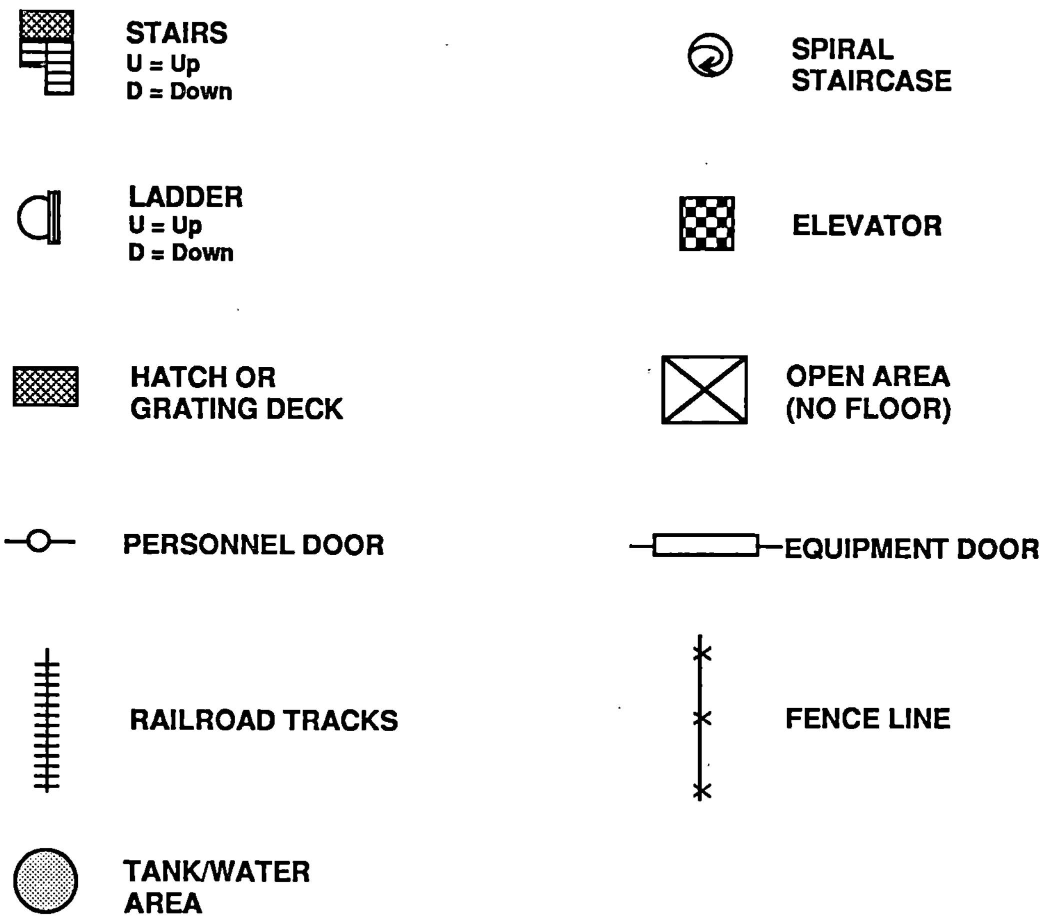

Figure A-4. Key To Symbols In Facility Layout Drawings

APPENDIX B
DEFINITION OF TERMS USED IN THE DATA TABLES

Terms appearing in the data tables in Sections 3 and 4 of this Sourcebook are defined as follows:

SYSTEM (also LOAD SYSTEM) - All components associated with a particular system description in the Sourcebook have the same system code in the data base. System codes used in this Sourcebook are the following:

Code	Definition
RCS	Reactor Coolant System
AFW	Auxiliary Feedwater System
ECCS	Emergency Core Cooling Systems (including HPSI, LPSI)
CVCS	Chemical and Volume Control (Charging) System
EP	Electric Power System
CCW	Component Cooling Water System
SW	Service Water System
FW	Fire Water System

COMPONENT ID (also LOAD COMPONENT ID) - The component identification (ID) code in a data table matches the component ID that appears in the corresponding system drawing. The component ID generally begins with a system preface followed by a component number. The system preface is not necessarily the same as the system code described above. For component IDs, the system preface corresponds to what the plant calls the component (e.g. HPI, RHR). An example is HPI-730, denoting valve number 730 in the high pressure injection system, which is part of the ECCS. The component number is a contraction of the component number appearing in the plant piping and instrumentation drawings (P&IDs) and electrical one-line system drawings.

