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9.0 AUXILIARY SYSTEMS

9.1 FUEL STORAGE AND HANDLING

9.1.1 New Fuel Storage

9.1.1.1 Design Bases

New fuel is stored in racks (Figure 9.1-1). Each rack is composed of individual vertical cells which can be fastened together in any number to form a module that can be firmly bolted to anchors in the floor of the new fuel storage pit. The new fuel storage racks are designed to include storage for 1/3 core for each unit at a center to center spacing of 21 inches. This spacing provides a minimum separation between adjacent fuel assemblies of 12 inches which is sufficient to maintain a subcritical array even in the event the building is flooded with unborated water. Space between storage positions is blocked to prevent insertion of fuel. All surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel, whereas the supporting structure may be painted carbon steel. A three inch drain is provided in the new fuel storage vault.

The racks are designed to withstand nominal operating loads as well as SSE and OBE seismic loads in accordance with Regulatory Guides 1.29 and 1.13.

The new fuel storage racks are located in the new fuel pit area which has a cover that protects the racks from dropped objects. Administrative controls are utilized when a section of the protective cover is removed for handling of the new fuel assemblies.

9.1.1.2 Facilities Description

The location of the new fuel storage vault is shown in Figures 1.2-3 and 1.2-8. The design of the new fuel storage racks is shown in Figure 9.1-1.

The new fuel storage vault is a reinforced concrete structure. This vault is a part of the Auxiliary Building, which is a Seismic Category I Structure (See Section 3.2)

The new fuel storage vault opens on to the elevation 757 floor, but is normally covered by a series of hatches which are designed to withstand the effects of an OBE or SSE. These hatches are removed as necessary during handling of the new fuel.

9.1.1.3 Safety Evaluation

The center-to-center distance between new fuel assemblies is sufficient to assure k_{eff} $\leq$ 0.98 when the new fuel storage area is dry or fogged (optimally moderated). For the fully flooded condition assuming cold, clean, unborated water, the value of k_{eff} is less than or equal to 0.95.

The new fuel assemblies are stored dry, the 21 inch center to center spacing ensuring an ever safe geometric array. Under these conditions, a criticality accident during refueling and storage is not considered credible.

Design of the storage racks is in accordance with Regulatory Guide 1.13 and 1.29 and ensures adequate safety under normal and postulated accidents.

Consideration of criticality safety analysis is discussed in Section 4.3.2.7.

9.1.2 SPENT FUEL STORAGE

9.1.2.1 Design Bases

The spent fuel racks are designed in accordance with the following listed criteria:

(1) The spent fuel storage racks were designed for storage of 1386 fuel assemblies. The design meets all the structural and seismic requirements of Category I equipment as defined by the NRC Position Paper dated April 14, 1978, on spent fuel storage and handling applications and the references listed in Table 9.1-3.

(2) Burnup credit and fuel assembly placement controls are used to ensure the the fuel array in the spent fuel racks is maintained subcritical assuming the array is fully flooded with nonborated water, the fuel is new with a maximum anticipated enrichment of 5.0 weight percent U-235, and the geometric array is the worst possible considering mechanical tolerances and abnormal conditions.

(3) The spent fuel storage facility is designed to prevent severe natural phenomena, including missiles generated from high winds, from causing damage to the spent fuel. The spent fuel storage facility, including the spent fuel racks, is Seismic Category I.

(4) The spent fuel storage racks are designed to withstand handling and normal operating loads and the maximum uplift forces generated by the fuel handling equipment.

(5) A loss of pool cooling accident is not considered a credible accident because the pool cooling system is Seismic Category I and single failure proof.

(6) The spent fuel storage racks are designed to withstand the impact of a dropped spent fuel assembly from the maximum lift height of the spent fuel pit bridge hoist.

(7) The spent fuel storage facilities provide the capability for limiting the potential offsite exposures, in the event of significant release of radioactivity from the stored fuel, to well less than 10 CFR 100 guidelines.

9.1.2.2 Facilities Description

The spent fuel storage pool is a reinforced concrete structure with a stainless steel liner for leak tightness. This storage pool is a part of the Seismic Category I Auxiliary Building, and is shared between units one and two. Both the liner and pool walls are designed to withstand the effects of an OBE and SSE. The location of the spent fuel storage pool is shown on Figures 1.2-3 and 1.2-8. The storage rack configuration in the pool is shown on Figure 9.1-15. Typical storage racks are shown on Figure 9.1-16.

The spent fuel storage pool opens onto the elevation 757 floor, and is protected by a guard rail which surrounds the pool. The depth of the pool is sufficient to allow some 26 feet of water shielding (nominally) above the spent fuel. This water depth ensures that the doses on the operating floor from stored spent fuel are negligibly small.

The spent fuel storage racks consist of stainless steel structures with cells or receptacles for nuclear fuel assemblies as they are used in a reactor. Twenty-four of these flux trap racks, provide 1386 storage positions in eighteen 7 x 8 cell array modules and six 7 x 9 cell array modules. Figure 9.1-15 shows the layout of the storage racks in the spent fuel pool. Each rack is supported by four pedestals (one rack has five pedestals) sitting on two-inch thick stainless steel bearing pads which spread the load on the pool floor.

9.1.2.3 Safety Evaluation

Design of these storage racks is in accordance with Regulatory Guide 1.13 and ensures a safe condition under normal and postulated accident conditions. The distance between spent fuel assemblies is maintained to ensure a $k_{eff} \leq 0.95$ even if unborated water is used to fill the spent fuel storage pool. Consideration of criticality safety analysis is discussed in Section 4.3.2.7.

The spent fuel racks are designed as free standing and are qualified as seismic Category I structures. The seismic design considered fully loaded racks in water at less than boiling temperature undergoing a safe shutdown earthquake (SSE). Composite, dynamic simulations which modeled all racks in the pool were utilized to determine limiting loads and displacements for each rack in the pool, to establish limiting relative motion between racks, and to evaluate the potential for and the consequences of inter-rack and rack-wall phenomena in the entire assemblage of racks. The racks were also checked for operating basis earthquake (OBE) loads and found to be satisfactory. See section 3.8.4 for related pool structure information.

The racks can withstand the drop of a fuel assembly from its maximum supported height and the drop of tools used in the pool. The racks are also capable of withstanding accidental drops of the gates which cover the slots between the spent fuel pool and the transfer canal and cask loading pit from a height of eight feet above the top of the racks. Electrical and mechanical stops prevent the movement of heavy objects over the spent fuel pool including the shipping casks. The movement of the casks is restricted to areas away from the pool. The wall which separates the fuel storage area from the cask loading area has been designed to restrict damage to the cask loading area if a cask were dropped even in a tipped position in the cask loading area.

Loss of pool cooling and pool water events are discussed in Section 9.1.3. Radiation sources and protection for the pool water are discussed in Sections 12.2.1 and 12.3.2.2. Although the number of stored fuel assemblies is increased, the capacity of the pool water cleanup system is adequate to maintain radionuclide concentrations within design limits. Therefore no increase in personnel exposures is expected.

9.1.2.4 Materials

The materials used in the construction of the spent fuel racks are 304 stainless, CF-3M stainless and 17-4 PH stainless. The neutron poison material is a commercial product known as Boral and contains B_4C powder in a matrix.

The flux trap racks contain the following proven materials:

(1) Poison inner can and outer tubes: 304 stainless steel, ASTM A-666-72 Grade B

(2) Top and bottom grid castings: CF-3M, ASTM A-296-77

(3) Threaded pedestal foot: 17-4 PH, ASTM A-564-66

In addition to the stainless steel material, the racks employ Boral, a patented product of AAR Brooks and Perkins, as the thermal neutron absorber material. Boral is a thermal neutron absorbing material consisting of finely divided particles of boron carbide (B_4C) uniformly distributed in type 1100 aluminum, pressed and sintered in a hot rolling process. Boron carbide is a compound having a high boron content in a physically stable and chemically inert form. The 1100 alloy aluminum is a light weight metal with high tensile strength which is protected from corrosion by a highly resistant oxide film. The two materials, boron carbide and aluminum, are chemically compatible and ideally suited for long term use in the radiation, thermal and chemical environment of a spent fuel pool.

9.1.3 Spent Fuel Pool Cooling and Cleanup System (SFPCCS)

The SFPCCS is designed to remove from the spent fuel pool water the decay heat generated by stored spent fuel assemblies. Additional functions of the SFPCCS are to clarify and purify the water in the spent fuel pool, transfer canal, and refueling water storage tanks. If a warning of flood above plant grade is received when one or both reactor vessels are open or vented to the containment atmosphere, the SFPCCS will be modified as indicated in Section 2.4.14 to accomplish cooling the reactor core(s).

9.1.3.1 Design Bases

SFPCCS design parameters are given in Table 9.1-1.

9.1.3.1.1 Spent Fuel Pool Cooling

The SFPCCS is designed to remove the decay heat from the spent fuel assemblies stored in the pool and maintain acceptable pool temperatures following a full core discharge. The temperatures listed in Table 9.1-1 can be maintained for the various full core offload scenarios assuming the SFPCCS heat exchangers are supplied with component cooling water at its design flow and temperature. If it is necessary to remove a complete core after a normal refueling, the system can maintain the spent fuel pool water at or below 159.2°F in the worst case design basis single failure scenario.

The SFPCCS incorporates two trains of equipment (plus a spare pump capable of operation in either train). The flow through the pool provides sufficient mixing to ensure uniform water conditions throughout the pool. For normal full core refueling and full core off load following normal refueling outages, the heat load in the spent fuel pool is normally limited to 32.6E+06 Btu/hr. Alternatively, up to 47.4E+06 Btu/hr can be placed in the spent fuel pool within specific limitations on spent fuel pool cooling heat exchanger fouling and component cooling system supply temperatures less than the design temperature of 95 degrees F. Sufficient spent fuel pool cooling equipment is operated and the rate of fuel transfer is controlled to assure that the spent fuel pool temperature does not exceed 150°F during anticipated refueling activities. Operating procedures provide the controls to ensure these limitations are met. A decay heat calculation is routinely performed at the end of each operating cycle to produce heat decay vs time curves for the core and spent fuel pool. This calculation can be used to determine the time to begin core offload and the rate at which the core can be off loaded.

9.1.3.1.2 Spent Fuel Pool Dewatering Protection

System piping is arranged so that failure of any pipeline cannot drain the spent fuel pool below the water level required for radiation shielding. A water level of ten feet or more above the top of the stored spent fuel assemblies is maintained to limit direct gamma dose rate to 2.5 mr/hr or less.

9.1.3.1.3 Water Purification

The system's demineralizer and filter are designed to provide adequate purification to permit unrestricted access to the spent fuel storage area for plant personnel and maintain optical clarity of the spent fuel pool water surface by use of the system's skimmers, strainer, and skimmer filter.

9.1.3.1.4 Flood Mode Cooling

Section 2.4.14 presents the design basis operation of the SFPCCS when it may be used for reactor core cooling during flooded plant conditions.

9.1.3.2 System Description

The SFPCCS, shown in Figure 9.1-3, consists of two cooling trains (plus a backup pump capable of operation in either train), a purification loop, and a separate skimmer loop. The electrical logic control diagrams for this system are shown in Figures 9.1-4 and 9.1-5.

The SFPCCS removes decay heat from fuel stored in the spent fuel pool. Spent fuel is placed in the pool during the refueling sequence and stored there until it is shipped offsite. The system normally handles the heat load from either a full core or 1/3 of a core freshly discharged from each reactor plus the decreasing heat load from previously discharged fuel. Heat is transferred from the SFPCCS through the heat exchangers to the component cooling system.

When the SFPCCS is in operation, water flows from the spent fuel pool to both spent fuel pool pump suctions, is pumped through the tube side of the heat exchangers, and is returned to the pool. Each pump's suction line, which is protected by a strainer, is located at an elevation four feet below the normal spent fuel pool water level, while the return line contains an anti-siphon hole near the surface of the water to prevent gravity drainage of the pool.

While the heat removal operation is in process, a portion of the spent fuel pool water may be diverted through a demineralizer and a filter to maintain spent fuel pool water clarity and purity. This purification loop is sufficient for removing fission products and other contaminants which may be introduced if a fuel assembly with defective cladding is transferred to the spent fuel pool.

The spent fuel pool demineralizer may be isolated, by manual valves, from the heat removal portion of the SFPCCS. By this means, the isolated demineralizer may be used in conjunction with a refueling water purification pump and filter to clean and purify the refueling water while spent fuel pool heat removal operations proceed. Connections are provided such that the refueling water may be pumped from either the refueling water storage tank (RWST) or the refueling cavity of either unit, through the demineralizer and filter, and discharged to the refueling cavity or RWST of either unit. Connections are also provided to allow cleanup of the water in the transfer canals. Water can be drawn from the canal, and is pumped by a refueling water purification pump through the spent fuel pool demineralizer and a refueling water purification filter before being returned to the transfer canal.

To further assist in maintaining spent fuel pool water clarity, the water surface is cleaned by a skimmer loop. Water is removed from the surface by the skimmers, pumped through a strainer and filter, and returned to the pool surface at three locations remote from the skimmers.

The spent fuel pool is filled with water that is at least 2000 ppm. Borated water may be supplied from the RWST via the refueling water purification pump connection, or by running a temporary line from the boric acid blender, located in the chemical and volume control system directly into the pool. Demineralized water can also be added for makeup purposes (i.e., to replace evaporative losses) through a connection in the recirculation return line.

The spent fuel pool water may be separated from the water in the transfer canal by a gate. The gate is installed so that the transfer canal may be drained to allow maintenance of the fuel transfer equipment. The water in the transfer canal is pumped via a refueling water purification pump (RWPP) to a refueling water storage tank (RWST). The transfer canal will be refilled from the refueling water storage tank (RWST) by the refueling water purification pump (RWPP) when the maintenance is complete.

An alternate method when the transfer canal water is outside the chemistry limit for use in the refueling water storage tank (RWST) is to pump the transfer canal water to the chemical and volume control system (CVCS) holdup tank via the refueling water purification pump (RWPP). The water will be pumped back to the transfer canal via the chemical and volume control system (CVCS) holdup tank recirculation pumps.

A description of the operation of the SFPCCS during flood mode operation is given in Section 2.4.14.

9.1.3.2.1 Component Description

Spent fuel pool cooling and cleanup system codes and classifications are given in Section 3.2. Equipment operating parameters are given in Table 9.1-2. System design parameters are given in Table 9.1-1.

Spent Fuel Pool Pumps

The two pumps are horizontal, centrifugal units. They circulate spent fuel pool water through the heat exchangers, demineralizer, and filter. The pumps are controlled manually from a local station. A third pump is installed to serve as a backup to either of the two pumps normally used for cooling the spent fuel pool water (refer to Section 2.4.14 and Section 9.1.3.3.1).

Spent Fuel Pool Skimmer Pump

This horizontal, centrifugal pump circulates surface water through a strainer and a filter and returns it to the pool.

Refueling Water Purification Pumps

These horizontal, centrifugal pumps are used to circulate water from the transfer canal, the refueling cavity and the refueling water storage tank through the spent fuel pool demineralizer, and a refueling water purification filter. The pumps are operated manually from a local station.

Spent Fuel Pool Heat Exchangers

The spent fuel pool heat exchangers are of the shell and U-tube type with the tubes welded to the tube sheet. Component cooling water circulates through the shell, and spent fuel pool water circulates through the tubes.

Spent Fuel Pool Demineralizer

This flushable, mixed-bed demineralizer is designed to provide adequate fuel pool water purity for unrestricted access by plant personnel to the pool working area, and to maintain water visual clarity.

Spent Fuel Pool Filter

The spent fuel pool filter is designed to improve the pool water clarity by removing particles which obscure visibility.

Spent Fuel Pool Skimmer Filter

The spent fuel pool skimmer filter is used to remove particles which are not removed by the strainer.

Refueling Water Purification Filters

The refueling water purification filters are designed to improve the clarity of the refueling water in the refueling canal or in the refueling water storage tank by removing particles which obscure visibility.

Spent Fuel Pool Strainer

A strainer is located in each spent-fuel pool pump suction line for removal of relatively large particles which might otherwise clog the spent fuel pool demineralizer or damage the spent fuel pool pumps.

Spent Fuel Pool Skimmer Strainer

The spent fuel pool skimmer strainer is designed to remove debris from the skimmer process stream.

Spent Fuel Pool Skimmers

Two spent fuel pool skimmers are provided to remove water from the spent fuel pool water surface in order to remove floating debris.

Valves

Manual stop valves are used to isolate equipment, and manual throttle valves provide flow control. Valves in contact with spent fuel pool water are of austenitic stainless steel or equivalent corrosion resistant material.

Piping

All piping in contact with spent fuel pool water is austenitic stainless steel. The piping is welded except where flanged connections are used to facilitate maintenance and access to shadowed fuel storage cells.

9.1.3.3 Safety Evaluation

9.1.3.3.1 Availability and Reliability

The SFPCCS is located in a Seismic Category I structure that is tornado missile protected. Active components of the cooling portion of the system are located above the design basis flood level in the Auxiliary Building (Section 2.4.14). The SFPCCS heat removal equipment is designed to remain functional for the design basis earthquake and within the required stress limits for the operational basis earthquake.

Electrical power is supplied from emergency power buses to each of the spent fuel pool pumps. Each pump is connected to these emergency power buses so that it receives power from a separate diesel generator set should offsite power be lost. The use of emergency power buses assures the operation of these pumps for open reactor cooling during plant flooding conditions. This manually controlled system may be shut down for limited periods of time for maintenance or replacement of malfunctioning components. The pool is sufficiently large that an extended period of time would be required for the water to heat up appreciably if cooling were interrupted (see Table 9.1-1). In the event of a failure of one spent fuel pool pump, the backup pump would be aligned and operated. In the event of loss of cooling to one spent fuel pool heat exchanger, cooling of the spent fuel pool water could be maintained by the remaining equipment; however, the reduced heat removal capacity would result in elevation of the spent fuel pool water equilibrium temperature to a higher, but acceptable, temperature.

In the event that cooling capability were lost for an extended period, the pool water temperature would approach boiling. At the maximum decay heat production rate, the water loss by vaporization would be about 102 gpm. A seismically qualified line is available from the common discharge of the refueling water purification pumps to the spent fuel pool cooling loop. All piping, valves, and pumps from the RWST to the common discharge of the refueling water purification pumps are seismically qualified. Other sources for makeup available are the demineralized water system and the fire protection system. A sufficient portion of the fire protection system is a Seismic Class I system. Fire hose stations located on seismic and non-seismic piping in the Fire Protection system are capable of supplying a sufficient quantity of makeup water.

9.1.3.3.2 Spent Fuel Pool Dewatering

The most serious failure of this system would be complete loss of water in the storage pool. To protect against this possibility, the spent fuel pool cooling suction connections enter near the normal water level such that it cannot be lowered appreciably by siphoning. The cooling water return line contains an anti-siphon hole to prevent draining of the pool. These design features assure that the pool cannot be drained below four feet of normal water level (normal water level in the spent fuel pool is approximately 26 feet above the top of the stored spent fuel).

The transfer canal has a drain connection in the bottom of the canal. The line runs upward, embedded in concrete, to a level about 13 feet below the normal pool surface. The line continues embedded, dropping below the bottom of the transfer canal. At the high point of the drain line, a siphon breaker line connects into the drain line, terminating in the canal above the normal pool surface. A valve in this line is locked open at all times except when the canal is to be drained. The transfer canal is isolated from the spent fuel pool with a sectionalizing gate during "Transfer Canal Dewatering", (draining operation). With this arrangement, if the transfer canal drain line ruptures, the pool level will not be affected. If the transfer canal drain line ruptures with the syphon valve open and the sectionalizing gate open, 13 feet of water will be above the fuel assemblies in the storage racks.

9.1.3.3.3 Pool and Fuel Temperatures

The cooling of the spent fuel assemblies stored within the storage racks has been analyzed for effective and adequate cooling under all postulated pool storage conditions.

Two discharge scenarios have been evaluated for both single and dual SFP cooling train operation. Case one considers a full core discharge while a second case considers a full core discharge following a normal refueling. Each case considers the accumulated decay heat of all previously discharged spent nuclear fuel assemblies stored in the SFP. Maximum bulk water temperatures for each core off load scenario are given in Table 9.1-1. With a 12 day decay time, the maximum heat load associated with a full core discharge is 28.1E+06 Btu/hr while the maximum heat load for a full core discharge following a normal refueling outage case is 32.6E+06 Btu/hr.

For normal full core refueling and full core off load following a normal refueling outage, the heat load in the spent fuel pool is normally limited to 32.6E+06 Btu/hr. Alternatively, up to 47.4E+06 Btu/hr can be placed in the spent fuel pool within specific limitations on spent fuel pool cooling heat exchanger fouling and component cooling system supply temperatures less than the design temperature of 95°F. Specific guidance in the form of allowable SFP decay heat curves for less than design conditions of SFP heat exchanger fouling and shell side cooling temperatures has been developed. Decay heat curves are provided which allow outage specific variation in maximum SFP decay heat load based on known values of SFP heat exchanger fouling factors and component cooling system temperatures. Sufficient spent fuel pool cooling equipment is operated and the rate of fuel transfer is controlled to assure that the spent fuel pool temperature does not exceed 150°F during anticipated refueling activities. Operating procedures provide the controls to ensure these limitations are met. A decay heat calculation is routinely performed at the end of each operating cycle to produce heat decay vs time curves for the core and spent fuel pool. This calculation may be used to determine the time to begin core off load and the rate at which the core can be off loaded.

The maximum local water temperature and maximum local fuel temperature have been determined to evaluate the possibility of nucleate boiling on the surface of the fuel assemblies. Analysis has shown that for any scenario with at least one SFPCCS cooling train available, localized boiling does not occur within the fuel racks. The decay heat flux of the rods is greatest at the fuel mid-height. Mid height fuel cladding temperatures of 208.2°F, 217.1°F, and 208.9°F have been calculated based on no blockage, partial blockage, and off-center placement of an assembly in a rack cell respectively. Local maximum water temperatures of 193.7°F, 204.1°F, and 195.2°F have been calculated for the no blockage, partial blockage, and off-center placement cases respectively. The local saturation temperature at the top of the racks (240.7°F) is greater than any calculated local water temperature, which precludes the possibility of nucleate boiling. Additionally, the local saturation temperature is greater than any calculated fuel cladding temperature, which would preclude the possibility of film boiling at the surface of the fuel rods.

The approach to localized boiling within the racks has been evaluated for highest allowable spent fuel decay heat load (47.4 Mbtu/hr) in Reference [1]. The conclusions of the evaluation indicate that greater than 6°F margin to localized boiling exist between the maximum calculated fuel clad temperature and the local saturation temperature even at the highest allowable heat load.

The total volume of water contained in the pool and cask pit area at the start of a loss of cooling scenario is 372,460 gallons. The expected water heat-up rates for a total loss of cooling capability accident for both a full core discharge and a full core discharge following a normal refueling are listed in Table 9.1-1.

9.1.3.3.4 Water Quality

Except for operation of this system in the flood mode of reactor cooling, only a very small amount of water is interchanged between the refueling canal and the spent fuel pool as fuel assemblies are transferred in the refueling process. Whenever a fuel assembly with defective cladding is transferred to the spent fuel pool, a small quantity of fission products may enter the spent fuel cooling water. The purification loop provided removes fission products and other contaminants from the water. Radioactivity concentrations in the spent fuel pool water are maintained at a level such that the dose rate at the surface of the pool is low enough to allow minimum-restricted access for plant personnel (refer to Section 12.3.2.2). With the use of high purity water, it is expected that the racks and pool walls will not see any significant crud buildup.

9.1.3.3.5 Leakage Detection for the Spent Fuel Pool

Leakage detection is provided for the spent fuel pool (SFP) by leakage channels located on the back side of each welded joint of the floor and walls of the SFP steel liner. Leakage into these channels will drain to the perimeter leakage channels located at the bottom of the SFP. The leakage will then flow into the SFP drain pipe to a normally open manual gate valve. Visual detection of the leakage from the SFP may be witnessed as the leakage exits the manual valve and drips into a funnel. The leakage is then routed to the tritiated drain collector tank (TDCT) of the waste disposal system. In the event of excessive leakage, the manual gate valve may be closed to prevent further leakage. Similar type design of leakage channels and visual display of leakage are also provided for the fuel transfer canal and the cask loading area. Non qualified instrumentation are provided in the SFP and the TDCT with MCR low and local high level alarms, respectively.

9.1.3.4 Tests and Inspections

Active components of the SFPCCS are either in continuous or intermittent use during normal plant operation. Periodic visual inspection and preventive maintenance are conducted using normal industry practice.

9.1.3.5 Instrument Application

The instrumentation for the SFPCCS is discussed below. Alarms and indicators are provided as noted.

9.1.3.5.1 Temperature

Instrumentation is provided to measure the temperature of the water in the spent fuel pool and give local indication as well as annunciation in the control room when normal temperatures are exceeded.

Instrumentation is also provided to give local indication of the temperature of the spent fuel pool water as it leaves the heat exchangers.

9.1.3.5.2 Pressure

Instrumentation is provided to give local indication of the pressure at points upstream and downstream of each pump and filter.

9.1.3.5.3 Flow

Instrumentation is provided to give local indication of the flow leaving the spent fuel pool filter and in the main cooling loops.

9.1.3.5.4 Level

Instrumentation is provided which gives an alarm in the control room when the water level in the spent fuel pool reaches either the high or low level condition.

9.1.4 FUEL HANDLING SYSTEM

9.1.4.1 Design Bases

The fuel handling system (FHS) consists of equipment and structures utilized for safely implementing refueling operation in accordance with requirements of General Design Criteria 61 and 62 of 10 CFR 5O, Appendix A.

The following design bases apply to the FHS.

(1) Fuel handling devices have provisions to avoid dropping or jamming of fuel assemblies during transfer operation.

(2) Handling equipment has provisions to avoid dropping of fuel handling devices during the fuel transfer operation.

(3) Handling equipment used to raise and lower spent fuel has a limited maximum lift height so that the minimum required depth of water shielding is maintained. See New Fuel Elevator description for use with spent fuel.

(4) The Fuel Transfer System (FTS), where it penetrates the containment, has provisions to preserve the integrity of the containment pressure boundary.

(5) Criticality during fuel handling operations is prevented by geometrically safe configuration of the fuel handling equipment.

(6) Handling equipment will not fail in such a manner as to damage Seismic Category I equipment in the event of a safe shutdown earthquake.

(7) The inertial loads imparted to the fuel assemblies or core components during handling operations are less than the loads which could cause damage.

(8) Physical safety features are provided for personnel operating handling equipment.

9.1.4.2 System Description

The FHS consists of the equipment needed for the refueling operation on the reactor core. Basically this equipment is comprised of a fuel assembly, core component and reactor component hoisting equipment, handling equipment and a FTS. The structures associated with the fuel handling equipment are the refueling cavity, the refueling canal, the transfer canal, the spent fuel storage pit, the cask loading area and the new fuel storage vault.

New fuel assemblies received for initial fuel loads are removed one at a time from the shipping container and stored in either the new and/or spent fuel storage racks. All new fuel assemblies received after the initial fuel loads are normally stored in the new fuel storage racks located in the new fuel storage vault.

A new fuel assembly is delivered to the reactor by removing it from the new fuel storage rack using the Auxiliary Building crane, placing it into the new fuel elevator, lowering it into the fuel transfer canal, and transferring it through the fuel transfer systems.

The fuel handling equipment is designed to handle the spent fuel under water from the time it leaves the reactor vessel until it is placed in a container for shipment from the site. Underwater transfer of spent fuel provides an effective, economic and transparent radiation shield, as well as a reliable cooling medium for removal of decay heat. The boric acid concentration in the water is sufficient to preclude criticality.

The associated fuel handling structures may be generally divided into three areas: the refueling cavity and refueling canal which are flooded only during plant shutdown for refueling, the spent fuel storage area which is kept full of water and is always accessible to operating personnel, and the new fuel storage vault which is separate and protected for dry storage. The refueling canal and the transfer canal are connected by a fuel transfer tube. This tube is fitted with a blind flange on the refueling canal end and a gate valve on the transfer canal end. The blind flange is in place except during refueling to ensure containment integrity. Fuel is carried through the tube on an underwater transfer car.

Fuel is moved between the reactor vessel and the refueling canal by the manipulator crane. A rod cluster control changing fixture is located on the refueling canal wall and may be used for transferring control elements from one fuel assembly to another. The Rod Cluster Control Assembly (RCCA) change tool is used from the spent fuel pool bridge crane to transfer control elements form one assembly to another in the spent fuel pool.

The lifting arm at either end of the fuel transfer tube is used to pivot a fuel assembly. Before entering the transfer tube the lifting arm pivots a fuel assembly to the horizontal position for passage through the transfer tube. After the transfer car transports the fuel assembly through the transfer tube, the lifting arm at that end of the tube pivots the assembly to a vertical position so that it can be lifted out of the upender frame.

In the spent fuel storage area, spent fuel assemblies are moved about by the spent fuel pit bridge hoist. When lifting spent fuel assemblies, the hoist uses a long-handled tool to assure that sufficient radiation shielding is maintained. A shorter tool is used to handle new fuel assemblies with the Auxiliary Building crane, but the new fuel elevator must be used to lower the assembly to a depth at which the spent fuel pit bridge crane using the long-handled tool, can place the new fuel assembly into the upending device.

The New Fuel Elevator may be used to raise or lower an irradiated fuel assembly to facilitate maintenance activities under administrative controls that ensure sufficient radiation shielding is maintained.

Decay heat, generated by the spent fuel assemblies in the spent fuel pit, is removed by the spent fuel pool cooling system.

9.1.4.2.1 Refueling Procedure

The refueling operation follows a detailed procedure which provides a safe, efficient refueling operation. Reactor core alterations or handling of irradiated fuel are suspended during a tornado warning. Prior to initiating refueling operations the reactor coolant system is borated and cooled down to refueling shutdown conditions as specified in the Technical Specifications. Criticality protection for refueling operations, including a requirement for periodic checks of boron concentration, is specified in the Technical Specifications.

The following significant points are assured by the refueling procedure:

(1) The refueling water and the reactor coolant contains the required concentration of boron. This concentration is sufficient to keep the core reactivity k_{eff}</=0.95 during the refueling operations with all control rods inserted, except the most reactive rod.

(2) The water level in the refueling cavity is high enough to keep the radiation levels within acceptable limits when the fuel assemblies are being removed from the core.

The refueling operation is divided into four major phases. A general description of a typical refueling operation through the four phases is given below:

(1) Phase I - Preparation

The reactor is shut down and cooled to refueling conditions with a final $k_{eff} \leq$ 0.95 (all rods in, except the most reactive rod). At this time, the coolant level in the reactor vessel is lowered to a point slightly below the vessel flange. Then the fuel transfer equipment is checked for proper operation prior to or during Phase 1.

(2) Phase II - Reactor Disassembly

Missile shields are removed from around the reactor head, allowing all piping, supports, cables, air ducts, and insulation to be removed from the vessel head. The refueling cavity is then prepared for flooding by sealing off the reactor cavity, checking of the underwater lights, tools, and FTS, closing the refueling canal drain holes, and removing the blind flange from the fuel transfer tube. After the reactor vessel head has been detensioned, the vessel head is unseated and raised above the vessel flange. Water from the RWST is pumped into the reactor coolant system by the residual heat removal pumps. During reactor pressure vessel (RPV) head removal and lift, radiation levels are monitored and direct inspections are performed to detect potential rod cluster control assembly (RCCA) withdrawal. The reactor cavity water level is raised to just above the vessel flange, leak inspections are initiated and the level is increased to cover the upper internals guide tubes. The RPV head is then raised to clear obstructions, moved to the storage stand, and the cavity water level is raised to the normal refueling level. The control rod drive shafts are disconnected and, with the upper internals, are removed from the vessel. The fuel is now free from obstructions and the core is ready for refueling. .

(3) Phase III - Fuel Handling

The general fuel handling sequence for a full core off load is:

(a) The refueling machine is placed over the first assembly to be removed.

(b) The fuel assembly is lifted and moved into the upender.

(c) The upender is then pivoted to the horizontal position by the lifting arm.

(d) The fuel is moved through the fuel transfer tube to the transfer canal area by the transfer car.

(e) The fuel assembly is pivoted to the vertical position by the lifting arm. The fuel assembly is lifted and moved by the spent fuel handling tool attached to the spent fuel pit bridge crane.

(f) The fuel assembly is then placed into a spent fuel rack storage cell.

(g) This sequence is repeated until all 193 fuel assemblies are removed from the core and placed into the spent fuel pit.

(h) Fuel related components are then shuffled/removed from assemblies and placed into their proper locations. After fuel related components shuffles are completed, the fuel is loaded back into the core in the prescribed sequence by reversing the above steps.

(4) Phase IV - Spent Fuel Cask Loading. WBN currently does not, and has no immediate plans to, ship spent fuel off-site. The following discussion is provided for Historical Information only.

(a) The fuel cask shipping conveyance is parked inside the Auxiliary Building with the hatch covers in the elevation 757 floor closed for ventilation control.

(b) When the outside door is closed, the hatch covers are opened.

(c) The shipping cask is picked up by the Auxiliary Building crane and is moved to an open area on the operating floor. If it is necessary to disengage the crane hook to free the crane for other uses, the cask is lowered to the cask decontamination facility or into the cask loading area of the spent fuel pool. In either of these locations, a seismic event would not overturn the cask.

(d) The gate is placed in the slot between the spent fuel pit and the cask loading area.

(e) The cask is picked up by the crane and is lowered onto the shelf in the loading area. The crane hook is disengaged from the cask, and an extension link is inserted between hook and cask. The cask then is lowered into the deep portion of the pit.

(f) The cask lid is removed and placed in the cask setdown area.

(g) The gate is removed from the slot.

(h) Using the spent fuel pit bridge crane, fuel assemblies are transferred, one at a time, from the spent fuel storage racks to the cask.

(i) The gate is placed in the slot and the cask lid is replaced.

(j) The cask is lifted onto the shelf, the extension link is removed, and the cask is removed from the loading areas. It is then placed in the cask decontamination room and tiedown devices are affixed.

(k) After decontamination the cask undergoes preshipment tests.

(l) The cask is placed on the shipping conveyance with the outer door closed.

(m) The hatch covers in the Elevation 757 floor are closed and the conveyance is moved out of the building.

9.1.4.2.2 Component Description

Refueling Machine

The refueling machine (Figure 9.1-6) is a rectilinear bridge and trolley crane with a vertical mast extending down into the refueling water. The bridge spans the refueling cavity and runs on rails set into the edge of the refueling cavity. The bridge and trolley motions are used to position the vertical mast over a fuel assembly. A long tube with a pneumatic gripper on the end is lowered down out of the mast to grip the fuel assembly. The gripper tube is long enough so that the upper end is still contained in the mast when the gripper end contacts the fuel. A winch mounted on the trolley raises the gripper tube and fuel assembly up into the mast tube. The fuel is transported while inside the mast tube to its new position.

The refueling machine uses three AC servo motors to control bridge, trolley, and hoist motions. Boundaries, interlocks, and speeds are controlled by an industrial programmable logic controller.

All major controls for the refueling machine are mounted in two consoles on the trolley. The bridge and trolley are positioned in relation to a grid pattern referenced to the core by a series of redundant digital encoder systems.

The drives for the bridge, trolley and hoist are variable speed. The maximum speed for the bridge is approximately 60 fpm and the maximum speed for the trolley is approximately 40 fpm. The maximum speed for the hoist is approximately 40 fpm.

The refueling machine has two auxiliary monorail hoists, one on each side of the bridge upper structure.

Electrical interlocks and limit switches on the bridge and trolley drives prevent damage to the fuel assemblies. The hoist is also provided with redundant limit switches to prevent a fuel assembly from being raised above a safe shielding depth should the limit switch fail. In an emergency, the bridge, trolley and hoist can be operated manually using a handwheel on the motor shaft to return the system to a safe configuration.

Portable underwater cameras are used, as required, during refueling operations and can permit viewing of all fuel assembly positions.

Spent Fuel Pit Bridge Crane

The spent fuel pit bridge crane (Figure 9.1-7) is a steel-mounted walkway spanning the spent fuel pit, which carries an electric monorail hoist on an overhead structure. The spent fuel pit bridge crane is used exclusively for handling fuel assemblies within the spent fuel pit and transfer canal by means of a long-handled tool suspended from the hoist. The hoist travel and tool length are designed to limit the maximum lift of a fuel assembly to a safe shielding depth.

The spent fuel bridge crane has two step magnetic controllers for the bridge and hoist. The bridge speeds are 11 and 33 fpm and the hoist speeds are 7 and 20 fpm. A hydraulic coupling is used in the bridge drive to limit starting acceleration.

The hoist pendent control is equipped with a load sensing device to indicate an overload in the up direction or an underload in the down direction to prevent damage to the fuel elements. The hoist trolley is hand operated by a chain drive.

New Fuel Elevator

The new fuel elevator (Figure 9.1-8) consists of a box-shaped elevator assembly with its top end open and sized to house one fuel assembly.

The new fuel elevator is used primarily to lower a new fuel assembly to the bottom of the fuel transfer canal where it is transported to the fuel transfer system by the spent fuel pit bridge hoist.

The New Fuel Elevator may also be used to raise and lower an irradiated fuel assembly to facilitate maintenance activities. Prior to placing an irradiated fuel assembly in the elevator, safety precautions will be implemented to limit the maximum lift of the fuel assembly to a safe shielding depth.

Fuel Transfer System

The fuel transfer system (Figure 9.1-9) includes an electric, gear motor-driven transfer car that runs on tracks extending from the reactor cavity through the transfer tube into the transfer canal. At each end of the transfer tube are operator actuated lifting arms. The upender in the refueling cavity receives a fuel assembly in the vertical position from the manipulator crane. The fuel assembly is then pivoted to a horizontal position with the lifting arm for passage through the transfer tube. The transfer car is positively connected to the drive train in the transfer canal. After passing through the tube, the fuel assembly is pivoted to a vertical position for removal to the spent fuel pit storage location via the spent fuel pit bridge crane.

During reactor operation, the transfer car is stored in the transfer canal. A blind flange is bolted on the refueling canal end of the transfer tube to seal the reactor containment. The terminus of the tube in the transfer canal is closed by a gate valve.

Rod Cluster Control (RCC) Changing Fixture

The RCC changing fixture is supplied for periodic RCC element inspections and for transfer of RCC elements from one fuel assembly to another in the event this operation is ever required (Figure 9.1-10). The major subassemblies which comprise the changing fixture are the frame and track structure, the carriage, the guide tube, the gripper, and the drive mechanism. The carriage is a moveable container supported by the frame and track structure. The tracks provide a guide for the four flanged carriage wheels and allows horizontal movement of the carriage during changing operation. The positioning stops on both the carriage and frame locate each of the three carriage compartments directly below the guide tube. Two of these compartments are designed to hold individual fuel assemblies while the third is made to support a single rod cluster control element. Situated above the carriage and mounted on the refueling canal wall is the guide tube. The guide tube provides for the guidance and proper orientation of the gripper and rod cluster control element as they are being raised and lowered. The gripper is a pneumatically actuated mechanism responsible for engaging the rod cluster control element. It has two flexure fingers which can be inserted into the top of the rod cluster control element when air pressure is applied to the gripper piston. Normally the fingers are locked in a radially extended position. Mounted on the operating deck is the drive mechanism assembly which consists of the manual carriage drive mechanism, the operating handle, the pneumatic selector valve for actuating the gripper piston, and the electric hoist for elevation control of the gripper.

Spent Fuel Assembly Handling Tool

The spent fuel assembly handling tool (Figure 9.1-11) is used to handle new and spent fuel assemblies in the spent fuel pit. It is a manually actuated tool, suspended from the spent fuel pit bridge crane, which uses four cam actuated latching fingers to grip the underside of the fuel assembly top nozzle. The operating handle to actuate the fingers is located at the top of the tool. When the fingers are latched, a pin is inserted into the operating handle which prevents the fingers from being accidently unlatched during fuel handling operations.

New Fuel Assembly Handling Tool

The new fuel assembly handling tool (Figure 9.1-12) is used to lift and transfer fuel assemblies between the new fuel shipping containers, the new fuel storage racks, and/or the new fuel elevator. It is a manually actuated tool suspended from the Auxiliary Building crane which uses four cam actuated latching fingers to grip the underside of the fuel assembly top nozzle. The operating handles to actuate the fingers are located on the side of tool. When the fingers are latched, the safety screw is turned in to prevent the accidental unlatching of the fingers.

Reactor Vessel Head Lifting Device

The reactor vessel head lifting device consists of a welded and bolted structural steel frame with suitable rigging to enable lifting and storing the head during refueling operations. The lifting device is permanently attached to the reactor vessel head.

Reactor Internals Lifting Device

The reactor internals lifting device (figure 9.1-13) is a structural steel frame. The frame is lowered onto the guide tube support plate of the internals, and is mechanically connected to the support plate by three bolts. Bushings on the frame engage guide studs in the vessel flange to provide guidance during removal and replacement of the internals package.

Reactor Vessel Stud Tensioner

The stud tensioners (Figure 9.1-14) are employed to secure the head closure joint at every refueling. The stud tensioner is a hydraulically operated device that uses oil as the working fluid. The device permits preloading and unloading of the reactor vessel closure studs at cold shutdown conditions. Stud tensioners minimize the time required for stud tensioning and detensioning operations. Three tensioners are provided and are applied simultaneously to three studs located 120 degrees apart. A single hydraulic pumping unit operates the tensioners, which are hydraulically connected in series. The studs are tensioned to their operational load in two steps to prevent high stresses in the flange region and unequal loadings in the studs. Relief valves on each tensioner prevent overtensioning of the studs due to excessive pressure.

9.1.4.3 Design Evaluation

9.1.4.3.1 Safe Handling

Design criteria for the Refueling Machine

(1) The primary design objective of the refueling machine is reliability. A conservative design approach is used for all load bearing parts. Where possible, components are used that have a proved record of reliable service. Throughout the design consideration is given to the fact that the machine spends long idle periods stored in an atmosphere of 80°F and high humidity. In general, the crane structure is considered in the Class AI, Standby Service, as defined by the Crane Manufacturers Association of American Specification No. 70.

(2) Seismic design considerations are discussed in Section 9.1.4.3.2.

(3) All components critical to the operation of the crane and parts which could fall into the reactor are positively restrained from loosening. Fasteners above water that cannot be lockwired or tack welded are coated with locking compound.

Industrial codes and standards used in the design of the fuel handling equipment are:

(1) Refueling machine and fuel handling machine: Applicable sections of Crane Manufacturer Association of America Specification No. 70.

(2) Structural: AISC, Part 5, 7th Edition

(3) Electrical: Applicable standards and requirements of the IEEE Standard 279, National Electric Code, NFPA#70, and NEMA Standards MGI and ICS shall be used in the design, installation, and manufacturing of all electrical equipment.

(4) Materials: Materials conform to the specifications of the ASTM standard.

(5) Safety: OSHA Standards 29 CFR 1910 and 29 CFR 1926, including load testing requirements, the requirements of ANSI N.18.2, Regulatory Guide 1.29, and General Design Criteria 61 and 62.

Refueling Machine

The refueling machine design includes the following provisions to ensure safe handling of fuel assemblies:

(6) Electrical Interlocks

(a) Bridge, Trolley and Hoist Drive Mutual Interlocks

Bridge, trolley and hoist drives are mutually interlocked, using redundant interlocks to prevent simultaneous operation of any two drives. Therefore they can withstand a single failure.

(b) Bridge Trolley Drive - Gripper Tube Up

Bridge and trolley drive operation is prevented except when the gripper tube up position switches are actuated. The interlock is redundant and can withstand a single failure.

(c) Gripper Interlock

An interlock is supplied which prevents the opening of a solenoid valve in the air line to the tripper except when zero suspended weight is indicated by a force gage. As backup protection for this interlock, the mechanical weight actuated lock in the gripper, prevents operation of the gripper under load even if air pressure is applied to the operating cylinder. This interlock is redundant and can withstand a single failure.

(d) Excessive Suspended Weight

Two redundant excessive suspended weight switches open the hoist drive circuit in the up direction when the loading is in excess of 110% of a fuel assembly weight. The interlock is redundant and can withstand a single failure.

The hoist is also provided with a low-load safety circuit, which prevents down-travel of the hoist if the load cell weight is suddenly reduced to 2100 lbs wet (2200 lbs dry). This minimizes the possibility of fuel assembly damage if one fuel assembly were to be lowered on top of another fuel assembly.

(e) Hoist-Gripper Position Interlock

An interlock in the hoist drive circuit in the up direction permits the hoist to be operated only when either the open or closed indicating switch on the gripper is actuated. The hoist-gripper position interlock consists of two separate circuits that work in parallel so that one circuit must be closed for the hoist to operate. If one or both interlocking circuits fail in the closed position, an audible and visual alarm on the console is actuated. The interlock, therefore, is not redundant but can withstand a single failure since both an interlocking circuit and the monitoring circuit must fail to cause a hazardous condition.

(2) Bridge and Trolley Hold-Down Devices

Both refueling machine bridge and trolley are horizontally restrained on the rails by two pairs of guide rollers, one pair at each wheel location on one truck only. The rollers are attached to the bridge truck and contact the vertical faces on either side of the rail to prevent horizontal movement. Vertical restraint is accomplished by anti-rotation bars located at each of the four wheels for both the bridge and trolley. The anti-rotation bars are bolted to the trucks and, for the bridge restraints, extended under the rail flange, while the trolley restraints extend beneath the top flange of the bridge girder which supports the trolley rail. Both horizontal and vertical restraints are adequately designed to withstand the forces and overturning moments resulting from the Safe Shutdown Earthquake.

(3) Design Load

The structure which supports the fuel assembly is designed for a static load of 5500 pounds. The manipulator crane hoist has a manufacturer's rated capacity of 4000 pounds but is capable of supporting a static load of 5000 pounds with a safety factor of 5.0, and has been evaluated to be capable of a 5500 lb. static load in an emergency. Under normal conditions, the working load of the hoist is 2500 pounds (the weight of a fuel assembly, approximately 1600 pounds, plus gripper tube which weighs less than 1000 pounds). During normal hoist operation, the overload setpoint limits the hoist load to 2700 pounds, which is well below the rated capacity of the hoist. The maximum allowable emergency pullout load (total maximum load which can be applied using the handwheel without danger of over stressing the hoist and supporting structure) is 5500 pounds. The 5500 pound load is a static load to be applied with the handwheel only, and only under emergency conditions. A load sensing device allows the load to be measured, so the operator knows the load being imposed on the hoist when using the handwheel.

(4) Main Hoist Braking System

The main hoist is equipped with two independent braking systems. A solenoid release, spring-set electric brake is mounted on the motor shaft.