LOCATION (also COMPONENT LOCATION and POWER SOURCE LOCATION) - Refer to the location codes defined in Section 4.

COMPONENT TYPE (COMP TYPE) - Refer to Table B-1 for a list of component type codes.

POWER SOURCE - The component ID of the power source is listed in this field (see COMPONENT ID, above). In this data base, a "power source" for a particular component (i.e. a load or a distribution component) is the next higher electrical distribution or generating component in a distribution system. A single component may have more than one power source (i.e. a DC bus powered from a battery and a battery charger).

POWER SOURCE VOLTAGE (also VOLTAGE) - The voltage "seen" by a load of a power source is entered in this field. The downstream (output) voltage of a transformer, inverter, or battery charger is used.

EMERGENCY LOAD GROUP (EMERG LOAD GROUP) - AC and DC load groups (or electrical divisions) are defined as appropriate to the plant. Generally, AC load groups are identified as AC/A, AC/B, etc. The emergency load group for a third-of-a-kind load (i.e. a "swing" load) that can be powered from either of two AC load groups would be identified as AC/AB. DC load group follows similar naming conventions.

Table B-1. Component Type Codes

Component	COMP TYPE
VALVES:	
Motor-operated valve	MOV
Pneumatic (air-operated) valve	NV or AOV
Hydraulic valve	HV
Solenoid-operated valve	SOV
Explosive (squib) valve	EXV
Manual valve	XV
Check valve	CV
Pneumatic non-return valve	NCV
Hydraulic non-return valve	HCV
Safety valve	SV
Dual function safety/relief valve	SRV
Power-operated relief valve (pneumatic or solenoid pilot-operated)	PORV
PUMPS:	
Motor-driven pump (centrifugal or PD)	MDP
Turbine-driven pump (centrifugal or PD)	TDP
Diesel-driven pump (centrifugal or PD)	DDP
OTHER FLUID SYSTEM COMPONENTS:	
Reactor vessel	RV
Steam generator (U-tube or once-through)	SG
Heat exchanger (water-to-water HX, or water-to-air HX)	HX
Cooling tower	CT
Tank	TANK or TK
Sump	SUMP
Rupture disk	RD
Orifice	ORIF
Filter or strainer	FLT
Spray nozzle	SN
Heaters (i.e. pressurizer heaters)	HTR
VENTILATION SYSTEM COMPONENTS:	
Fan (motor-driven, any type)	FAN
Air cooling unit (air-to-water HX, usually including a fan)	ACU or FCU
Condensing (air-conditioning) unit	COND
Motor-operated damper	MOD
Pneumatic (air-operated) damper	ND
Hydraulic damper	HD
Manual damper	XD
Back-flow preventing damper	BPD
High-efficiency particulate air filter	HEPA

Table B-1. Component Type Codes (Continued)

Component	COMP TYPE
EMERGENCY POWER SOURCES:	
Diesel generator	DG
Gas turbine generator	GT
Battery	BATT
ELECTRIC POWER DISTRIBUTION EQUIPMENT:	
Bus or switchgear	BUS
Motor control center	MCC
Distribution panel or cabinet	PNL or CAB
Transformer	TRAN or XFMR
Battery charger (rectifier)	BC or RECT
Inverter	INV
Uninterruptible power supply (a unit that may include battery, battery charger, and inverter)	UPS
Motor generator	MG
Circuit breaker	CB
Switch	SW
Automatic transfer switch	ATS
Manual transfer switch	MTS