This brake operates in the normal manner to release upon application of current to the motor and set when current is interrupted. The second brake is a mechanically actuated load brake internal to the hoist gear box that sets if the load starts to overhaul the hoist. It is necessary to apply torque from the motor to raise or lower the load. In raising, this motor cams to brake open; in lowering, the motor slips the brake allowing the load to lower. This brake actuates upon loss of torque from the motor for any reason and is not dependent on any electrical circuits. The motor brake capacity is 100% of the rated hoist capacity of 4000 pounds. The mechanical brake has a capacity of 150% of the rated hoist capacity.

(5) Fuel Assembly Support System

The main hoist system is supplied with redundant paths of load support such that failure of any one component will not result in free fall of the fuel assembly. Two wire ropes are anchored to the winch drum and carried over independent sheaves to a load equalizing mechanism on the top of the gripper tube. In addition, supports for the sheaves and equalizing mechanism are backed up by passive restraints to pick up the load in the event of failure of this primary support. Each wire rope is capable of supporting a maximum static load of 3160 pounds with a safety factor of 5. This capacity is in excess of the 2700 pound hoisting limit, thus enabling each load path the capability to lift the normal load. Acting together, the wire ropes have a capacity of 6320 pounds with a safety factor of 5. This capacity is in excess of the 5500 pound emergency pullout load to be applied with the handwheel.

The working load of fuel assembly plus gripper is approximately 2500 pounds.

The gripper itself has four fingers gripping the fuel, any two of which will support the fuel assembly weight.

The gripper mechanism contains a spring actuated mechanical lock which prevents the gripper from opening unless the gripper is under a compressive load.

During each refueling outage and prior to removing fuel the gripper and hoist systems are routinely load tested to the requirements listed in plant Technical Requirements Manual.

Fuel Transfer System

The following safety features are provided for in the fuel transfer system.

(1) Transfer Car Permissive Switch

The primary transfer car controls are located on the operating floor and conditions in the containment are, therefore, not visible to the operator. The transfer car permissive switch allows a second operator in the containment to exercise some control over car movement if conditions visible to him warrant such control. Transfer car operation is possible only when both lifting arms are in the down position as indicated by the limit switches. The permissive switch is a backup for the transfer car lifting arm interlock. Assuming the upender is in the upright position in the containment and the lifting arm interlock circuit fails in the permissive condition, the operator on the operating floor still cannot operate the car because of the permissive switch interlock. The interlock, therefore can withstand a single failure.

(2) Lifting Arm - Transfer Car Position

Two redundant interlocks allow lifting arm operation only when the transfer car is at either end of its travel and therefore can withstand a single failure.

Two redundant interlocks allow lifting arm operation only when the transfer car is at the end of its travel. One interlock is provided by a transfer car position indication, limit sensing, and braking controls displayed on the control panel. The backup interlock is a mechanical latch device on the lifting arm that is opened by the car moving into position.

(3) Transfer Car - Valve Open

Two redundant interlocks on the transfer tube valve permit transfer car operation only when the transfer tube valve position switch indicates the valve is fully open and therefore can withstand single failure.

(4) Transfer Car - Lifting Arm

The transfer car lifting arm interlock is primarily designed to protect the equipment from overload and possible damage if an attempt is made to move the car when the upender is not in the horizontal position. This interlock is redundant and can withstand a single failure. The basic interlock is a position limit switch in the control circuit. The backup interlock is a mechanical latch device, that is opened by the weight of the upender when in the horizontal position.

(5) Lifting Arm - Refueling Machine

The refueling canal lifting arm is interlocked with the refueling machine. Whenever the transfer car is located in the refueling canal, the lifting arm cannot be operated unless the refueling machine mast is in the fully retracted position or the refueling machine is over the core.

The circuits which interlock the refueling canal lifting arm with the refueling machine are redundant and can withstand a single failure.

(6) Lifting Arm - Spent Fuel Pit Bridge

The transfer canal lifting arm is interlocked with the spent fuel pit bridge. The lifting arm cannot be operated unless the spent fuel pit bridge is not over the lifting arm area. The interlocks are redundant and can withstand a single failure.

Spent Fuel Pit Bridge

The spent fuel pit bridge includes the following safety features.

(1) The spent fuel pit bridge controls are interlocked to prevent simultaneous operation of bridge drive and hoist.

(2) Bridge drive operation is prevented except when the hoist is in the full up position.

(3) An overload protection device is included on the hoist to limit the uplift force. The protection device limits the hoist load to 100% (4000 lbs) of the rated 2 ton hoist capacity.

(4) The design load on the hoist is the weight of one fuel assembly (1600 lbs), weight of one failed fuel container (1000 lbs), and the weight of the tool which gives it a total weight of approximately 3000 lbs.

(5) Restraining bars are provided on each track to prevent the bridge from overturning.

Fuel Handling Tools and Equipment

All fuel handling tools and equipment handled over an open reactor vessel are designed to prevent inadvertent decoupling from machine hooks (i.e., lifting rigs are pinned to the machine hook and safety latches are provided on hooks supporting tools).

Tools required for handling internal reactor components are designed with fail safe features that prevent disengagement of the component in the event of operating mechanism malfunction. These safety features apply to all tools which handle or service new or spent fuel or fuel related components.

9.1.4.3.2 Seismic Considerations

The safety classifications for all fuel handling and storage equipment are listed in Table 3.2-2. These safety classes provide criteria for the seismic design of the various components. Class 1 and Class 2 equipment is designed to withstand the forces of the operating basis earthquake (OBE) and safe shutdown earthquake (SSE). For normal conditions plus OBE loadings, the resulting stresses are limited to allowable working stresses as defined in the ASME Code, Section III, Appendix XVII, Subarticle XVII-2200 for normal and upset conditions. For normal conditions plus SSE loadings, the stresses are limited to within the allowable values given by Subarticle XVII-2110 for critical parts of the equipment which are required to maintain the capability of the equipment to perform its safety function. Permanent deformation is allowed for the loading combination which includes the SSE to the extent that there is no loss of safety function.

The Class 3 fuel handling and storage equipment satisfies the Class 1 and Class 2 criteria given above for the SSE. Consideration is given to the OBE only insofar as failure of the Class 3 equipment might adversely affect Class 1 or 2 equipment.

For non-nuclear safety equipment, design for the SSE is considered if failure might adversely affect a Safety Class 1, 2 or 3 component. Design for the OBE is considered if failure of the non-nuclear safety component might adversely affect a Safety Class 1 or 2 component.

9.1.4.3.3 Containment Pressure Boundary Integrity

The fuel transfer tube which connects the refueling cavity (inside the reactor containment) and the operating floor (outside the containment) is closed on the refueling cavity side by a blind flange when containment integrity is required, except during refueling operations. Two seals are located around the periphery of the blind flange with leak-check provisions between them.

9.1.4.3.4 Radiation Shielding

During all phases of spent fuel transfer, the gamma dose rate at the refueling bridge is 2.5 mr/hr or less. This is accomplished by maintaining a minimum of 9.9 feet of water above the active fuel region which correlates to 8 feet and 10.875 inches above the top of the fuel assembly during all handling operations.

The two fuel handling devices used to lift spent fuel assemblies are the refueling machine and the spent fuel pit bridge. The refueling machine contains positive stops which prevent the active fuel region of a fuel assembly from being raised to within a minimum of 9.9 feet of the water level in the refueling cavity. The hoist on the spent fuel pit bridge moves spent fuel assemblies with a long handled tool. Hoist travel and tool length likewise limit the maximum lift of the active fuel region of a fuel assembly to within a minimum of 9.9 feet of the water level in the spent fuel pit and transfer canal.

9.1.4.4 Tests and Inspections

As part of normal plant operations, the fuel handling equipment is inspected for operating conditions prior to each refueling operation. During the operational testing of this equipment, procedures are followed that will affirm the correct performance of the fuel handling system interlocks.

REFERENCES

(1) Holtec Report No. HI-2002607, R0, “LOCA Temperature Analysis of the Watts Bar Spent Fuel Pool.”

Table 9.1-1 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM DESIGN PARAMETERS

Spent fuel pool storage capacity	1386 Assemblies
Spent fuel pool water volume, gal	372,460[(1)]
Nominal boron concentration of the spent fuel pool water, ppm	2000

[(1)] Including cask pit area volume.

	Decay Heat MBtu/hr	**Maximum SFP Temperature (2-Train)** °F	**Maximum SFP Temperature (1-Train)** °F	**SFP Heat Rate** °F/hr	**Boil-Off Time to 10' Above Rack With No Makeup hrs**
Normal Full Core Discharge Case-1579 assemblies[(2)]	28.10	124.7	151.2	9.88	47.4
Unplanned Discharge Case[(3)]	32.60	129.3	159.2	10.2	45.8
Maximum Allowed Decay Heat at Sub-Design SFP HX Fouling and CCS temperatures	47.4	129.3	159.2	15.54	30

[(2)] Stored plus an additional full core discharge (193 assemblies)

[(3)] 600 assemblies stored one additional 80 assembly discharge, following a full Core discharge (193 assemblies).*

*The 1600 assemblies are a conservative value. The 1600 assemblies include the number of baby racks, however the baby racks have been removed from the WBN design.

Table 9.1-2 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM DESIGN AND OPERATING PARAMETERS
(Page 1 of 4)

Spent Fuel Pool Pump	
Number	3
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	2300
Total developed head, ft	125
Material	Stainless Steel
Spent Fuel Pool Skimmer Pump	
Number	1
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	100
Total developed head, ft	50
Material	Stainless Steel
Refueling Water Purification Pump	
Number	2
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	200
Total developed head, ft	170
Material	Stainless Steel

Table 9.1-2 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM DESIGN AND OPERATING PARAMETERS (Continued) (Page 2 of 4)

Spent Fuel Pool Heat Exchanger		
Number	2	
Design heat transfer, Btu/hr	11.94×10^6	
	Shell	Tube
Design pressure, psig	150	150
Design temperature, °F	200	200
Design flow lb/hr	1.49×10^6	1.14×10^6
Inlet temperature, °F	95	120
Outlet temperature, °F	103	109.5
Fluid circulated	Component Cooling Water	Spent Fuel Pool Water
Material	Carbon Steel	Stainless Steel
Spent Fuel Pool Demineralizer		
Number	1	
Design pressure, psig	300	
Design temperature, °F	250	
Design flow, gpm	100	
Resin volume, ft^1	30	
Material	Stainless Steel	
Spent Fuel Pool Filter		
Number		1
Design pressure, psig		300
Design temperature, °F		250
Design flow, gpm		150
Filtration requirement		98% retention of particles above 5 microns
Materials, vessel		Stainless Steel

Table 9.1-2 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM DESIGN AND OPERATING PARAMETERS (Continued)
(Page 3 of 4)

Spent Fuel Pool Skimmer Filter	
Number	1
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm (Filter)	150
Rated flow, gpm (Pump)	100
Filtration requirement	98% retention of particles above 5 microns
Material, vessel	Stainless Steel
Refueling Water Purification Filter	
Number	2
Design pressure, psig	200
Design temperature, °F	250
Design flow, gpm	200
Filtration requirement	98% retention of particles above 5 microns
Material, vessel	Stainless Steel
Spent Fuel Pool Strainer	
Number	2
Rated flow, gpm	2300
Perforation, inches	Approximately 0.2
Material	Stainless Steel
Spent Fuel Pool Skimmer Strainer	
Number	1
Rater flow, gpm	100
Design pressure, psig	50
Design temperature, °F	200
Perforation, inches	1/8
Material	Stainless Steel

Table 9.1-2 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM DESIGN AND OPERATING PARAMETERS (Continued)
(Page 4 of 4)

Spent Fuel Pool Skimmers	
Number	2
Design flow, gpm	50
Piping and Valves	
Design pressure, psig	150
Design temperature, °F	200
Material	Stainless Steel

Table 9.1-3 BASIS FOR DESIGN CRITERIA OF THE WATTS BAR NUCLEAR PLANT SPENT FUEL RACKS

ASME B&PV Code, Section III, Subsection NF
AISC Manual of Steel Construction, Seventh Edition, 1970.
USNRC Standard Review Plan, Section 3.8.4, "Other Seismic Category I Structures".
USNRC Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis."
USNRC Regulatory Guide 1.29, "Seismic Design Classification".
USNRC Regulatory Guide 1.92, "Combining Model Responses and Spatial Components in Seismic Response Analysis".
OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications, dated April 14, 1978.
10 CFR Part 50, Appendix B, "Quality Assurance Criteria For Nuclear Power Plants and Fuel Reprocessing Plants".

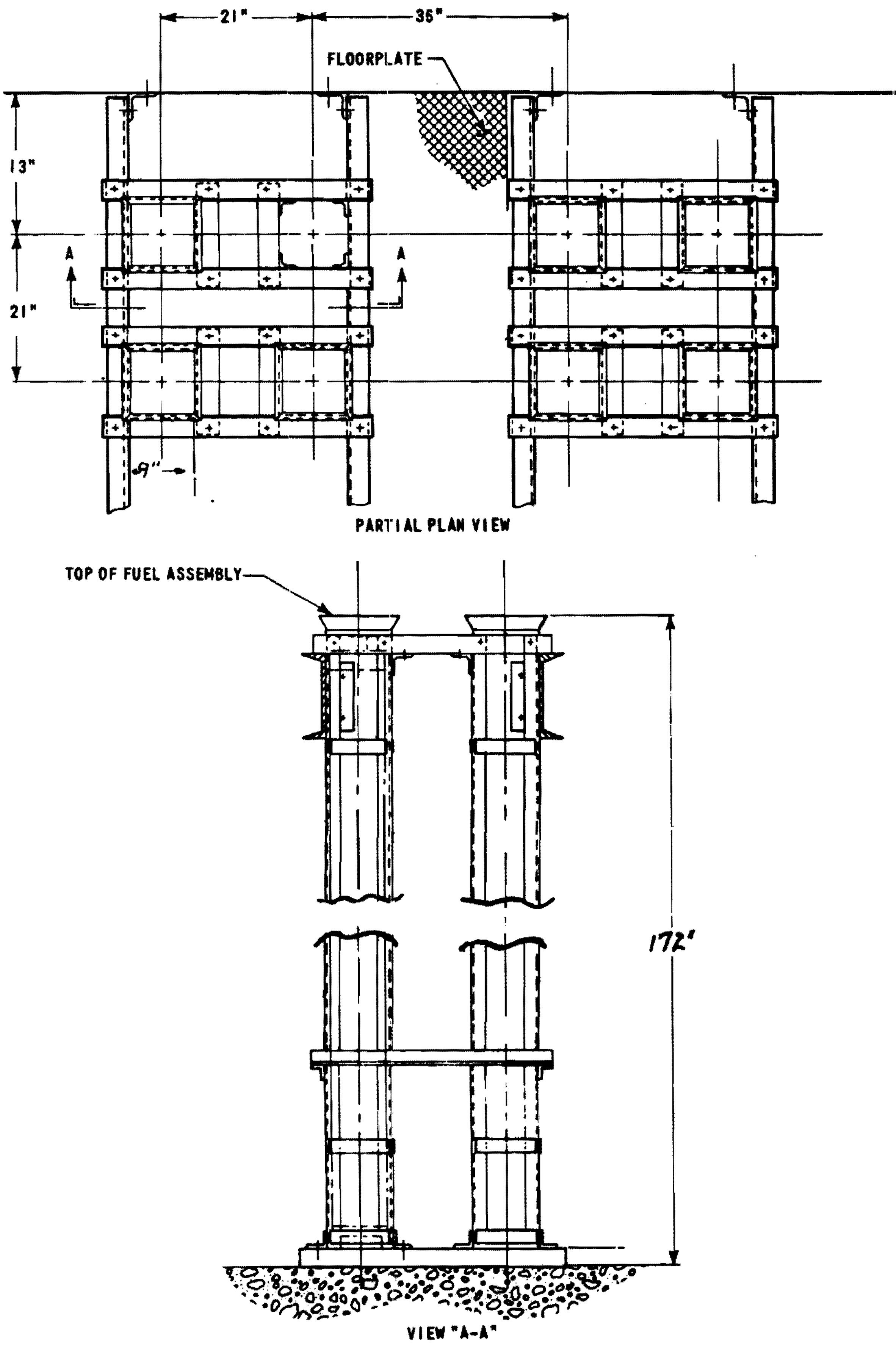


Figure 9.1-1. New Fuel Storage Racks

Figure 9.1-1 New Fuel Storage Racks

Figure 9.1-2 Deleted by Amendment 44

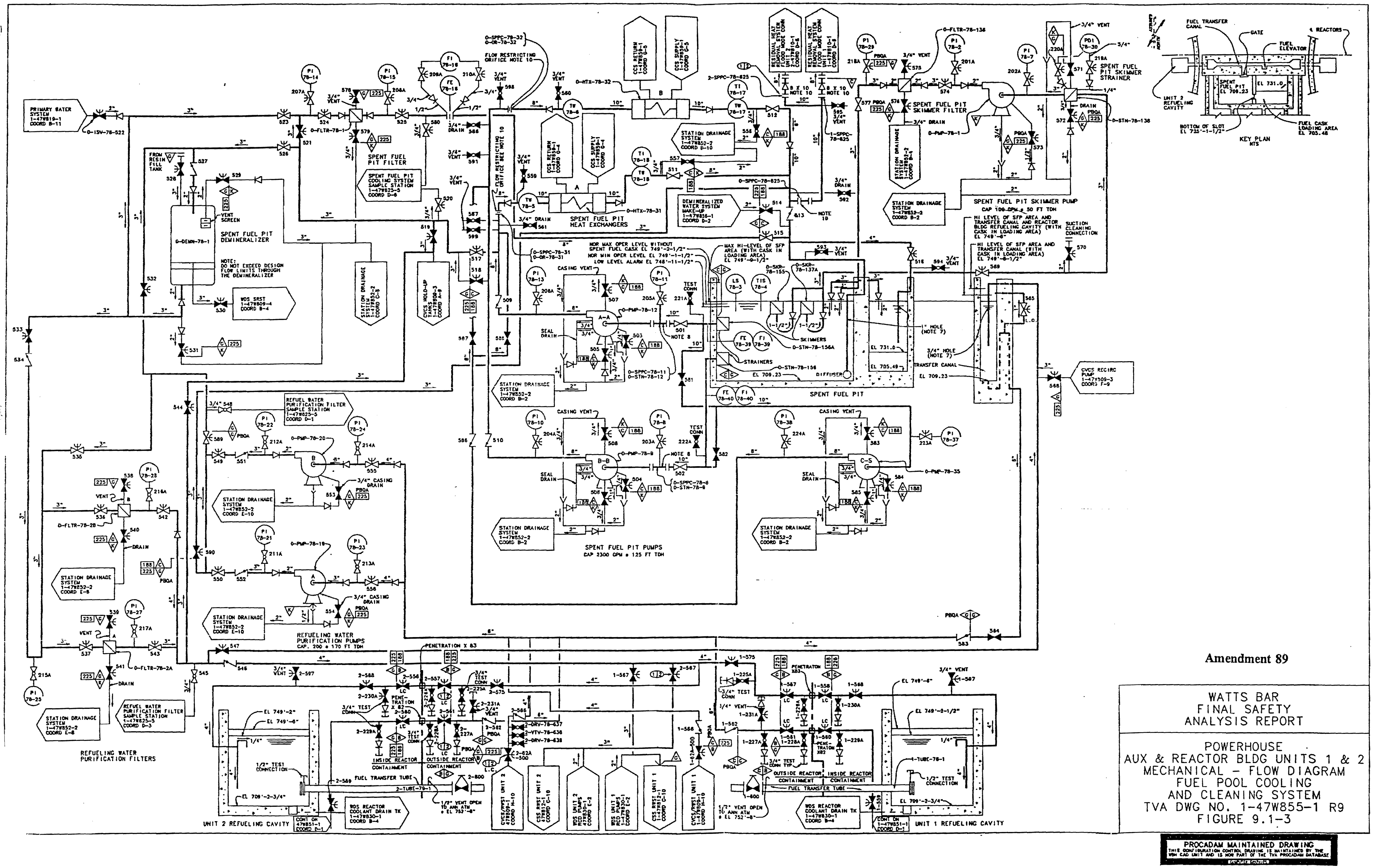
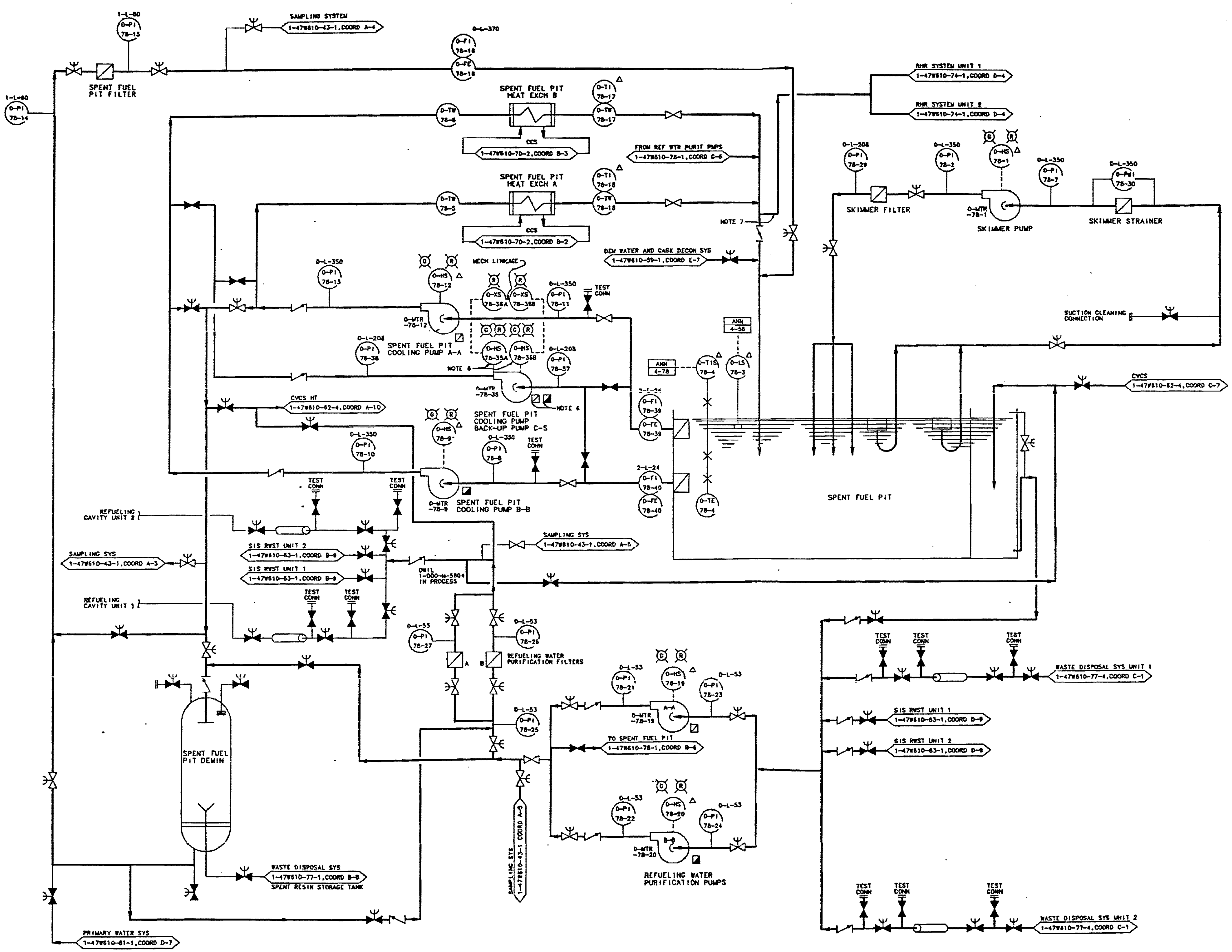


Figure 9.1-3 Powerhouse, Auxiliary, and Reactor Buildings Units 1 & 2 Mechanical - Flow Diagram for Fuel Pool Cooling and Cleaning System



Amendment 89

WATTS BAR
FINAL SAFETY
ANALYSIS REPORT

POWERHOUSE
UNITS 1 & 2
ELECTRICAL
CONTROL DIAGRAM
SPENT FUEL PIT COOL SYS
TVA DWG NO. 1-47W610-78-1 R4
FIGURE 9.1-4

PROCADAM MAINTAINED DRAWING

Figure 9.1-4 Powerhouse Units 1 & 2 Electrical Control Diagram for Spent Fuel Pit Cooling System

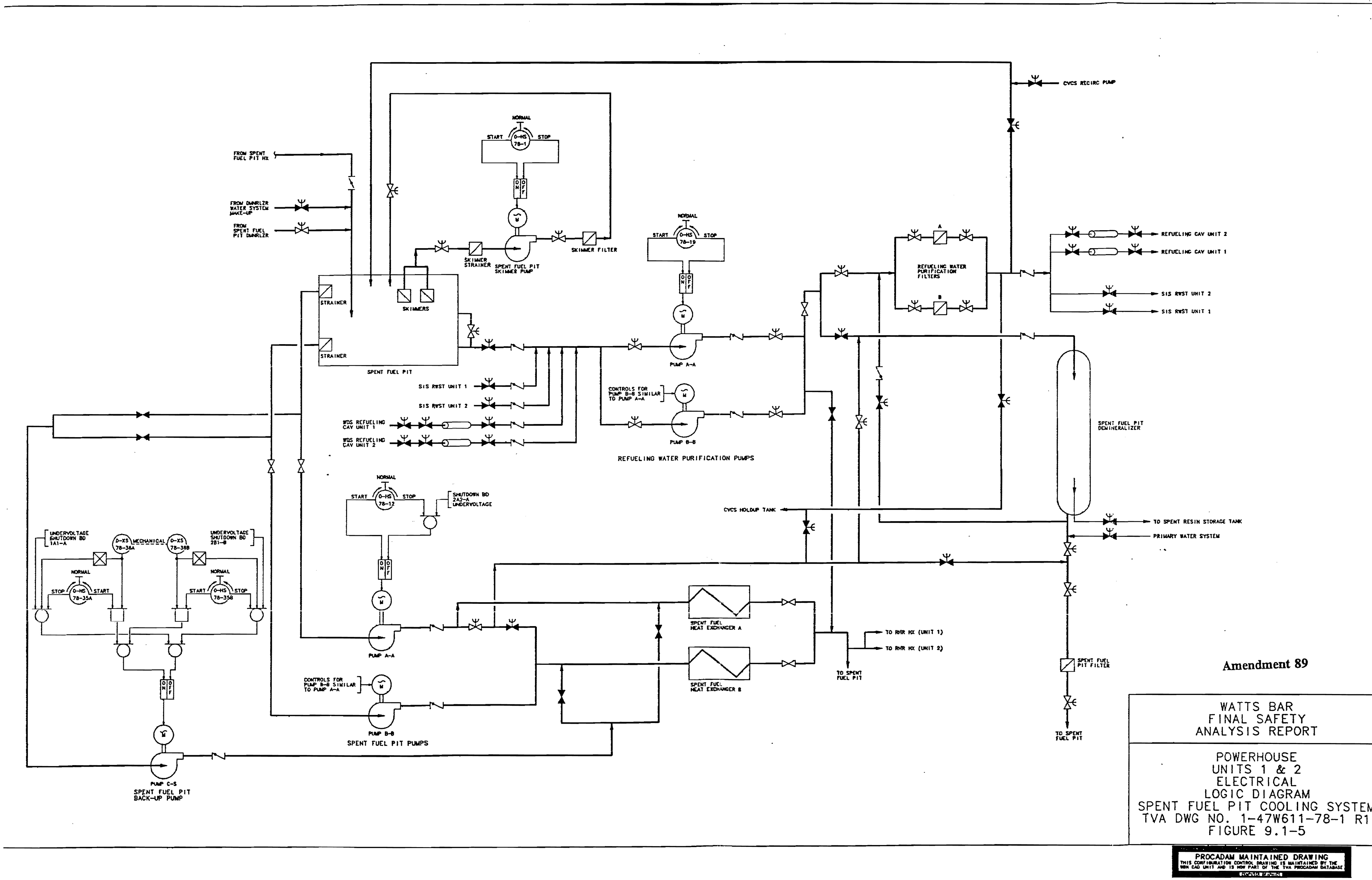


Figure 9.1-5 Powerhouse Units 1 & 2 Electrical Logic Diagram for Spent Fuel Pit Cooling System

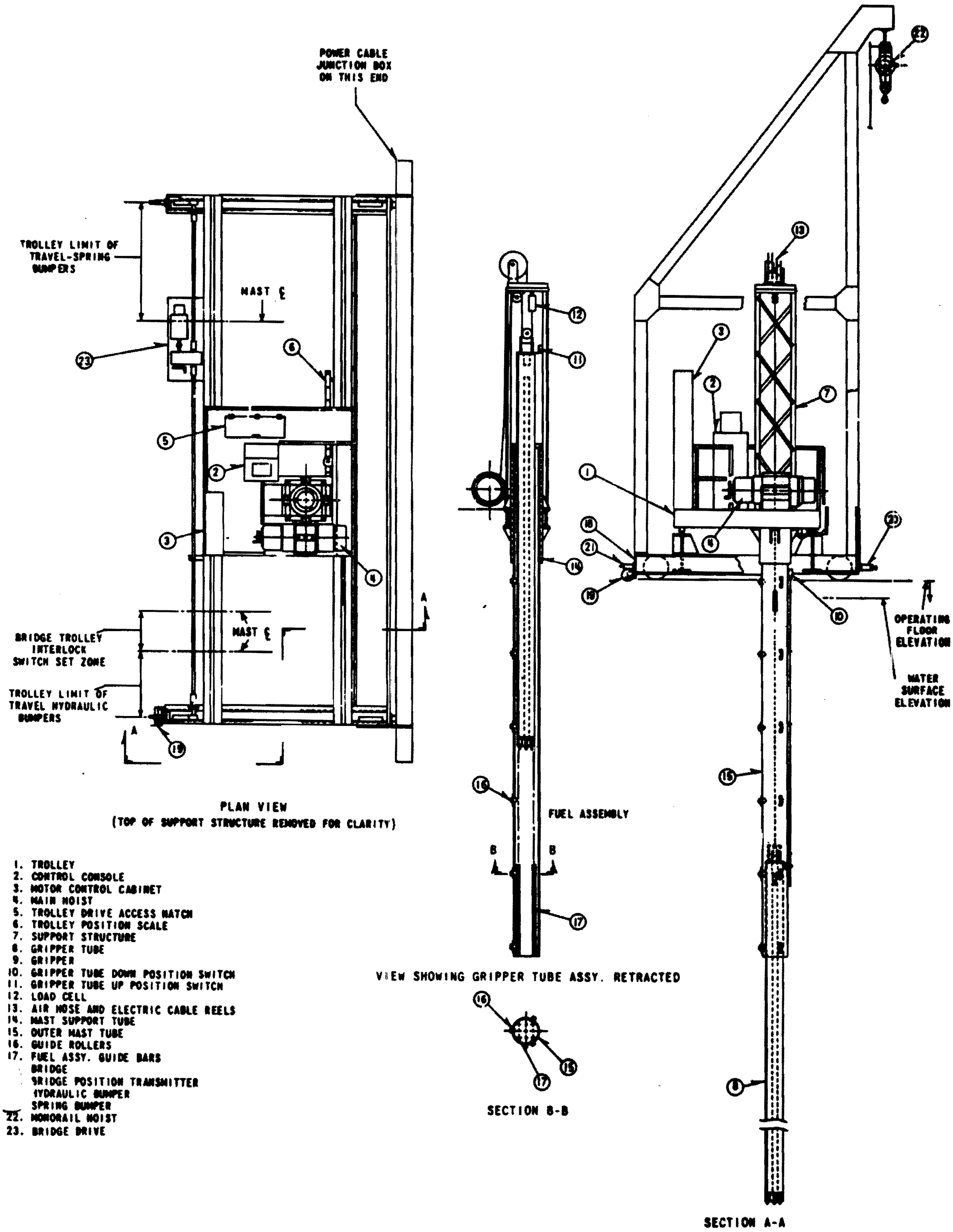


Figure 9.1-6 Typical Manipulator Crane

Figure 9.1-6 Typical Manipulator Crane

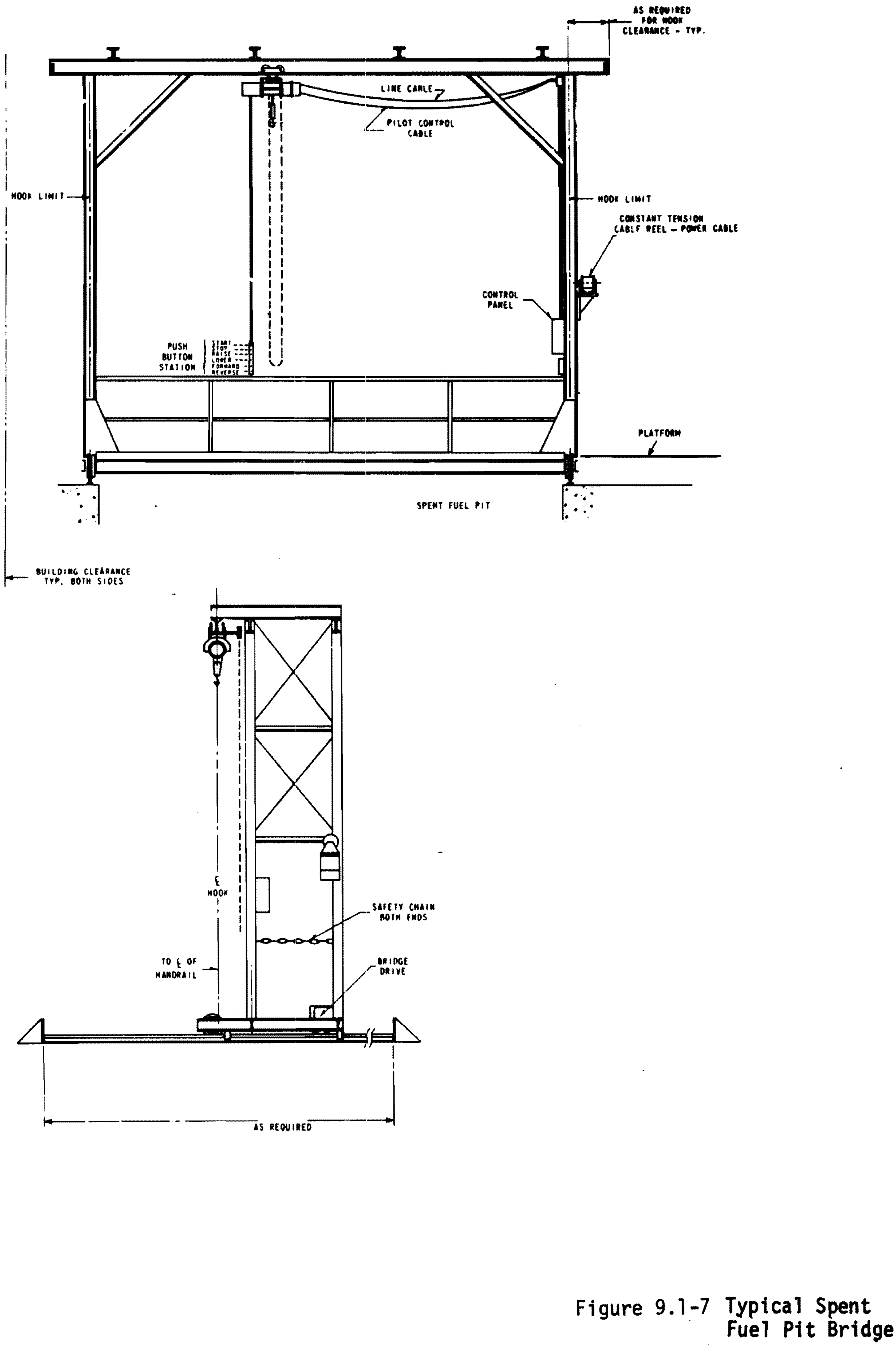


Figure 9.1-7 Typical Spent Fuel Pit Bridge

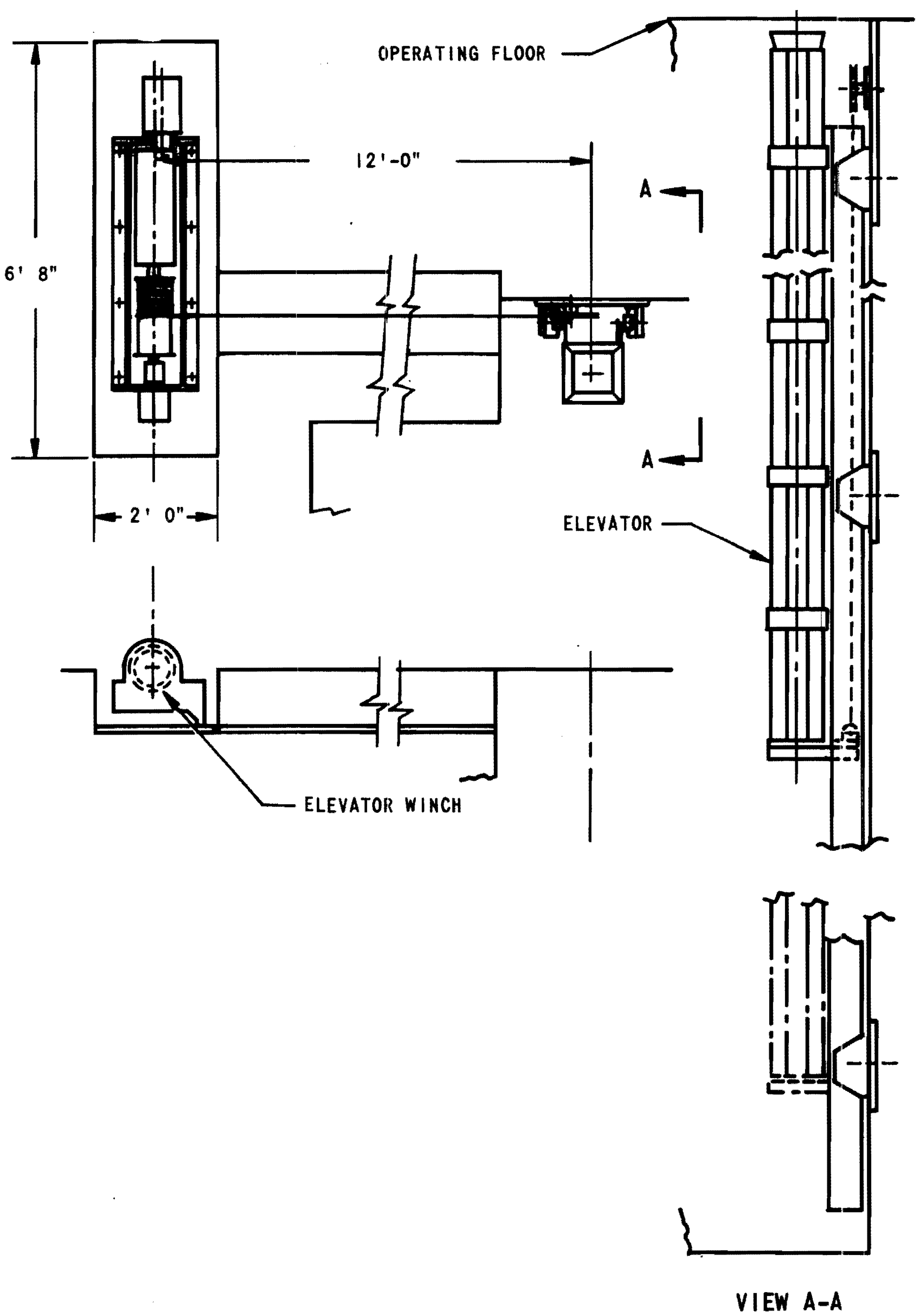


Figure 9.1-8 New Fuel Elevator

Figure 9.1-8 New Fuel Elevator

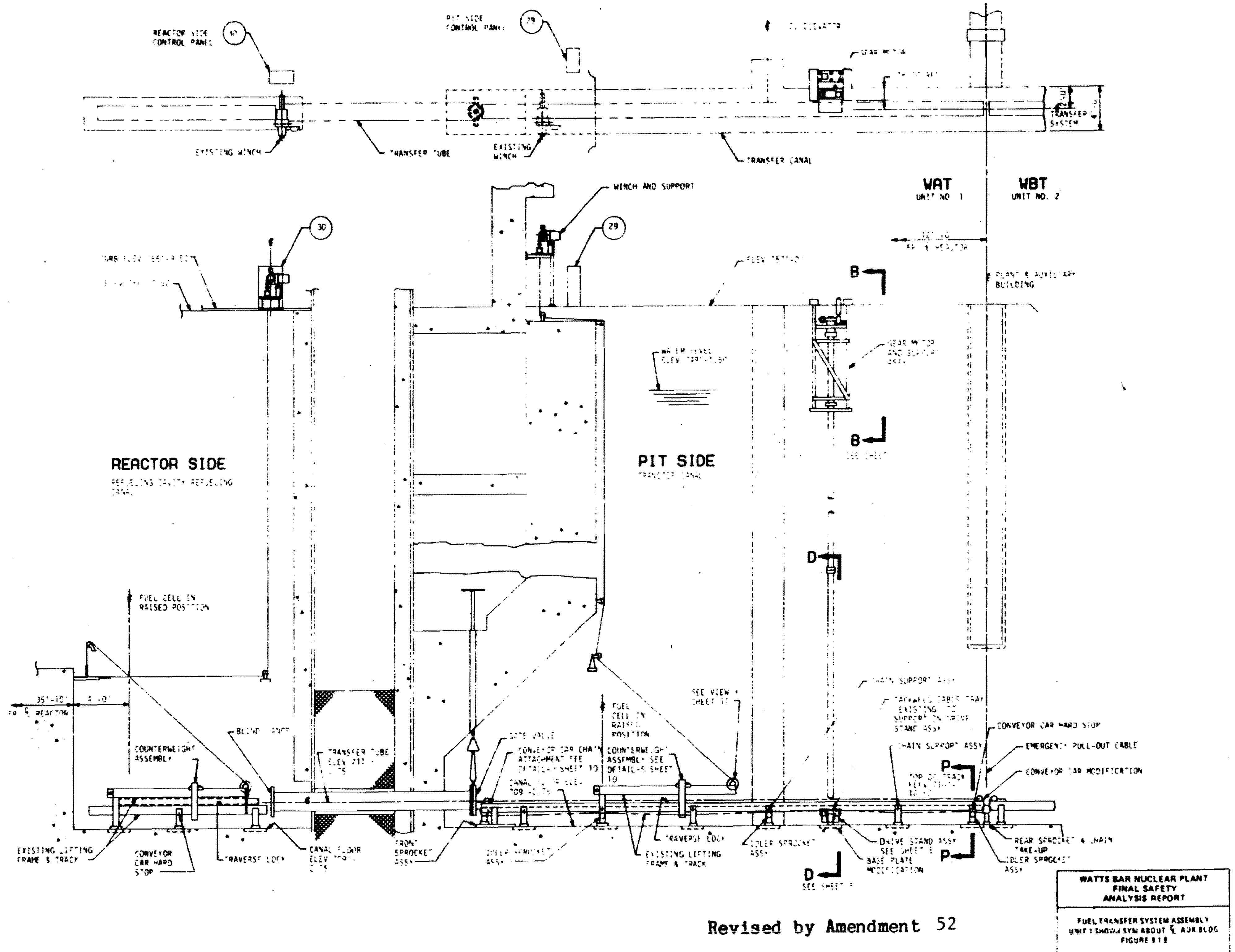


Figure 9.1-9 Fuel Transfer System Assembly

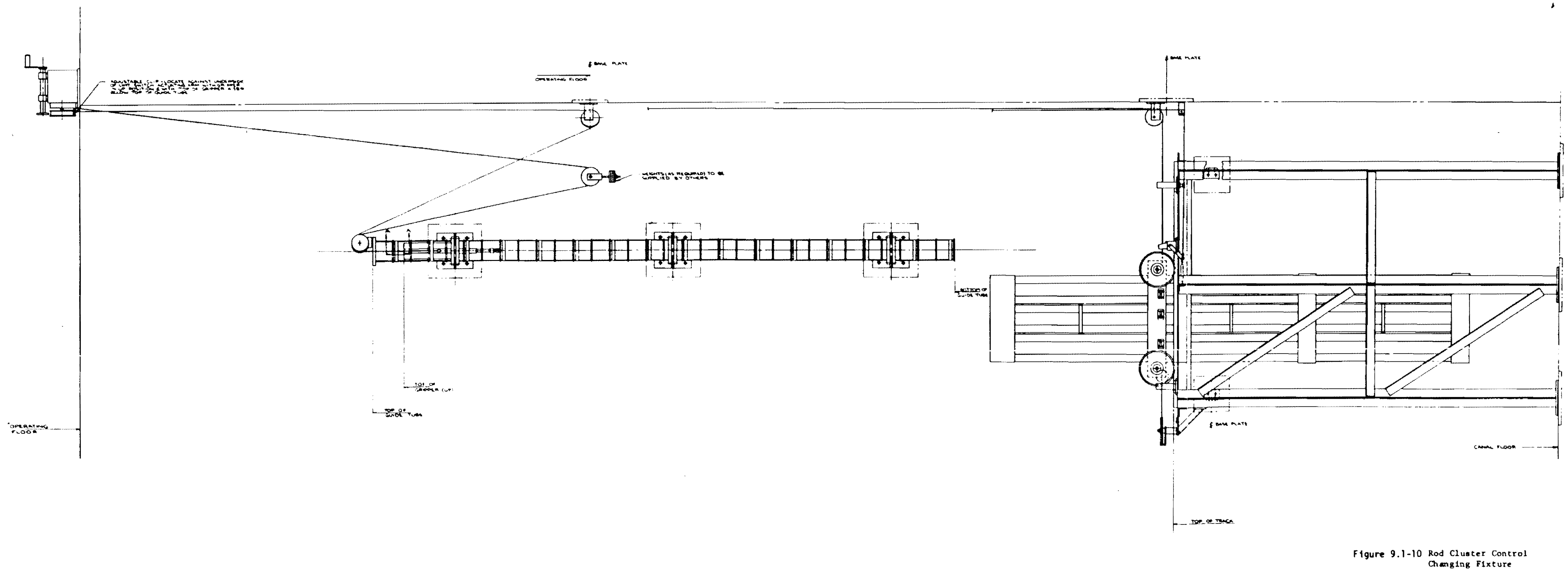


Figure 9.1-10 Rod Cluster Control Changing Fixture

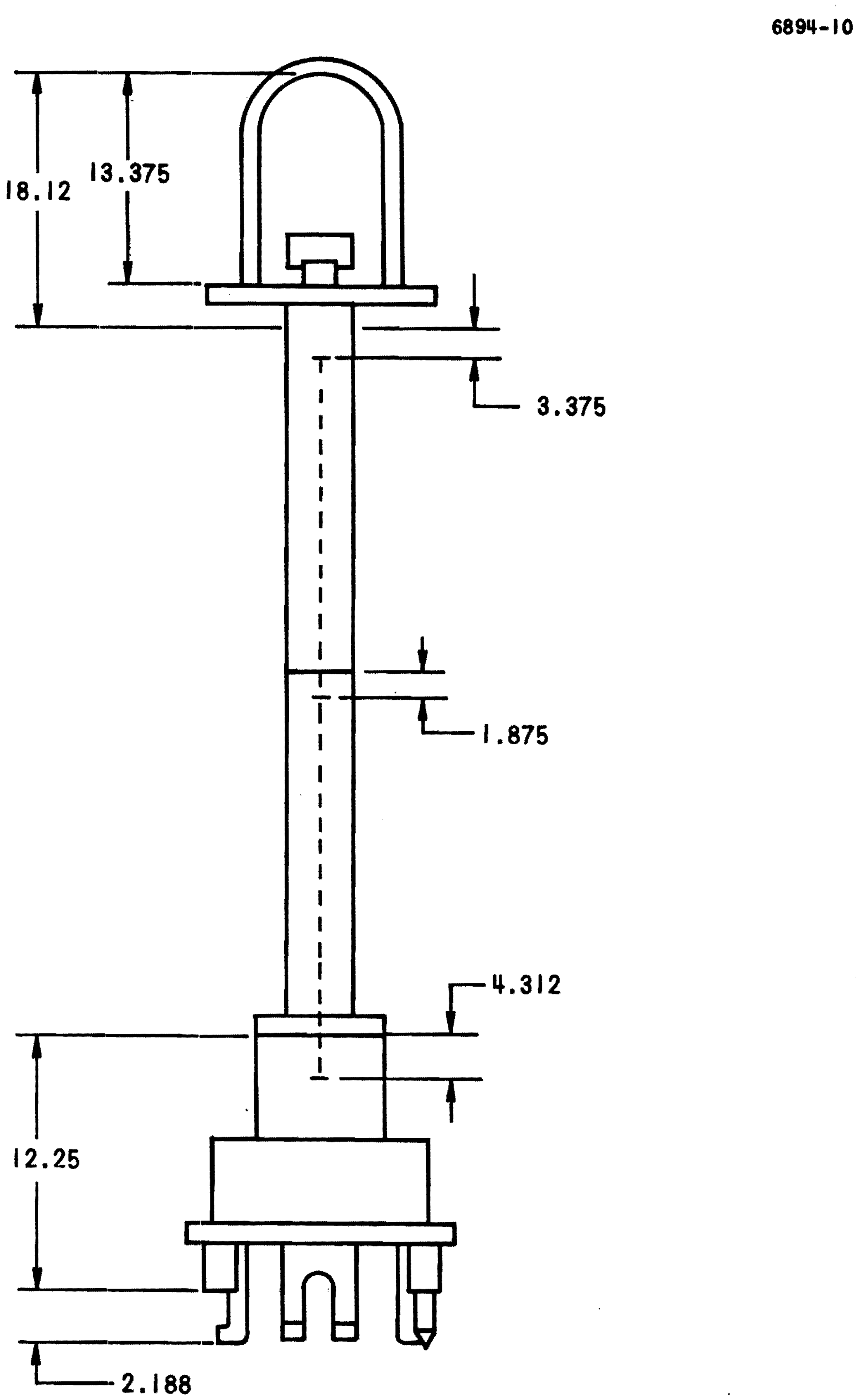


Figure 9.1-11 Typical Spent Fuel Handling Tool

Figure 9.1-11 Typical Spent Fuel Handling Tool

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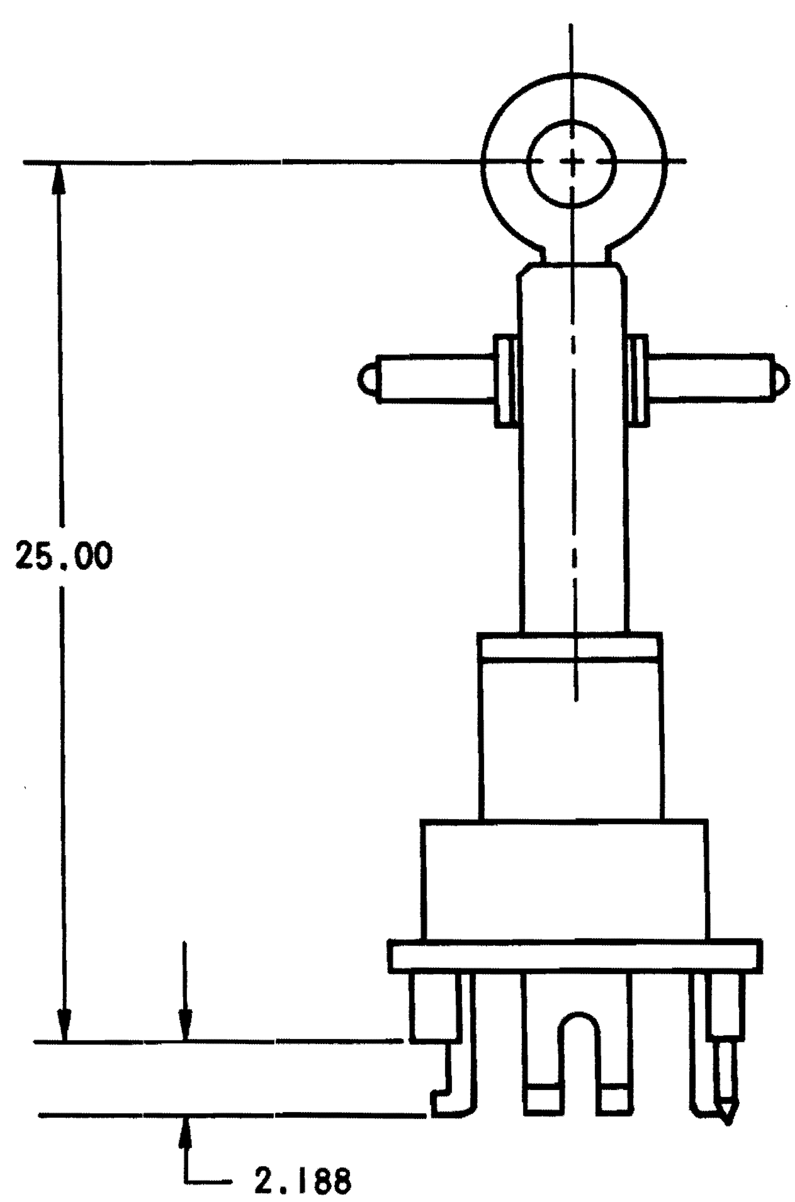

Figure 9.1-12 Typical New Fuel Handling Tool

Figure 9.1-12 Typical New Fuel Handling Tool

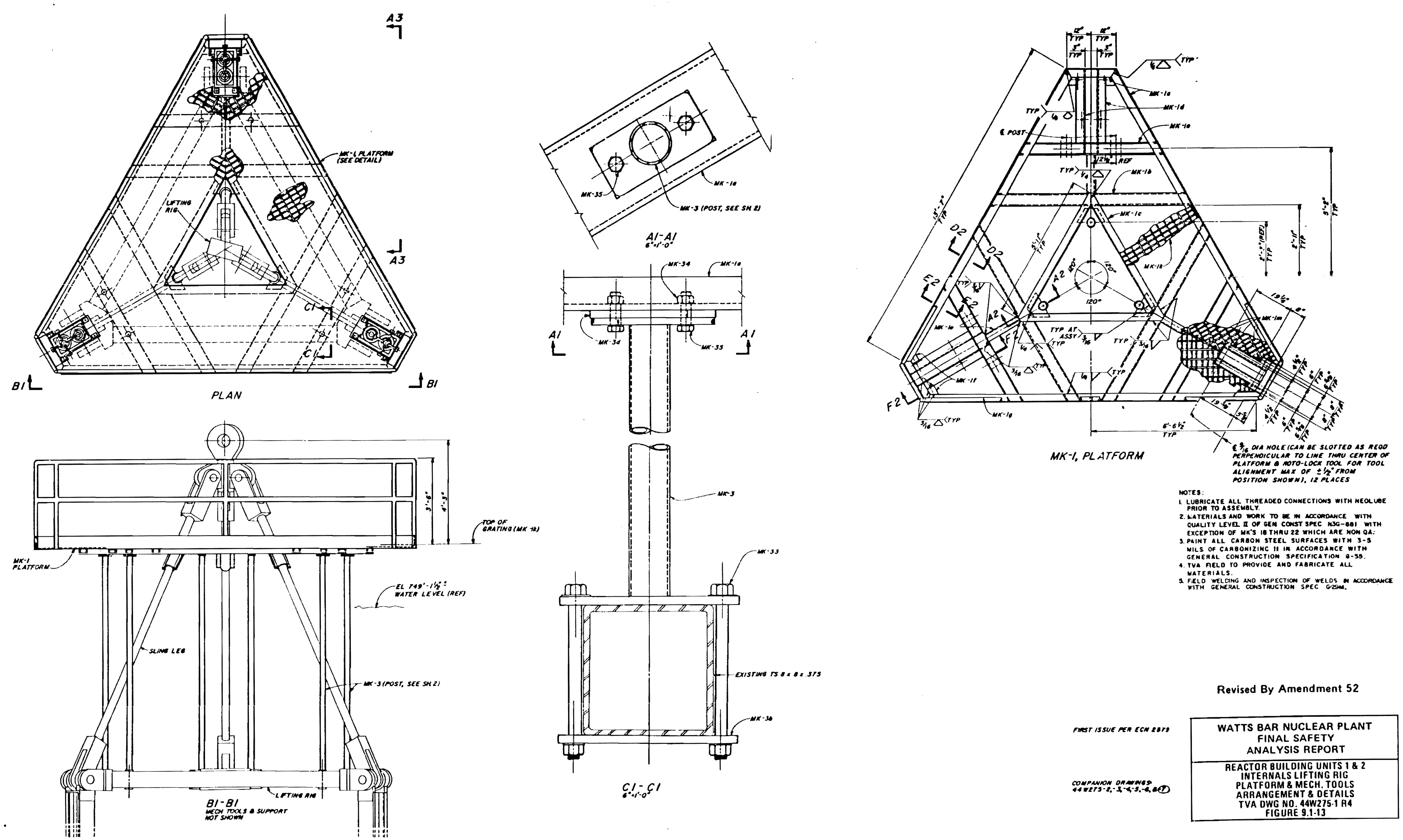

Figure 9.1-13 Reactor Building Internals Lifting Rig Platform and Mech. Tools Arrangement and Details

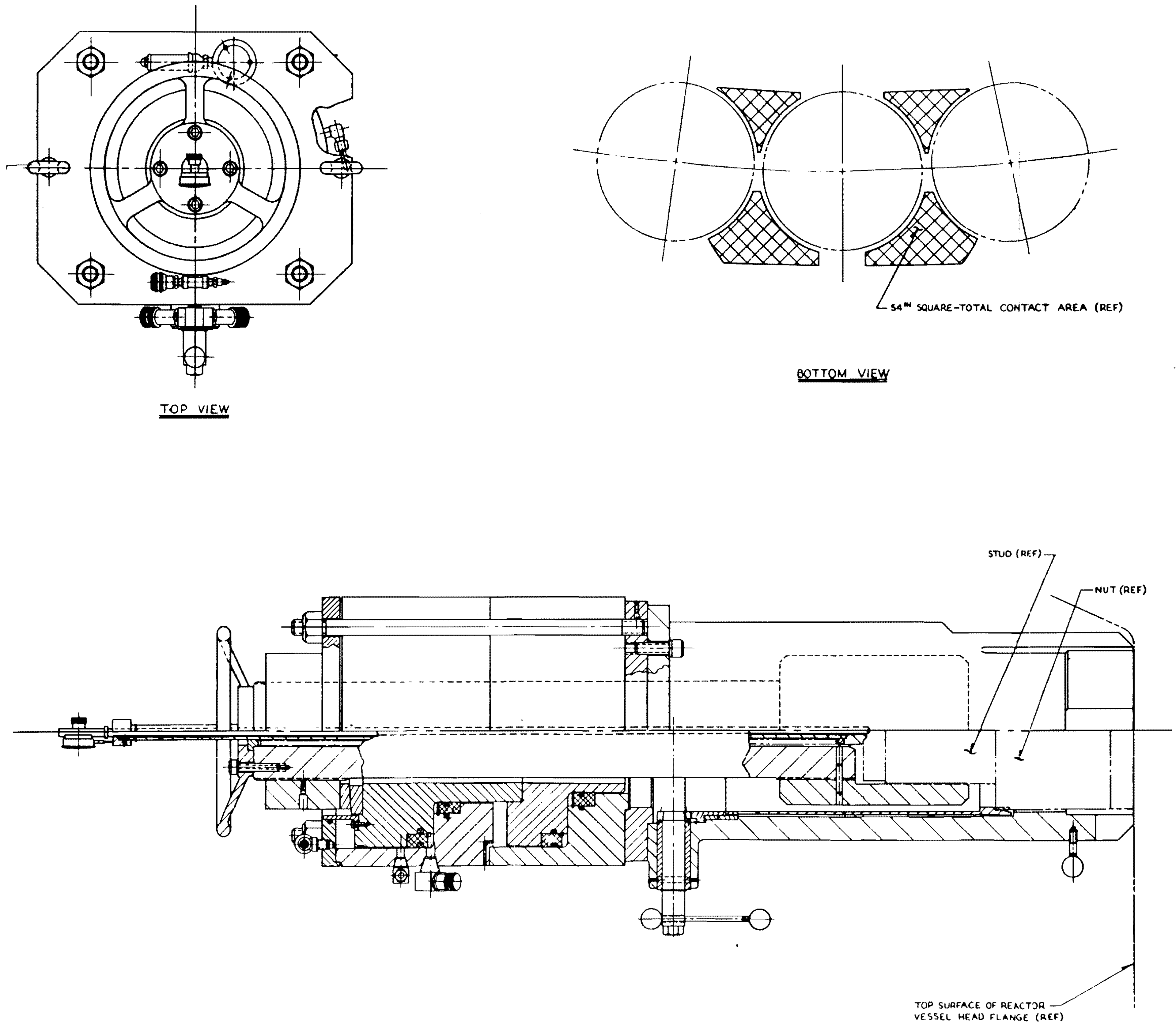

Figure 9.1-14 Typical Stud Tensioner

Figure 9.1-14 Typical Stud Tensioner

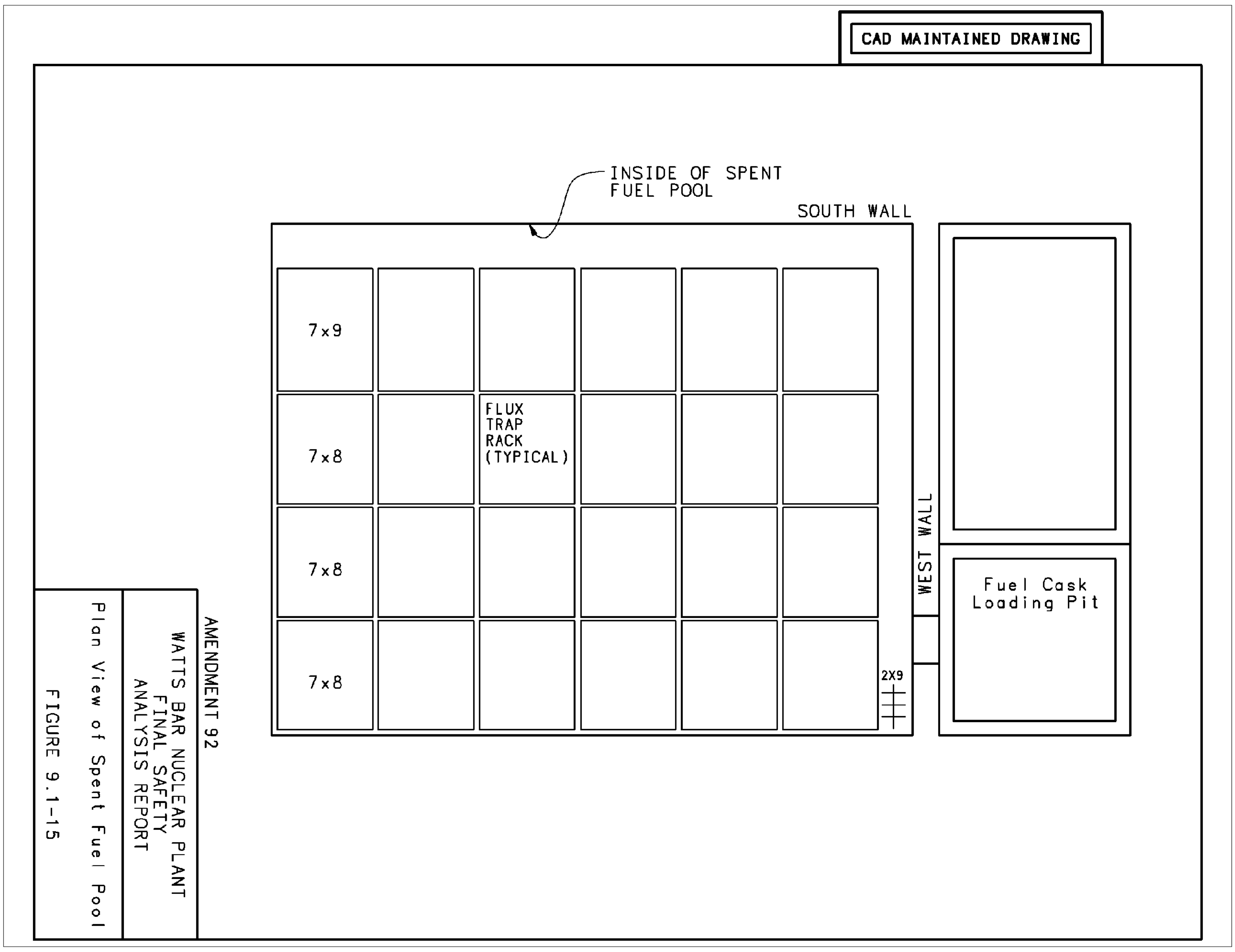

Figure 9.1-15 Plan View of Spent Fuel Pool

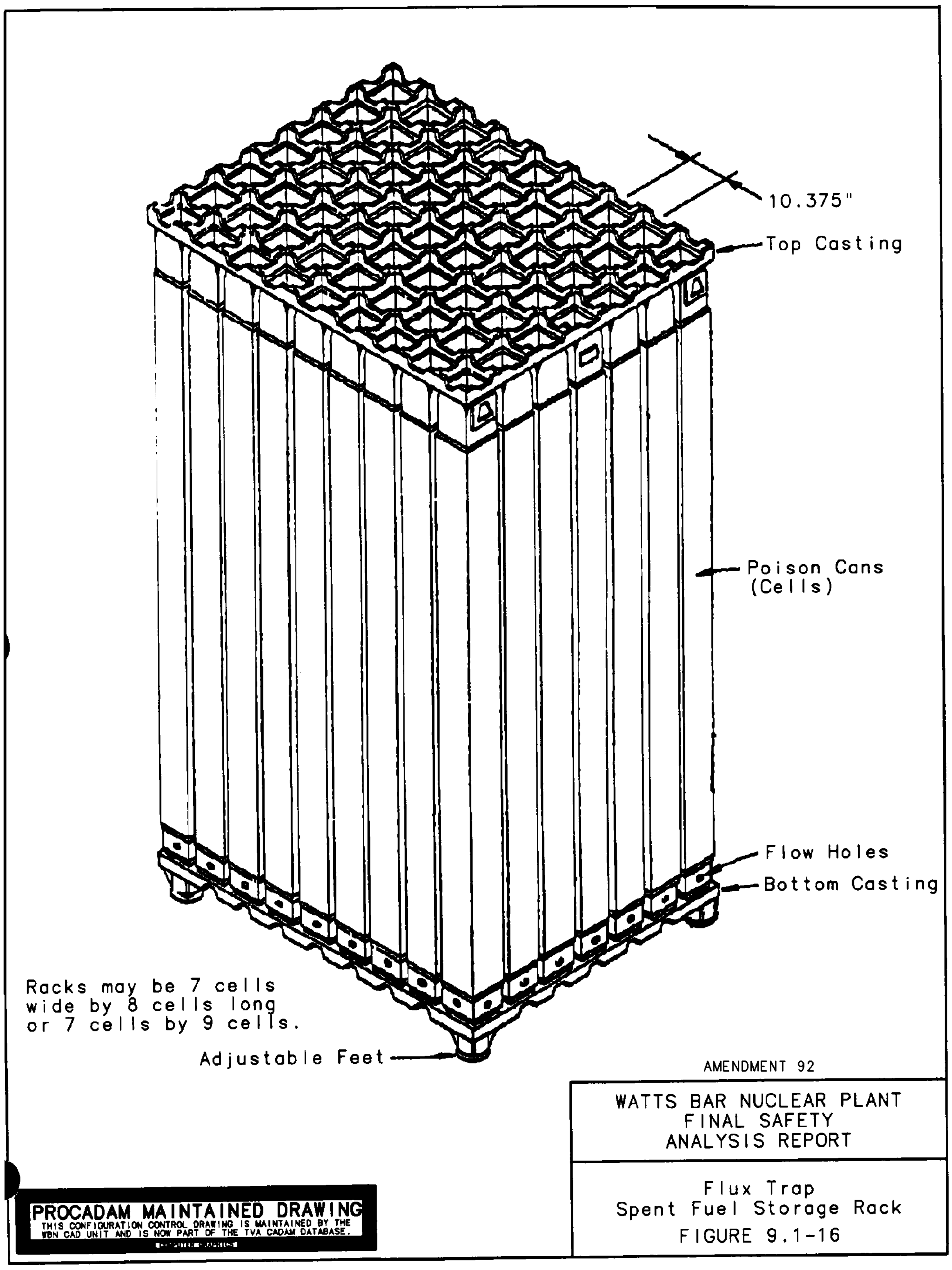

Figure 9.1-16 Flux Trap Spent Fuel Storage Rack

9.2 WATER SYSTEMS

9.2.1 Essential Raw Cooling Water (ERCW)

9.2.1.1 Design Bases

The ERCW system is safety-related because it provides essential auxiliary support functions to the engineered safety features of the plant. The system is designed to supply cooling water to various heat loads in both the safety and non-safety portions of each unit. Provisions are made to ensure a continuous flow of cooling water to those systems and components necessary for plant safety either during normal operation or under accident conditions. Sufficient redundancy of piping and components is provided to ensure that cooling is maintained to vital loads at all times.

9.2.1.2 System Description

The ERCW system consists of eight ERCW pumps, four traveling water screens, four screen wash pumps, four strainers located in the main intake pumping station, and associated piping and valves as shown in Figures 9.2-1 through 9.2-4B. The logic and control diagrams are presented in Figures 9.2-5 through 9.2-14A. The design data for all pumps required for two-unit operation is shown in Table 9.2-1.

The eight ERCW pumps are mounted on the intake pumping station at Elevation 741.0 which is above the probable maximum flood level.

The ERCW system is designed to supply cooling water to the following components:

(1) Component cooling heat exchangers

(2) Containment spray heat exchangers

(3) Emergency diesel generators

(4) Emergency makeup for component cooling system

(5) Control Building air conditioning system

(6) Auxiliary Building ventilation coolers (for ESF equipment)

(7) Containment ventilation system

(8) Air compressors

(9) Reactor coolant pump (RCP) motor coolers

(10) Control rod drive ventilation coolers

(11) Residual heat removal heat exchangers*

(12) Spent fuel pool heat exchangers*

(13) Reactor coolant pump thermal barrier*

(14) Ice machine refrigeration condenser*

(15) Instrument room chillers

(16) Auxiliary feedwater**

(17) Sample system (SS) heat exchangers*

*Provided with ERCW only during flood above Elevation 728.0.

**Supplied by the ERCW system only when normal supply from the condensate storage tank is not available to the auxiliary feedwater pump suction.

The only loads on the system during normal operations are the component cooling heat exchangers, RCP motor coolers, control rod drive ventilation coolers, the air conditioning and ventilation systems (including the upper and lower containment coolers and the instrument room coolers water chiller units), the air compressors, and the diesel generators (although not normally in service).

The intake pumping station is located approximately 800 feet from the reservoir at the end of the plant intake channel which provides direct communication with the main river channel for all reservoir levels including loss of downstream dam. The intake pumping station is so designed that all ERCW related equipment located therein will remain operable during the probable maximum flood.

Water for the ERCW system enters two separate sump areas of the pumping station through four traveling water screens, two for each sump. Four ERCW pumping units, all on the same plant train, take suction from one of the sumps, and four more on the opposite plant train take suction from the other sump. One set of pumps and associated equipment is designated Train A, and the other Train B. These trains are redundant and are normally maintained separate and independent of each other. Each set of four pumps discharges into a common manifold, from which two separate headers (1A and 2A for Train A, 1B and 2B for Train B), each with its own automatic backwashing strainer, supply water to the various system users.

Two paths are available for water discharge from the ERCW system. The normal path is to the cooling tower basins of the condenser circulating water system for use as makeup for evaporative losses. The alternate path is to the yard holding pond through yard ERCW standpipes and an ERCW overflow box. The alternate path is seismically qualified up to and including the ERCW overflow box.

The alignment of ERCW headers and system users is as follows:

(1) Containment spray heat exchangers 1A, 1B, 2A, and 2B are supplied from ERCW headers 1A, 1B, 2A and 2B, respectively.

(2) The normal supply for both Train A diesel generators is from header 1A, although a backup source from header 2B is also provided. The normal supply for both Train B diesel generators is from header 1B with a backup supply from header 2A.

(3) During Unit 1 only operation, the normal supply for component cooling heat exchangers A, B, and C is from ERCW header 2A, 2A, and 2B, respectively. However, interconnections between headers 1B and 2A, and between 1A and 2B have been incorporated to permit alternate supplies.

(4) Each header provides essential raw cooling water to its corresponding Control Room and Control Building electrical board room air-conditioning systems, the Auxiliary Building ventilation coolers for ESF equipment, the containment ventilation system, the RCP motor coolers, the control rod drive vent coolers, and the containment instrument room coolers water chillers (i.e., header 1A supplies Train A equipment in Unit 1, header 1B supplies Train B equipment in Unit 1, etc.).

(5) Headers 1A and 1B provide a normal and backup source of cooling water for the station air compressors. For the auxiliary control air compressors there is one compressor on header 1A and one on header 2B.

(6) Under flood conditions, the ERCW system will provide water to the spent fuel pool heat exchangers, reactor coolant pump thermal barrier, ice machine refrigeration condensers, and under certain conditions, residual heat removal heat exchangers and sample system heat exchangers (refer to Section 2.4.14) using spool piece inter-ties.

(7) In the event of a need to supply ERCW to the auxiliary feedwater system, when the normal supply of water is not available from the condensate storage tank, discharge headers A and B automatically provide an emergency water supply to the motor-driven auxiliary feedwater pumps of the same train assignment as the header and to each unit's turbine driven auxiliary feedwater pump.

The supply headers are arranged and fitted with isolation valves such that a critical crack in either header can be isolated and will not jeopardize the safety functions of the system.

The operation of two pumps on the same plant train is sufficient to supply all cooling water requirements for the two-unit plant for unit cooldown, refueling or post-accident operation, and two pumps per plant train will operate during the hypothetical combined accident and loss of normal power if all four diesel generators are in operation. In an accident the safety injection signal automatically starts two pumps on each plant train, thus providing full redundancy.

Pump motors, traveling screen motors, screen wash pump motors, and backwashing strainer motors are supplied with power from normal and emergency sources, thereby ensuring a continuous flow of cooling water under all conditions. Since there are two independent power trains with two emergency diesel generators for each train, four of the eight ERCW pumps are assigned to Train A and four to Train B. Each diesel generator is aligned to supply power to either of two specific ERCW pumps; the generator capacity is such that only one pump per generator can be loaded automatically. Two traveling screens, two screen wash pumps, and two strainers are assigned to the power train corresponding to that of the ERCW pumps which this equipment serves. The motor-operated valves in the ERCW system are generally supplied with emergency power from the train of diesel generators which corresponds to the pump supplying the header in which the valve is located.

The component cooling system (CCS) heat exchanger discharge by-pass valves incorporate special trim to suppress cavitation. Flow is directed through the by-pass lines at low and intermediate heat exchanger flow rates by opening the by-pass line and closing the main 24-inch motor-operated butterfly valve at the heat exchanger outlet. For conditions which require flow rates beyond the capacity of the anti-cavitation valve, the 24-inch butterfly valve will be opened and the anti-cavitation valve closed. To minimize cavitation of the butterfly valves, a multi-holed orifice is located in each of the two CCS heat exchanger vertical discharge headers to increase the back pressure at the valves.

9.2.1.3 Safety Evaluation

The essential raw cooling water system is designed to prevent any postulated failure from curtailing normal plant operation or limiting the ability of the engineered safety features to perform their functions in the event of natural disasters or plant accidents. Sufficient pump capacity is provided for design cooling water flows under all conditions and the system is arranged in such a way that even a complete header loss can be isolated in a manner that does not jeopardize plant safety.

The essential raw cooling water system has eight pumps (four pumps per train). However, minimum combined safety requirements for one 'accident' unit and one 'non-accident' unit, or two 'non-accident' units, are met by only two pumps on the same plant train. Sufficient redundancy, separation and independence of piping and components are provided to ensure that cooling is maintained to vital loads at all times despite the occurrence of a random single failure. A single active failure will not remove more than one supply train per unit (i.e., either headers 1A and 2A or headers 1B and 2B will always remain in service). The ERCW system is sufficiently independent so that a single active failure of any one component in one train will not preclude safe plant operations in either unit. A failure modes and effects analysis is presented in Table 9.2-2.

The safety-related portion of the ERCW system is designed such that total loss of either train, or the loss of offsite power and an entire plant shutdown power train will not prevent safe shutdown of either unit under any credible condition.

CCS Heat Exchanger C, which is shared between the two units, serves the train B engineered safety features for both units. During normal operation, this heat exchanger is aligned to supply component cooling water to the condensate demineralizer waste evaporate (CDWE). (The CDWE is isolated during Unit 1 only operation.) For this case, the ERCW flow path will be through anti-cavitation bypass valve, FCV-67-144. A safety injection actuation signal in either unit or loss of offsite power signal will cause valve FCV-67-152 to automatically open to assure ERCW flow from header 2B. Once the flow is established through valve FCV-67-152, the operator shall determine which valve to close manually.

The Train A safeguards are capable of meeting the safety requirements independently of the Train B safeguards equipment. During a LOCA, it may be necessary to reduce flow to the component cooling heat exchanger prior to admitting flow to the containment spray heat exchanger. The earliest that this action is required is specified in Table 6.3-3a.

Under extreme flood conditions, the essential raw cooling water system provides a heat sink for all required cooling systems, except the high pressure fire protection system water is used for steam generator feedwater for reactor cooling. The ERCW system is designed to continue operation during the postflood situation in which the loss of the downstream dam has also been assumed.

The ERCW system is designed to furnish a continuous supply of cooling water under normal conditions, as well as under the following extreme circumstances:

(1) Tornado or other violent weather condition which might disrupt normal offsite power. The ERCW pumps are protected from tornadic winds and tornado-borne missiles, as described in Section 3.5, by a walled enclosure covered with a roof composed of structural steel wide-flanged I-beams. The walls and roof are designed to withstand the tornado wind loading and tornado-driven missile impact. In addition, the pumps on power train A are separated from those on train B by a wall on the pumping station deck. The traveling water screens and related screen wash pumps are also located within this protective structure. Yard piping (Class C) will be protected by a minimum rock cover or concrete slabs where the minimum rock cover is not possible.

(2) The ERCW pumps, intake pumping station traveling screens and screenwash pumps, and associated piping and structures must remain operable during and after a safe shutdown earthquake which might destroy non-seismic structures and equipment and the main river dams upstream and downstream of the site. The components required for operation are therefore designed either to Seismic Category I or I(L) - pressure boundary integrity requirements. The pumping station is designed to maintain direct communication with the main river channel at minimum possible water level resulting from loss of the downstream dams.

(3) The design provides for the probable maximum flood with the coincident or subsequent loss of the upstream and/or downstream dams. To meet these conditions, the essential raw cooling water pumps, traveling screens, and screenwash pumps located in the intake pumping station are above the maximum possible flood level.

(4) In the event of blockage of the non-qualified, normal discharge path, the alternative discharge path would be functional. In this event, the discharge water would flow through the ERCW standpipes and ERCW overflow box to the holding pond which can overflow to the reservoir at a point downstream of the plant intake. If the normal discharge path is blocked, no change in valve alignment or operator action is necessary to activate the alternate path. The alternate path is seismically qualified up to and including the ERCW overflow box. If the alternate path were in use and the non-qualified piping became blocked, the discharge water would flow out of the overflow box and drain away from the plant. Even with the maximum flow out of the overflow box, the water would not build up to reach the elevation of any of the entrances to safety-related buildings.

For purposes of maintenance to the cooling towers, a valve is provided in each of the normal discharge headers so that the ERCW flow can be terminated to the cooling towers and diverted to the holding pond via the alternate discharge path.

Cooling water is supplied in an open cycle cooling mode to the various heat exchangers served by the essential raw cooling water pumps during all modes of plant operation. With normal offsite power sources available, water is normally supplied to both units by operating up to two ERCW pumps per train. More than 2 pumps may be operated during pump changeover, etc. The ERCW system provides the required flow necessary to dissipate the heat loads imposed under the design basis operating mode combination, i.e., one unit in LOCA and the other unit in hot standby, based on a maximum river temperature. Maximum ERCW supply temperature is 85°F and is consistent with the recommendations in Regulatory Guide 1.27. Minimum river temperature is 35°F.

The availability of water for the design basis condition on the ERCW system is based on one unit being in a LOCA and the other unit in hot standby and the following events occurring simultaneously:

(1) Loss of offsite power.

(2) Loss of downstream dam.

(3) Loss of an emergency power train.

Since emergency power is used to supply power for the pumps and valves in case of loss of offsite power, the loss of an emergency power train automatically dictates that cooling water must be supplied with two ERCW pumps operating through train headers.

Design basis safe shutdown for WBN is the hot standby mode. If one unit is in an accident condition, the other unit should be maintained at hot standby (if it can not be maintained in its operating mode) until the accident unit cooldown is accomplished.

In order to preclude leakage of radioactivity from the containment, the supply lines to the upper containment coolers are provided with double isolation by use of a check valve and motor-operated valve. The supply lines to the lower containment cooler groups and the discharge lines are doubly protected by use of two motor-operated valves operated on separate power trains as shown in Figure 9.2-12.

Radiation detectors are installed in each ERCW discharge header at a point downstream of the last equipment discharge point. If an abnormal radiation level is detected in either ERCW discharge header, the radiation source is located and isolated.

9.2.1.4 Tests and Inspections

All system components are hydrostatically tested in accordance with the applicable industry code before station startup. The yard piping is hydrostatically tested in accordance with Section III of the ASME Code. Subsequent to closing out Section III activities, the yard piping was opened at a number of locations and a cement-mortar lining was applied as a replacement under the provisions of Section XI of the ASME Code. Section XI defines a replacement as a design change to improve equipment service. Welds at pipe access points were examined visually and by magnetic particle test, and vacuum box leak tested before application of mortar to the weld area. After completion of cement-mortar lining, the piping was tested to the ASME Section III hydrostatic test requirements. The exposed welds were examined in accordance with the requirements of ASME Section III. ASME Section III examination pressure was maintained until the total time at pressure was one hour or greater. Following return of the system to service and before fuel load a visual examination (VT-2) will be performed in accordance with ASME Section XI IWA-5244 for buried components.

This alternative to visual examination during ASME Section III hydrostatic pressure testing was approved by NRC Inspection Report No. 50-390/89-04 and 50-391/89-04 for ERCW piping having inaccessible welds.

9.2.1.5 Instrument Applications

9.2.1.5.1 General Description

ERCW instrumentation and controls (see Figures 9.2-10 through 9.2-14A) for equipment supplied for a particular ERCW main supply header are powered from the same electrical power source as the pumps which normally supply the water to that header. Therefore, loss of one power train would result in the loss of only the instrumentation and controls associated with that particular ERCW header. Motor-operated containment isolation valves are arranged and powered such that isolation may be accomplished utilizing either one of the available power trains. Backup controls (see Section 7.4) are provided for all devices which are required for operation in the event of a main control room evacuation.

9.2.1.5.2 Pressure Instrumentation

Pressure transmitters are provided on each ERCW pump discharge line and main supply header for displaying pressures locally and in the main control room, as well as actuating main control room annunciators when pressure drops below the setpoint. Each screenwash pump is provided with a local pressure gauge on the pump discharge line. Pressure differential indicating switches are connected across each traveling screen of the intake pumping station. These switches are provided to start the associated screen wash pump whenever a high differential is detected. An additional setting is provided so that if the differential continues to increase, an alarm is initiated in the main control room. Since this operation uses service air, a nonqualified system, the screenwash system is put in continuous operation within three hours after an earthquake, tornado, flood, loop, loss of upstream or downstream dam, or within 12 hours of a LOCA. Screen wash pump discharge pressure switches are utilized to start the traveling screen motor when screen wash pressure has been established. Local pressure gauges and differential switches are provided on each ERCW strainer to monitor strainer pressures and indicate status. Local pressure test points are provided on the ERCW inlet and outlet of the water chillers of each electric board room air conditioner and each main control room air conditioner.

9.2.1.5.3 Flow Instrumentation

Flow elements and transmitters are provided for each ERCW main supply header to display the flow rates. The ERCW flow rate through each containment spray and component cooling heat exchanger is also displayed in the main control room. Local flow indicators are provided for the flow rate through the emergency diesel engine heat exchangers, the flow rate inlet and discharge from each lower containment, RC pump motor, and control rod drive ventilation cooler group, and each upper containment ventilation cooler. Flow elements are provided in the discharge lines of most other coolers and heat exchangers for use during testing and system balancing.

9.2.1.5.4 Temperature Instrumentation

ERCW pump motor winding and bearing temperatures are recorded on a temperature recorder in the main control room. Local temperature indicators are provided for the discharge from each emergency diesel engine heat exchanger and for various other users. Temperature test wells are provided on the inlet of each air conditioner condensing unit and the discharge side of each component cooling system heat exchanger, containment spray heat exchanger, RC pump motor cooler, and control rod drive cooler. Temperature test wells are also provided in the inlet and discharge lines for most space coolers, room coolers, and in the main supply and return header.

9.2.1.5.5 Deleted by Amendment 87

9.2.1.5.6 Control Valves

The open and closed positions of all ERCW air operated and motor-operated valves are displayed in the main control room by means of lights incorporated either on the controlling hand switch or on a valve status light subpanel. All air operated temperature and flow control valves are designed to fail open on loss of electrical power and/or operating air, thereby providing maximum ERCW cooling flow to the equipment being supplied.

ERCW is supplied to each upper and lower containment and control rod drive ventilation cooler through a throttling action type valve controlled by a temperature indicating controller. Manual and/or automatic override to fully close the control valve is provided by means of a hand switch and/or logic signal (Figures 9.2-5 through 9.2-9).

ERCW is supplied to each air conditioner condensing unit through an automatic water regulating valve controlled by condenser pressure.

Each CCS heat exchanger incorporates a motor-operated butterfly valve in its main ERCW discharge line. Each valve may be placed in either of two intermediate, throttled positions in addition to the full open or closed positions. The desired position is selected manually from the control room for the particular plant operating condition. In addition, the heat exchanger C valve has automatic controls to open the valve to the low-flow intermediate position in response to a loss of offsite power signal or a safety injection signal in either unit. Such automatic controls are not required for heat exchangers A or B since their bypass valves are normally open, whereas the heat exchanger C valve may be normally closed.

The by-pass lines at the CCS heat exchangers discharges have a special motor-operated, anti-cavitation modulating valve to control ERCW flow rate through the associated CCS heat exchanger at low and intermediate flow rates. These anti-cavitation valves may be manually adjusted to the open, closed, and/or intermediate position to achieve desired CCS heat exchanger performance for various operating modes. Control switches are provided in the main control room. The valves are designed to ASME Section III, Class 3, with Class 1E motor operators.

ERCW is supplied to each additional cooler or heat exchanger through an on-off action type valve controlled by either a hand switch, a temperature switch, a manual valve, a logic signal, or various combinations of these.

9.2.1.6 Corrosion, Organic Fouling, and Environmental Qualification

Watts Bar Nuclear Plant (WBN) has a comprehensive chemical treatment program for treating raw water systems. This treatment is a major part of WBN Raw Water Corrosion Program. The chemical treatment is used to control corrosion in carbon steel and yellow metals, to control organic fouling, including slime, to minimize the effect of microbiologically induced corrosion (MIC) and inhibit growth of Asiatic clams. Chemical treatment for the ERCW may include the following:

(a) Chemical treatment to control deposition and fouling

(b) A corrosion inhibitor and sequestrant to remove existing deposits

(c) Chemical treatment to control carbon steel corrosion

(d) Chemical treatment to protect yellow metal

(e) Chemical treatment to kill clams, zebra mussels and prevent MIC

(f) A biocide to reduce MIC and control clams

The dead legs to the containment spray system (CSS) heat exchangers (Hxs) and auxiliary feedwater (AFW) Pumps shall have biocide/chemical treatment lines which permit flow through those lines on a continuous basis. In addition, the CSS Hxs and piping between the motor-operated supply and discharge isolation valves shall be filled with demineralized water treated for corrosion control.

The ERCW piping to the diesel generators is treated during periods of biocide injection. During Unit 1 only operation, flow is provided to the diesel generators continuously.

For the ERCW line to the CCS surge tank, the blind flange at the spool piece connection is provided with a flushing connection to facilitate chemical treatment of the piping. Other lines used to connect to CCS piping during flood mode operation would be treated in a similar manner. These lines are not connected to the CCS during the flushing operation.

Control of organic fouling and Asiatic clams is further enhanced by the use of strainers in the supply headers. Each supply header is provided with a strainer (auto-backwash type) capable of removing particles and organic matter larger than 1/32-inch diameter. The strainers are located in the Intake Pumping Station downstream of the ERCW pumps.

Normal system operation and maintenance is considered adequate to disperse chemicals in the instrument lines, drains, and vents in the ERCW system.

Allowances for the effects of corrosion on the structural integrity of this system were made by increasing the wall thickness of the pump pressure boundary, pipe, heat exchanger shells and tubes, and other system pressure retaining components. Measures have also been taken to compensate for the effects of corrosion on the flow passing capability of the system. The normally wetted portion of the buried supply and discharge headers have been lined in situ with cement mortar, most of the 2-inch and smaller diameter piping is stainless steel, and selected runs of larger piping in the Auxiliary and Turbine Buildings are stainless steel, and almost all of the piping in the Reactor Building is stainless steel.

To the extent to which they are exposed to atmospheric conditions, all pumps and valves will be designed to operate under the most extreme climatic conditions that are expected to prevail in the southeastern United States.

9.2.1.7 Design Codes

The ERCW system components are designed to the codes listed in Table 3.2-2a.

9.2.2 Component Cooling System (CCS)

9.2.2.1 Design Bases

The CCS is designed for operation during all phases of plant operation and shutdown. The system serves to remove residual and sensible heat from the reactor coolant system via the residual heat removal system during plant cooldown; cool the spent fuel pool water and the letdown flow of the chemical and volume control system; provide cooling to dissipate waste heat from various plant components; and provide cooling for safeguard loads after an accident.

The systems served by the CCS are:

(1) Reactor coolant system (RCS), Section 5.5.1

Reactor coolant pumps (RCPs)

(a) RCP upper and lower oil coolers

(b) RCP thermal barriers.

(2) Residual heat removal (RHR) system, Section 5.5.7

(a) RHR heat exchangers (Hxs)

(b) RHR pump seal coolers

(3) Safety injection system (SIS), Section 6.3

(a) Safety injection pump oil coolers

(4) Chemical and volume control system (CVCS), Section 9.3.4

(a) Letdown Hx

(b) Excess letdown Hx

(c) CVCS seal water Hx

(d) Reciprocating charging pump oil coolers

(e) Centrifugal charging pump lube and gear oil coolers

(f) Gas stripper and boric acid evaporator package; not used for Unit 1 operation, (Sections 9.3.7 and 12.2.1.2.8)

(5) Spent fuel pool cooling system (SFPCS), Section 9.1.3

(a) SFPCS Hxs

(6) Containment spray system (CSS), Section 6.2.2

(a) Containment spray pump bearing oil cooler

(7) Gaseous waste processing disposal system (GWPS), Section 11.3

(a) Waste gas compressor Hxs

(b) Condensate demineralizer waste evaporator package; not used for Unit 1

(8) Sampling system (SS), Section 11.5

(a) Sample Hxs

(b) Sample chiller package

(c) Gross failed fuel detector (GFFD) coolers; not used for Unit 1 operation, (Section 9.3.5).

(d) Post accident sampling (PAS) coolers

The CCS serves as an intermediate loop between systems 1 through 8, listed above, and the ERCW system. Heat from the listed systems is transferred by the CCS through the component cooling heat exchangers to the ERCW system, which is the heat sink for these heat loads. The intermediate loop provides a double barrier to reduce the possibility of leakage of radioactive water to the environment.

The CCS design is based on a maximum ERCW inlet temperature of 85°F. The ERCW supply from the river will be available under all conditions. The design temperature places no undue limitations on normal plant operation. It affects the time required for plant cooldown and the number of component cooling heat exchangers in use during the various plant operations.

Since the CCS is required for post-accident removal of heat from the reactor, the CCS is designed such that no single active or passive failure will interrupt cooling water to both A and B Engineered Safety Feature (ESF) trains. One ESF train is capable of providing sufficient heat removal capability for maintaining safe reactor shutdown.

The CCS pumps, thermal barrier booster pumps and required motor-operated valves will be automatically transferred to auxiliary onsite power upon loss of offsite power.

9.2.2.2 System Description

The CCS, shown in Figures 9.2-16, 9.2-17, 9.2-18, and 9.2-19, consists of five CCS pumps, four thermal barrier booster pumps, three heat exchangers, two surge tanks, one CCS pump seal water collection unit, and associated valves, piping and instrumentation serving both units. The coolers associated with the systems served by CCS (see Section 9.2.2.1) are not part of CCS but rather are included in the serviced systems. Such coolers are discussed more fully in the references listed in Section 9.2.2.1.

The logic and control diagrams for this system are presented in Figures 9.2-20, 9.2-20A, 9.2-21, 9.2-21A, 9.2-22, 9.2-22A, 9.2-23, 9.2-24, 9.2.25, and 9.2-25A.

The CCS design pressure and temperature are 150 psig and 200°F, respectively, except as noted below:

(i) The design pressure and temperature for piping from thermal barrier booster pumps (TBBPS) discharge to the first of redundant check valves in each thermal barrier supply line are 200 psig and 200°F, respectively.

(ii) From the first redundant check valve of each thermal barrier supply line to the outboard containment isolation valve on the thermal barrier return line, the design pressure and temperature are the same as the RCS design pressure and temperature which are 2485 psig and 650°F. This prevents overpressurization of this portion of the CCS piping in the event of thermal barrier leakage. A 3/4-inch check valve installed across the inboard containment isolation valve, incorporates a soft seat which is not designed for fluid temperatures above 300°F. In order for the temperature to exceed 300°F, reactor coolant must leak through the thermal barrier into the CCS. A thermal barrier tube rupture event will not degrade the soft seat since isolation would occur rapidly. In order to guard against leakage through the check valve, inspection and repair of the check valve seat will be performed whenever repairs for thermal barrier tube leakage are needed.

(iii) In order to maintain containment integrity during and after a LOCA, CCS piping between and including the containment isolation valves is design for 250°F.

During normal full power operation, with all CCS equipment available, pumps 1A-A and 1B-B and Heat Exchanger A are aligned with Unit 1, Train 1A ESF and miscellaneous equipment; pumps 2A-A and 2B-B and Heat Exchanger B are aligned with Unit 2 Train 2A ESF and miscellaneous equipment. Pump C-S and Heat Exchanger C are aligned with either Unit 1, Train 1B or Unit 2, Train 2B equipment. Pump 1B-B is used as additional capacity for Train 1A, as required, and as a replacement for pumps 1A-A or C-S, if one should be out of service. Pump 2B-B is used as additional capacity for Train 2A as required and as a replacement for pumps 2A-A or C-S, if one should be out of service. For Unit 1 only operation, pump 2B-B will be aligned in parallel with pump C-S to supply Train 1B/2B, Heat Exchanger C.

Train 1A and Train 2A equipment will provide all the cooling water necessary for the safe operation of Units 1 and 2, respectively. Train 1B/2B (common) supplies additional cooling capacity to the unit it is aligned with during various operational modes. Train 1B/2B equipment has been sized to maintain plant safety in the event of Units 1 and 2, Train A power loss.

A surge tank is provided for each unit. Each surge tank is separated into two parts by a baffle, providing separate minimum surge volumes for each ESF cooling train.

Both units are served by two cooling system trains (A and B) serving ESF equipment, with train A also serving miscellaneous non-safety related components and train B serving the non-safety related condensate demineralizer waste evaporator, (not in service during Unit 1 only operation). Except for the RHR Hxs, excess letdown Hx, and PAS coolers, both trains of the safeguards equipment of both units served by the CCS are normally aligned and supplied with CCS water and will automatically continue to be supplied in a LOCA. During Unit 1 only operation, RHR Heat Exchanger 1B-B will normally be aligned to receive component cooling water during all operating modes. In the event of an accident, nonsafety-related components are not required; therefore, CCS flow to these components may be manually isolated. The excess letdown heat exchanger is required only during startup and when normal letdown is lost, and is manually valved in at that time. The PAS system coolers are also manually aligned while performing sampling operations following an accident; at other times the associated CCS valves are locked closed. Prior to switchover from injection to recirculation phase of safety injection it is necessary for the operator to open the CCS valves at the RHR heat exchangers of the accident unit in order to supply these heat exchangers with cooling water. This action is part of the switchover sequence specified in Section 6.3.2.2 and Table 6.3-3. The earliest time at which this operator action is required to be performed is 10 minutes. If an emergency power train is lost during an accident condition no additional operator action on the CCS is required for plant safety except for the following cases:

(1) If the non-accident unit is utilizing RHR cooling it will be necessary to close the CCS supply to these heat exchangers. RHR cooling will be terminated when the non-accident unit is in RHR cooldown with the reactor coolant system not vented. If the reactor coolant system hasbeen vented, RHR cooling of the non-accident unit will continue, but at a reduced rate.

(2) During two unit operation, if train A power is lost, the operator will terminate CCS flow to the condensate demineralizer waste evaporator (not in service during Unit 1 only operation). CCS pump 1B-B will supply cooling water to SFPCS heat exchanger A via CCS header 1A and CCS heat exchanger A during two unit operation. During Unit 1 only operation, flow to the spent fuel pool cooling system (SFPCS) heat exchanger will be provided after CCS Pump 1B-B has been realigned to CCS Train 1B/2B.

(3) During one and two unit operation, if Train B electrical power is lost, Pump C-S will be manually realigned to Train A power and valved into the Unit 1 Train A header to provide SFPC heat exchanger cooling. The SFPCS heat exchanger shall be isolated until this realignment occurs.

In the event of a design basis flood at WBN, the CCS pumps will be submerged since the maximum flood level will be above the CCS pumps. Since cooling must be maintained to certain CCS users during the flood, provisions have been made to interconnect the ERCW and CCS systems to supply ERCW to the following loads:

(a) SFP heat exchangers,

(b) RHR heat exchangers,

(c) RCP thermal barriers,

(d) Sample heat exchangers.

The interconnections are accomplished by installing spool pieces and opening normally-closed valves during flood mode preparation. The thermal barrier booster pumps are required to operate during flood mode and remain above the maximum flood. Some normally-open CCS valves will be closed during this phase to isolate nonessential equipment. The surge tanks shall be isolated upon ERCW interconnection to prevent potential overpressurization.

Provisions have been provided to reestablish CCS flow to the reactor coolant pump thermal barrier following a Phase B isolation signal. This action will protect the integrity of the seals in the event of passive failure of the chemical and volume control system seal injection flow to the reactor coolant pump seals.

The CCS water is circulated through the shell side of the CCS heat exchangers to the components using the cooling water and then back to the CCS pump suction. The surge tank for each unit is separated into two sections by a baffle. Each section is tied into the pump suction lines from safeguard trains. This tank accommodates expansion and contraction of the system water due to temperature changes or leakage, and provides a continuous water supply until a small leak from the system can be isolated. Because the surge tank is normally vented to the building atmosphere, a radiation monitor is provided in each component cooling water heat exchanger discharge line. These monitors actuate an alarm and close both surge tank vent valves when the radiation reaches a preset level above the normal background.

Cooling water is available to the components served by the system. The system is provided with adequate motor-operated-valves to permit realignment or isolation of equipment and cooling water headers by the control room operator. (Motor-operated valves are opened as necessary, to provide the RHR heat exchangers with cooling water during startup, cooldown, refueling, and LOCA.)

Normal system makeup is provided from the demineralized water system. Emergency makeup is provided from the ERCW system.

The component cooling water contains a corrosion inhibitor to protect the carbon steel piping. Corrosion inhibitor type is consistent with current water chemistry technology.

The design provides radiation monitors at each CCS heat exchanger outlet for the detection of radioactivity entering the system from the RCS and its associated auxiliary systems, and includes provisions for isolation of system components.

9.2.2.3 Components

All the components for this system are located within the controlled environment of the Auxiliary Building, Reactor Building, and CDWE Building and are designed to withstand the environmental occurrences within those structures such that the components will perform their design function(s). During flooding, connections are made to the ERCW system to maintain a cooling supply to the safeguard trains, since the CCS pumps will be inoperative.

The only safety-related CCS equipment subject to water spray damage includes the CCS pump motors and certain valve motors.

All motor-operated valves have totally enclosed, waterproof motors. The CCS pump motors have a NEMA weather-protected Type II enclosure. Drip-proof motors have been provided for the thermal barrier booster pumps.

CCS component design data is listed in Table 9.2-8.

9.2.2.3.1 Component Cooling Heat Exchangers

The three component cooling water heat exchangers are of the shell and tube type. ERCW circulates through the tubes while component cooling water circulates through the shell side. The shell is of carbon steel and the tubes are AL-6X, an austenitic chromium, nickel, molybdenum-containing alloy.

9.2.2.3.2 Component Cooling Pumps

The five component cooling water pumps which circulate water through the component cooling loops are horizontal, centrifugal units of standard commercial construction. The pump motors receive electric power from normal or emergency sources. Each of the four normally assigned pumps (2 per unit) is connected to one of the four electric power trains. The fifth pump can be powered from either of two assigned electric power trains.

9.2.2.3.3 Thermal Barrier Booster Pumps

The four booster pumps (2 per unit) circulate cooling water through the reactor coolant pump thermal barriers. The booster pumps provide the additional head necessary to overcome high head loss through the thermal barriers, and thereby allow the CCS pumps to operate at a lower total head, supplying the remaining component cooling loads at a lower operating pressure. One booster pump supplies the thermal barrier requirements (160 gpm) for each reactor unit. A second pump is assigned to each unit to provide 100% redundancy. The pumps are horizontal, centrifugal units of standard commercial construction. The pump motors receive electric power from Class 1E power systems, which are described in Chapter 8.

9.2.2.3.4 Component Cooling Surge Tanks

The component cooling water surge tanks accommodate changes in component cooling water volume. Each unit is provided with one tank for unit separation. Each tank has an internal baffle divider to provide two separate surge volumes for safeguard train separation within each unit. This arrangement provides redundancy for a passive failure during recirculation following a loss-of-coolant accident.

9.2.2.3.5 Seal Leakage Return Unit

The seal leakage return unit (SLRU) consists of a tank and two pumps. The tank serves as a collection point for seal leakage from the CCS pumps. The SLRU pumps return this water to the CCS surge tanks. This unit is not a safety class item, because its only function is the collection of pump seal leakage.

9.2.2.3.6 Valves

Valves used in the component cooling system are standard commercial types of carbon steel construction, designed to minimize leakage. Self-actuated, spring-loaded relief valves are provided for lines and components that could be pressurized beyond their design pressure by improper operation or malfunction.

The relief valve protecting the reactor coolant pump thermal barrier and its associated piping is designed to relieve thermal expansion if the cooling line is isolated while the reactor coolant system is hot. The cooling water piping from the check valve upstream of the barrier to the last containment isolation valve downstream is designed for primary system pressure (see Section 9.2.2.2). If the thermal barrier tube ruptures, the cooling line is automatically isolated and the relief valve accommodates thermal expansion of the fluid in the isolated section (this condition will also exist after containment isolation). The valve set pressure equals the design pressure of that particular segment of piping as described below under piping. Discharged water is directed to the floor drain sump tank.

Cooling water to the RCP thermal barrier is made available to assure that there will be no mechanical damage to the pump. The cooling water supply and discharge lines to the RCP thermal barriers each contain two remote-operated valves in series: One valve operates on power train A, the other on train B. The redundant discharge valves assure the ability to isolate this circuit if a barrier leak is detected. Leak detection is accomplished by measuring thermal barrier supply and discharge cooling water flows.

The cooling water supply line to the excess letdown heat exchanger contains a motor-operated and a manual valve outside the containment wall. A pilot- operated, fail closed, pneumatic valve is provided in the return line outside containment. Both the motor-operated and pneumatic valves are normally closed except during startup, but also have automatic control signals to assure closure under containment isolation conditions. A relief valve is supplied on the cooling water line downstream of the excess letdown heat exchanger. It is sized for thermal expansion occurring when the CCS side is isolated and high temperature fluid continues to flow on the opposite side. If both sides of the heat exchanger are isolated, the relief valve is also sized to relieve any leakage through the high pressure letdown inlet isolation valve and into the cooling water piping via a heat exchanger tube leak.

Except for the normally closed makeup line and equipment vent and drain lines, there are no connections between the component cooling water and other systems. The equipment vent and drain lines outside the containment have manual valves which are normally closed unless the equipment is being vented or drained for maintenance or repair.

Relief valves other than those on the CCS surge tank or excess letdown heat exchanger have been sized to relieve the volumetric expansion occurring if the exchanger CCS side is isolated and high temperature coolant flows through the opposite side. The set pressure equals the design pressure of the CCS side of the heat exchangers or the CCS piping whichever is less. Water from the relief valves discharge into the floor drains, and the relief valves inside containment discharge to the waste disposal system.

Relief valves on the component cooling surge tanks are sized to relieve the maximum flow rate of water which enters the surge tank following a tube rupture of the RHR heat exchanger, excess letdown heat exchanger, or letdown heat exchangers. The set pressure ensures the working pressure of the surge tank will not be exceeded. The discharge of those valves is directed to the floor drain collector tank.

The surge tank vent-overflow line, which is open to the Auxiliary Building atmosphere, is equipped with an air-operated valve that closes automatically if radiation is detected in the system. A vacuum breaker valve is also provided to prevent collapsing the tank in the event of a large loss of water in the system.

9.2.2.3.7 Piping

Component cooling water system piping is carbon steel, with welded joints and connections except flanges at components which might require removal for maintenance. CCS piping is standard weight except the portion of piping to reactor coolant pump thermal barriers which is Schedule 160 from the first of the redundant check valves to the last containment isolation valve or the return piping.

9.2.2.4 Safety Evaluation

The CCS is comprised of two trains (A&B) per unit where the B train and C heat exchangers are shared between the two units. Each train has the capability to provide the maximum cooling water requirement for both units. These equipment trains are sufficiently independent to guarantee the availability of at least one train at any time. The system has been analyzed for "worst case" heat loads under combinations of maximum river water temperature, design basis accident conditions, normal cooldown requirements, power train failures, etc., for both units. Design basis safe shutdown for WBN is the hot standby mode. If one unit is in an accident condition, the other unit should be maintained at hot standby (if it can not be maintained in its operating mode) until the accident unit cooldown is accomplished. It is found through these analyses that sharing of this system by the two nuclear units does not introduce factors that prevent the system from performing its required function for the plant design basis condition.

Component cooling water pumps, heat exchangers, and associated valves, piping, and instrumentation (except flow, pressure and temperature transmitters) are located outside the containment and are therefore available for maintenance and inspection during power operation. Maintenance on a pump or heat exchanger is practical while redundant equipment is in service, subject to limitations of the Technical Specifications.

Sufficient cooling capacity is provided to fulfill system requirements under normal and accident conditions. Adequate safety margins are included in the size and number of components to preclude the possibility of a component malfunction adversely affecting operation of safeguards equipment. Active system components considered vital to the cooling function are redundant; i.e., any single active or passive failure in the system will not prevent the system from performing its design function.

The component cooling water pumps are automatically placed on emergency power in the event of loss of offsite power; therefore, the minimum ESF requirements are met with regard to supply of component cooling water. Separate trains provide component cooling water to the engineered safety features. Each train services its safety related cooling loads associated with the same train. Should a single failure result in the loss of a train of equipment (A or B) the other train is available for handling all required heat loads.

9.2.2.5 Leakage Provisions

To minimize the possibility of leakage from piping, valves, and equipment, welded joints are used wherever possible. Flanged joints are used only in sections or connections to components which require inspection and/or maintenance on a periodic basis, and for butterfly valves.

A seal leakage return unit is provided to collect seal leakage from the component cooling pumps and return it to the system via the CCS surge tanks. The return unit consists of one collection tank and two seal leakage return pumps. The pumps alternate operation to return equal seal leakage volume to each unit surge tank.

The component cooling water could become contaminated with radioactive water due to one of the following conditions:

(1) A leak in any heat exchanger tube in the CVCS, RHR system, sampling system, or the SFPCS.

(2) A leaking cooling coil for the thermal barrier cooler on a reactor coolant pump.

(3) Seal leakage from ESF pumps.

9.2.2.6 Incidental Control

If outleakage occurs anywhere in the system, detection is accomplished through a falling level in the surge tank, which will actuate a low level alarm in the control room. Leak detection and control is also provided for the sample heat exchanger and chiller package by the level alarms in the waste disposal system sump where any system leakage will be collected. Detection of low-low level in the Train B side of either surge tank results in automatic isolation of CCS water to the Class G condensate demineralizer waste evaporator piping, as discussed in Section 9.2.2.7.3. Leak detection and control is also provided for the Train A side of either surge tank, which contains the Class G sample heat exchangers and chiller package, by both flow and level instrumentation as discussed in Sections 9.2.2.7.2 and 9.2.2.7.3. Inleakage is detected by a surge tank high level alarm. The leaking portion of the system is located by visual inspection, and is isolated. The backup train is then put into operation.

Since the system does not service any engineered safety feature component inside the containment following a LOCA, containment isolation valves on the component cooling lines entering and leaving the containment are automatically closed on high-high containment pressure signal (Phase B containment isolation) except isolation valves for the excess letdown heat exchanger which closes on Phase A containment isolation signal.

9.2.2.7 Instrument Applications

9.2.2.7.1 General Description

The CCS, being a water to water heat transfer system, uses inputs of flow rate, level, pressure, and temperature for instrumentation. Electric power to the transducers in the instrument loops is from the same train as the equipment being served. Loss of a power train would result in loss of only instrumentation and control for equipment that is being served by that particular power train. Control of the system is through air and motor-operated valves. (See Figures 9.2-16, 9.2-17, 9.2-18, and 9.2-19.)

9.2.2.7.2 Flow Instrumentation

Maintaining ample flow rates is essential to proper heat transfer; therefore, flow measurements are taken at the outlet of virtually all heat exchangers and displayed in the control room. In addition, flows entering the power-trained headers are measured and displayed locally. Differential flow instrumentation is also provided for the sample heat exchangers and chiller package, but for a different reason. These coolers, as well as portions of the CCS piping, are designed to TVA Class G and therefore may break under seismic loading. Consequently, to preclude loss of water inventory, this flow instrumentation has been provided to detect outleakage and to provide control signals to isolate the Class G piping from the remainder of the system by automatic closure of valves FCV-70-183 and FCV-70-215. Main control room annunciation of this condition has also been provided. See Figures 9.2-18, 9.2-21, and 9.2-24.

The thermal barrier lines use differential flow to isolate a thermal barrier leak from the rest of the CCS. Flow rates are measured in both the supply and return headers. The two are compared, and should a mismatch occur due to in-leakage, the line is isolated. This comparison is done in each power train so the isolation function is completely redundant. Annunciation and flow rates on the individual thermal barriers give the operator the required data for proper control.

9.2.2.7.3 Level Instrumentation

Surge tank level measurements are used to monitor and control the total amount of water in the system. Should there be leakage into the system, the level will rise and activate a high-level switch for annunciation in the control room. Level is displayed in both the main and auxiliary control rooms.

Leakage out of the system is detected by a low level switch that activates valve LCV-70-63 to provide demineralized water makeup to the system. Low-low level switches have also been provided on both the Train A side and the Train B side of both surge tanks. A low-low level signal from the Train A side of either tank indicates a probable break or tube leak in the nonqualified sample cooler/chiller piping and causes automatic closure of valves FCV-70-183 and FCV-70-215. A low-low level signal from the Train B side of either tank indicates a probable break in the nonqualified CDWE piping and causes automatic closure of valves 1-FCV-70-207 and 2-FCV-70-207 in the supply lines and valve FCV-70-206 on the CDWE return header.

9.2.2.7.4 Pressure Instrumentation

Pressure measurement is essential for proper monitoring of pump performance. Local pressure indications are available for both suction and discharge of all pumps in the system. Local indication is also available for the main supply headers to various equipment. Pressure in the three discharge headers of the CCS pumps is displayed in the main control room and ACR. Discharge headers for trains 1A and 2A are annunciated in the MCR on low-pressure setting. Low header pressure in one train will automatically start the standby pump in that train. MCR annunciation is also given when an abnormally high pressure is sensed at the discharge of each CCS pump. Automatic control signals have been provided to isolate the CCS supply to the CDWE package on indication of low supply header pressure.

This is provided for the same reason and accomplishes the same function as the low-low surge tank level controls discussed in Section 9.2.2.7.3.

9.2.2.7.5 Temperature Instrumentation

Temperature can be monitored at the outlet of every heat exchanger or heat exchanger group. Temperature indication is provided in the main control room for the main return headers to the pumps and for the outlet of the CCS heat exchangers. Should temperatures at the outlet of the major heat exchangers become excessive, annunciation will occur in the MCR to alert the operator to take corrective action.

9.2.2.7.6 Valves

Most of the valves in the system are motor-operated, non-throttling, fail-as-is type valves. They are used mostly to isolate sections of the system. The motor-operated valves are power trained. Valve LCV-70-63 is an air operated, fail-closed, makeup water level control valve for the surge tank. Valve FCV-70-66 is an air-operated, fail-closed, vent valve for the surge tank. Valve FCV-70-85 is an air-operated, fail-closed, isolation valve to the excess letdown heat exchanger. Throttling valves are used for process control and are not actuated by safety systems.

9.2.2.7.7 Conclusion

Since the CCS is a safety buffer system between the radioactive primary water and the essential raw cooling water, appropriate instrumentation provides the necessary data and controls for the operator to ensure the functional safety of the system.

9.2.2.8 Malfunction Analysis

The CCS is sufficiently independent so that a single active failure of any one component will not preclude safe plant operations in either unit. A failure analysis is presented in Table 9.2-9.

This paragraph discusses the consequences of a loss of component cooling water to the RHR pump seal coolers and the indicators that are available to alert the operator of this loss. The RHR pumps were procured to be operable without cooling water being supplied to the seal coolers. A loss of component cooling water to the seal cooler, however, would result in higher seal unit temperature and consequently shorter seal lifetime but would not cause or require a rapid shutdown of the pumps. Indication of a loss of component cooling water to an RHR seal cooler would be available from several sources. The component cooling lines serving the coolers are each provided with a flow element downstream of the cooler. Flow indication and alarm is provided in the main control room from each of the flow elements. This instrumentation circuit is Class 1E and meets IEEE-279 criteria. The instrumentation discussed above is illustrated in Figures 9.2-21 and 9.2-22. Additionally, there is a temperature sensor in each RHR seal piping loop which will alarm in the MCR on high seal fluid temperature. A loss of component cooling water flow to one of the RHR seal coolers would not affect the redundant RHR pump.

9.2.2.9 Tests and Inspections

All systems piping and components are hydrostatically tested and CCS operability is verified prior to station startup. Virtually all CCS components outside the containment are accessible for periodic inspection during operation. The position of all system valves and automatic start of the CCS pumps on a safety injection signal will be verified periodically.

9.2.2.10 Codes and Classification

All piping and components of the CCS are designed to the applicable codes and standards listed in Table 9.2-11.

The entire system is TVA Class C with the following exceptions:

(1) All containment penetrations and associated containment isolation valves are TVA Class B.

(2) The excess letdown heat exchanger piping inside containment is TVA Class B.

(3) The sample cooler/chiller piping and valves between FCV-70-215 and FCV-70-183 is TVA Class G.

(4) The Condensate Demineralizer Waste Evaporator piping and valves between FCV-70-208 and FCV-70-206 is TVA Class G and H.

(5) The CCS pump seal leakage collection tank is TVA Class L. The associated drain piping, valves, and seal leakage return pumps are TVA Class G from the collection point to the pumps outlet check valves 1-70-535 and 2-70-535.

(6) The piping between valve 1-ISV-70-775, and the pipe cap and the piping between valve 1-ISV-70-777 and the pipe cap are TVA Class G.

9.2.3 Demineralized Water Makeup System

The demineralized water makeup system is a shared system serving both units.

9.2.3.1 Design Bases

The system is designed to supply the requirements for high purity water for makeup to the steam generators, the primary water system, and the demineralized water system for cask decontamination, cleaning, flushing, and makeup for miscellaneous services.

A secondary function is to supply filtered water to the condenser circulating water pumps for bearing lubrication.

9.2.3.2 System Description

The system consists of the following three sub-systems: a filtration plant, a two train demineralizer system, and the demineralized water storage and distribution system. The filtration plant and two train demineralizer system discussed below are not required for Unit 1 operation. This equipment has been replaced with a vendor supplied water purification system which is also described below.

Flow diagrams are shown in Figures 9.2-26, 9.2-27 and 9.2-28.

The filtration plant consists of a flocculator tank, a pair of settler-filter tanks, two treated water clearwalls, chemical feed equipment, and demineralizer supply pumps. Primary supply to the filtration plant is from the raw service water system. An alternate source is provided from the raw cooling water system.

Raw river water is chlorinated as required upon entering the flocculator; then chemical coagulants are added in the tank and mixed.

Clarified water flows through the filters to the clearwell tanks. Filter effluent turbidity is continually monitored and recorded. The principal piping system is black steel; chemical feed lines are polyvinyl chloride, TVA Class H. All of the filtration plant equipment is located in the Turbine Building.

Each demineralizer train consists of a cation, anion, and mixed bed unit. A two-stage vacuum degassifier and regeneration facilities are common to the two trains. Water is pumped to the demineralizer trains from the clearwells by the demineralizer supply pumps. Discharge is to the two stage degassifier where oxygen (as 0_2) is reduced to

0.2 parts per million. The degassifier booster pumps supply water from the degassifier to the demineralized water system.

Normally either one or two demineralizer trains will be operated continually. During periods of low or no demand, the demineralizer effluent will be automatically recycled.

Regenerate wastes drain by gravity to a 3500 gallon batch neutralizer tank (not required for Unit 1). The unit is designed to produce a neutral effluent in the range of pH from 6.0 to 9.0. Demineralizer system principal process piping is saran-lined steel, TVA Class H. The cation, anion, mixed bed, waste neutralizer and caustic storage tanks are rubber lined. All demineralizer equipment is located in the Turbine Building, except the acid and caustic storage tanks and supply pumps, which are located in the yard.

The vendor supplied water purification system for Unit 1 has been designed to comply with the aspects of the plant. The system takes raw water from an existing header. The raw water is filtered for suspended solids removal. Water is then normally passed through a reverse osmosis (RO) system designed to remove dissolved solids and organics. RO effluent is then passed through a process designed to remove CO_2 from the water. Water from this process is then deoxygenated as necessary. Water from the deoxygenation system then flows through a standard demineralizer for final polishing.

Water not meeting the specification is automatically recycled either to the RO influent or the demineralizer influent, depending on the parameter that is out of specification. In-line analyzers continuously monitor the effluent quality. Once the effluent is in specification, it is pumped directly to the 500,000 gallon demineralizer water storage tank and then is pumped in the existing plant piping for distribution.

The demineralized water system consists of a 10,000 gallon demineralized water head tank, a 15,000 gallon cask decontamination head tank, main piping loop and supply headers. The loop supplies water for various services as shown in Figure 9.2-28. The services include emergency showers, eye wash stations, water for cask washdown room, fuel transfer canals and makeup water for various system tanks and equipment.

The main piping loop is supplied from the demineralized water head tank. Makeup water for the condensate storage tanks is supplied from the treatment plant. Washdown water for the cask washdown room is supplied from the cask decontamination head tank. Makeup for the primary water storage tanks is supplied directly from the loop.

Storage tanks and system principal piping are aluminum except piping inside reactor containment which is stainless steel. Piping is TVA Class H except reactor containment isolation valves and connecting piping which are TVA Class B, and piping in the Reactor Building which is TVA Class G.

9.2.3.3 Safety Evaluation

The demineralized water makeup system is not required for maintenance of plant safety in the event of an accident and is not a part of the engineered safety systems; therefore, the reactor containment isolation valves and the piping connecting the valves are the only portions of this system which have a nuclear safety class designation in accordance with TVA Classification B. There are no safety-related implications due to sharing this system between the two units.

All pipe hangers and supports in the Control Building, Auxiliary Building, and Reactor Buildings are designed for seismic loading to prevent damage to adjacent safety related equipment necessary for the safe shutdown of the plant.

9.2.3.4 Test and Inspection

Prior to startup piping and equipment are tested. After startup routine visual inspection of the system components and instrumentation is adequate to verify system operability.

9.2.3.5 Instrumentation Applications

Instrumentation is provided for treatment plant operation and to maintain storage tank levels. The filtration plant effluent is provided with a finished water turbidity monitor recorder and alarm. The high turbidity alarm is annunciated locally and in the control room.

The demineralizers are provided with an alarm panel which is monitored. High effluent conductivity automatically closes the outlet valve and actuates an alarm. Remote reflash annunciation is provided in the control room.

A flow control valve in the demineralized water supply line is set to open when the demineralized water head tank level falls below a predetermined setpoint. After the level rises above the setpoint the valve will close.

The cask decontamination head tank fills by gravity through a level seeking connection from the demineralized water system. Flow is controlled by a restrictive orifice and check valve.

High and low level switches annunciate both tank levels in the control room.

9.2.4 Potable and Sanitary Water Systems

9.2.4.1 Potable Water System

9.2.4.1.1 System Description

Potable water for this project is purchased from a water supply system operated by Watts Bar Utility District.

Potable water from the supply system enters the plant site through a water meter and a backflow prevention valve and is routed to two storage tanks in the Turbine Building.

Most potable water used on site is taken from the outlets of these tanks in order to keep the stored water fresh and maintain adequate chlorine residual. Some of the more remote facilities are supplied directly from the main supply line. Pressure reducing valves are used where required. The main supply line and the return lines from the storage tanks supply the yard distribution system which conveys potable water to the various buildings and to other points of usage. Concrete backing is poured where lines change direction or dead end. The materials used for pipelines of the potable water system are in compliance with the Standard Plumbing Code.

Plumbing fixtures, water coolers, water heaters, eyewash equipment, and emergency shower equipment are supplied with potable water. Some eyewash and emergency shower equipment are also supplied water from the demineralized water system. Applicable laboratory, hospital, kitchen, and laundry equipment are also supplied. Hose bibs and service outlets receive potable water where raw water is not readily available or where water cleaner than raw water is needed. There are no potable water lines in the Reactor Building.

Hard-drawn copper tubing and solder joint fittings or galvanized steel pipe and galvanized malleable iron fittings are normally used on water lines in the buildings. Potable water lines are normally sized to limit fluid velocities to a maximum of seven to eight feet per second.

Flow diagrams are as shown on Figures 9.2-29A, 9.2-29B, 9.2-29C and 9.2-29D.

9.2.4.1.2 Safety Evaluation

Potable water is not essential for the normal operation or the safe shutdown of the nuclear reactors. An adequate supply is important, however, to operate emergency eyewash and shower equipment, to wash contaminated clothing, to provide drinking water, and to carry away human waste. Interruptions in supply are minimized by storage in the two tanks in the Turbine Building.

The potable water system is not cross-connected with any radioactive system. Contamination protection is by the air gap normal to plumbing fixtures. Backflow preventers and vacuum breakers are provided throughout the plant to protect the potable water system from contamination due to backflow from contaminating sources. A reduced pressure backflow preventer is also installed in the main supply line to the plant to prevent any possible onsite contamination of the system from spreading offsite.

9.2.4.1.3 Tests and Inspections

All parts of the potable water systems are tested and inspected for leaks. Fixtures are accessible for inspection during normal operation.

When repairs or additions are made, potable water quality and treatment is monitored in accordance with the requirements of the Tennessee Department of Public Health.

9.2.4.1.4 Instrumentation Applications

Water level in the two storage tanks is controlled by a flow control valve operated by level switches. Level switches also actuate a local alarm.

Potable water flow entering the nuclear plant site is recorded by a conventional water meter.

9.2.4.2 Sanitary Water System

9.2.4.2.1 Design Bases

The maximum quantity of sanitary waste to be handled, treated, and disposed of is approximately 120,000 gallons per day. The average for normal operation is approximately 100,000 gallons per day. These quantities differ from potable water usage quantities because some potable water drains to other systems. See Sections 9.2.4.2.2 and 9.2.4.2.3.

Sanitary waste is treated in an extended aeration sewage treatment plant with a total treatment capacity of 120,000 gallons per day. The plant location is fairly remote from the powerhouse. Treated effluent is routed to the runoff holding pond and eventually discharged to the river.

9.2.4.2.2 System Description

Sanitary waste is collected in individual sanitary waste systems for those buildings which have sanitary facilities and conveyed into the plant yard sewage system, except as noted below and in Section 9.2.4.2.3.

The environmental data station, located far from the main plant, has its own septic tank and drain field.

In general, for building sanitary waste systems, the embedded lines and fittings are extra heavy cast-iron soil pipe, bell and spigot with neoprene gaskets. Exposed lines are galvanized steel and the fittings are the black cast-iron drainage type. Vent lines are galvanized steel and fittings are galvanized malleable iron.

The sanitary waste from most buildings flows by gravity into the yard sewage system. Some buildings, which have sanitary facilities on the lower levels, also have sewage ejectors.

The Turbine Building sanitary waste lines are run to the lower floor, which is below grade, collected in a sewage basin system that contains duplex grinder pumps and pumped to the yard system.

The Service Building sanitary waste is collected and pumped by a similar system.

Control Building sanitary waste lines flow by gravity to the Service Building sewage basin system.

The yard sewage system consists of a number of buried gravity flow and pressurized sewers, a number of lift stations and a sewage treatment plant. Gravity flow sewers are provided with precast manholes.

Gravity flow sewers are normally of cast-iron soil pipe, vitrified clay, or polyvinyl chloride (PVC) construction. Pressurized sewers are PVC.

A lift station unit is provided in the yard at the Diesel Generator Building, consisting of a collection basin, two grinder pumps and associated controls.

Similar units are provided at the additional makeup water treatment plant and for the field services facility. These are duplex units with centrifugal sewage pumps located in a concrete basin. A lift station is also provided in the yard near the Office Building to deliver the sanitary waste to the treatment plant. The lift station has a concrete basin and two sets of duplex pumps to send the waste to a connection in the construction sewer system. From there, the waste flows by gravity to the sewage treatment plant.

Waste routed to the sewage treatment plant passes through a comminutor and into a lift station containing duplex alternating centrifugal sewage pumps. The waste is lifted into an equalization tank which provides storage during periods of high flow. Duplex alternating grinder pumps feed the sewage at a fairly slow even rate to the aeration units (four 30,000 gallon per day units).

Effluent from the aeration units passes through a chlorine contact tank and into a ditch which leads to the runoff holding pond.

9.2.4.2.3 Safety Evaluation

The sanitary water system does not receive radioactive waste. Drainage from other plumbing equipment with the potential of receiving radioactive waste is as follows:

(a) AUXILIARY BUILDING:

Radiochemical Laboratory

(1) Fume hood cup sink drains to the tritiated drain collector tank (TDCT).

(2) Hospital-type sink and an eyewash drain to the laundry tank.

(3) Fume hood cup sinks and one counter cup sink drain to the chemical drain tank.

(4) Counter sinks drain to the floor drain collector tank (FDCT).

Titration Room

(1) Fume hood cup sink drains to the chemical drain tank.

(2) Counter sink drains to the FDCT.

(3) Counter sinks drain to the Turbine Building station sump.

Hot Instrument Shop

(1) Sink drains to the chemical drain tank.

125 V Vital Battery Rooms, 1-4

(1) Sinks and eyewashes drain to the Turbine Building station sump.

(b) SERVICE BUILDING

Health Physics Laboratory

(1) Counter sink drains to the laundry and hot shower tank.

Personnel Decontamination Room

(1) The hot shower drains to the laundry and hot shower tank.

Instrument Shop

(1) Counter sinks and one service sink drain to the laundry and hot shower tank.

Hot Shop Area

(1) Emergency shower drains to the FDCT tank in the Auxiliary Building.

(2) One decontamination shower and one sink drain to the laundry and hot shower tank.

Details of these drains and tanks are discussed in Section 9.3.3.

9.2.4.2.4 Tests And Inspections

Chlorinated effluent will be monitored in accordance with the requirements of the NPDES Permit.

9.2.4.2.5 Instrumentation Applications

A float-operated switch on each sewage pump in the plant will start the pump and force accumulated sewage into the yard sewer system.

An air bubbler control arrangement is provided for the field services facility lift station and the sewage treatment plant lift station and equalization tank pumps.

The grinder pump lift stations in the yard have integral float or pressure switch control and alarm systems.

The grinder pumps in the equalization tank are provided with an hour meter which allows the calculation of approximate total flow through the sewage treatment plant.

9.2.5 Ultimate Heat Sink

9.2.5.1 General Description

The ultimate heat sink (subsequently referred to as 'sink') for a nuclear plant is that complex of water sources and associated retaining structures used to remove waste heat from the plant during all normal, shutdown, and accident plant conditions. The sink is designed to perform one principal safety function throughout the plant's life: dissipation of residual heat after an accident.

The sink is comprised of a single water source, the Tennessee River, including the complex of TVA-controlled dams upstream of the plant intake, TVA's Chickamauga Dam (the nearest downstream dam), and the plant intake channel.

In normal operation, cooling water (approximately 85°F maximum) will flow from Chickamauga Reservoir through the plant intake channel to the intake pumping station. The intake channel is located on the inside of a bend in the river about 2 miles downstream of Watts Bar Dam. The intake channel extends about 800 feet from the edge of the reservoir through the flood plain along a line approximately perpendicular to the river flow, with the bottom at sufficient depth to ensure direct flow from the main river channel to the pumping station during all low water levels. A floating pontoon type structure is provided across the channel to serve as a barrier and discourage direct approach to the pumping station from the reservoir. The barrier is designed to make it virtually impossible to sink; however, if it were to sink, it could not block the channel to the extent of preventing the required flow from reaching the station.

Water is pumped to the plant by the essential raw cooling water (ERCW) and raw cooling water pumps (described in Sections 9.2.1 and 9.2.8, respectively), and in certain events, the fire protection pumps housed in the Seismic Category I intake pumping station. The station design will assure protection of the safety-related ERCW pumps and fire protection pumps from the design basis flood. The ERCW pumps and fire protection pumps are capable of functioning under any plant design basis condition including a SSE plus loss of downstream dam and a LOCA. The ERCW system description and performance capabilities are discussed in detail in Section 9.2.1.

9.2.5.2 Design Bases

The sink for Watts Bar Nuclear Plant is designed to comply with the following regulatory positions in Regulatory Guide 1.27, Revision 1, March, 1974.

(1) The ultimate heat sink is capable of providing sufficient cooling for at least 30 days (a) to permit simultaneous safe shutdown and cooldown of all nuclear reactor units and maintain them in a safe shutdown condition, and (b) in the event of an accident in one unit, to limit the effects of that accident safely, to permit simultaneous and safe shutdown of the remaining unit, and maintain them in a safe shutdown condition. Procedures for assuring a continued capability after 30 days are available.

(2) The ultimate heat sink is capable of withstanding, without loss of the capability specified in regulatory position 1 above, the effects of (a) the most severe natural phenomena associated with this location taken individually, (b) the site related events that historically have occurred or that may occur during the plant lifetime, (c) reasonably probable combinations of less severe natural phenomena and/or site related events, and (d) a single failure of man-made structural features.

(3) The ultimate heat sink consists of one source of water, with the capability to perform the safety functions specified in regulatory position 1, above. It can be demonstrated that there is an extremely low probability of losing the capability of the single source. There is one canal connecting the source with the intake structures of the nuclear power units. It can be demonstrated that there is an extremely low probability that the single canal can fail entirely as a result of natural phenomena. The water source and associated canal are highly reliable and can be protected such that a complete failure cannot happen.

(4) The Technical Specifications for the plant include actions to be taken in the event that conditions threaten partial loss of the capability of the ultimate heat sink or it temporarily does not satisfy regulatory positions 1 and 3, above, during operation.

9.2.5.3 Safety Evaluation

This safety evaluation is sectionalized to correspond with the points of the preceding regulatory positions.

(1) The cooling water requirements for the most demanding accident shutdown and cooldown of the plant's reactors are presented in Section 9.2.1. The adequacy of the Tennessee River to provide this amount of water, and therefore to satisfy regulatory position 1, is confirmed in Sections 2.4.11.1, 2.4.11.3, and 2.4.11.5.

(2) Under the most adverse events expected at the site or a reasonable combination of less severe events and any single failure of a man-made feature, the sink is designed to retain its capability to perform the specified safety functions. The most severe natural phenomena (including flood, drought, tornado, wind, and earthquake) that might conceivably occur at this site are thoroughly discussed in Chapter 2.

As stated previously, the ERCW pumps are protected from the design basis flood including the effects of wind waves, and therefore will be capable of functioning in all flood conditions up to and including the design basis flood. The intake channel extends from the pumping station into the reservoir to the original river bed and is dredged down to Elevation 660 to provide free access to the river under low flow conditions described in Section 2.4.11. Both the normally exposed and submerged portions of the channel are dredged to sufficient width, riprapped on the sides, and seismically qualified (as discussed in Section 2.5) to eliminate the possibility of channel blockage due to an earth or mud slide. The channel will be monitored and dredged as required to maintain free access to the river. Therefore, adequate water will be available to the ERCW pumps at all times and for all events including the loss of downstream dam for any reason. Since the intake channel is seismically qualified, the unlikely occurrence of the SSE could significantly affect the sink only by causing failure of the non-Category I downstream dam and/or upstream dams. For the resulting low and/or high reservoir event, water will be available to the intake at all times. A seismically induced disturbance of the rock surfaces could only block a small percentage of the intake channel due to its high conservative width.

A tornado cannot disrupt the ERCW water supply to the intake station.

Protection of the intake channel and station against blockage or impact by river traffic is afforded by its location. For all conditions of river navigation (up to water level 698 which corresponds to the 40 year flood level in Watts Bar Dam tailwaters at which lock operation ceases), the grade elevation of the river flood plain through which the channel passes is such that even when the flood plain is submerged, sufficient depth will not exist for passage of any major river vessel. In addition, due to the close proximity of the upstream dam, the possibility of a barge being accidentally released upstream and reaching the plant site would be extremely remote. However, if such an incident does occur, the barge will be carried away from and past the intake channel and station by the high velocity water passing the plant on the outside of the river bend on the opposite side of the reservoir.

For lake levels which would provide sufficient water depth for a barge to approach the intake station, it is not considered credible that serious damage would be incurred. The intake station would be in relatively stagnant, shallow water approximately 800 feet from the main river channel, and would be a relatively small target.

TVA regulation of the Tennessee River is such that drought will not jeopardize the sink's capability required in regulatory position 1; this is historically confirmed by the data in Section 2.4.11.3.

The most severe combination of events considered credible to occur would be the simultaneous occurrence of a loss-of-coolant accident in one unit and hot standby of the other, loss of offsite power, and loss of upstream and/or downstream dams either individually or concurrently. Under this extreme situation, the sink retains the capability required by regulatory position 1.

Section 9.2.1.3 states that the ERCW system provides the required flow to remove the design basis heat load necessary to maintain the plant in a safe condition. Section 2.4.11.3 shows that the minimum available flow from the Tennessee River will be well in excess of this requirement.

(3) The Tennessee River is the common supply for all plant cooling water requirements. Total interruption of this supply is incredible. Additionally, the integrity of the river's dams is not essential for safe reactor shutdown and

cooldown. While only a single channel is provided to convey water from the river to the intake station, total failure is considered incredible due to the location, maintenance, and seismic qualification of the channel.

(4) The limiting conditions and surveillance requirements for the ERCW system are given in the Technical Specifications. The limiting conditions for the plant's flood protection program are also stated in the Technical Specifications.

9.2.5.4 Instrumentation Application

This requirement is not applicable to the ultimate heat sink at WBNP.

9.2.6 Condensate Storage Facilities

The condensate storage facilities store and supply treated water for:

(1) initial charging of the secondary system,

(2) makeup water,

(3) replacement of water lost by safety valve or relief valve operation, and (4) the preferred source of an adequate quantity of feed quality water for emergency cooling (auxiliary feedwater system).

9.2.6.1 Design Bases

The condensate storage facilities are designed to serve as a receiver of water from the main condenser high level dump and to provide treated water for makeup to the main condenser while reserving a minimum amount for the auxiliary feedwater system. This amount is required to hold the plant for two hours at hot standby, then cool down the reactor coolant system at 50°F per hour to the point at which the residual heat removal system can take over.

The condensate storage tanks are not an engineered safety feature and are not seismically qualified. They supply the preferred source of water to the auxiliary feedwater system, but the engineered safety feature source is the essential raw cooling water system (Safety Class 2b).

9.2.6.2 System Description

The condensate facility, shown in Figure 9.2-31, consists of one condensate transfer pump and two condensate storage tanks connected in parallel (one tank for each unit) and all associated piping, controls, and instrumentation. The tanks are located in the plant yard adjacent to the east wall of the Turbine Building.

The auxiliary feedwater pumps take suction directly from the condensate storage tanks to supply treated water for cooldown of the reactor coolant system. A minimum of 200,000 gallons in each tank is reserved for the auxiliary feedwater system. This quantity is assured by means of standpipes through which other systems are supplied.

Makeup to the condenser is supplied by gravity flow from the tanks while reject water from the condenser flows to the tanks through the hotwell pumps. Makeup of deareated and demineralized water to the condensate storage tanks is from the water treatment plant. The tanks are equipped with a level control system which will indicate the tank volumes at all times.

The condensate storage tanks are constructed from ASTM A283 Grade C carbon steel plate to AWWA Standard D100. The inside has a coating of epoxy-phenolic resin to prevent corrosion. Each tank has a capacity of 385,000 gallons with an overflow at 395,000 gallons.

Air removal (nitrogen purging) connections have been added to each of the condensate storage tanks. Low pressure nitrogen is introduced into the bottom of each condensate storage tanks through a multinozzled distribution header. The nitrogen is bubbled through the stored condensate and then is released to the atmosphere. Through this process dissolved oxygen content of the condensate storage tank water is reduced to and maintained at acceptable levels during periods of time when water in the tank is not exchanged with water in the steam cycle.

The condensate transfer pump (CTP) is an electric motor driven pump rated to discharge 1000 gpm at 55 feet total head. During preoperational testing, the CTP did not deliver 1000 gpm at 55 ft. head. The CTP did deliver 850 gpm at a head sufficient to overcome static head in the CST, and this is acceptable. The main purpose of the condensate transfer pump is for the transfer of water from one tank to the other.

9.2.6.3 Safety Evaluation

The condensate storage tanks are the preferred source of clean water supply for the auxiliary feedwater pumps and a storage reservoir for secondary system water. The tanks are not an engineered safety feature. The engineered safety feature water source for the auxiliary feedwater system is the essential raw cooling water system (Safety Class 2b). Either tank is isolable, but auxiliary feedwater can be obtained from both tanks. This will be done only if necessary since each condensate storage tank normally contains auxiliary feedwater for just one unit.

The essential raw cooling water system pool quality feedwater will be used during an extreme emergency when safety is the prime consideration and steam generator cleanliness is of secondary importance.

All piping connected to the condensate storage tanks is conducted through a heated tunnel under the tanks. Ice formation in the tanks during a period of prolonged low temperatures can be prevented, if necessary, by recirculation of water through the condensate transfer pump. The tank and its connecting piping can accommodate water whose temperature is in the range of 40°F to 120°F.

The water in the condensate storage tanks is not normally radioactive. However, in the event of primary-to-secondary leakage due to a steam generator tube leak, it is possible for the condensate and feedwater system to become radioactively contaminated. The water in the condensate storage tanks can become contaminated by reject water from the main condenser in situations where the secondary system is contaminated. The maximum level of contamination in the tanks can be conservatively estimated to be comparable to that of the main condenser. (Section 10.4.1)

Each condensate storage tank has an overflow level at 395,000 gallons. The overflow lines terminate beside the tanks just above ground level. A tank overflow or rupture would allow the water to be drained to the Turbine Building sump or to the river by way of the holding pond. The radiological consequences of this are less than other postulated accidents discussed in Chapter 15.

Tank repairs necessitated by damage or leaks can be made after closing tank isolation valves in the interconnecting headers, and transferring water from the defective tank to the other storage tank using the condensate transfer pump. Excess water can be drained to waste through normally locked closed tank drain valves which lead to the yard drainage system.

9.2.6.4 Test and Inspections

The condensate storage tanks are tested during the preoperational test program for both the condensate system and the auxiliary feedwater system. Periodic visual inspections are performed in accordance with plant procedure to ensure integrity of the tank.

Preoperational test requirements are given in Chapter 14.

9.2.6.5 Instrument Applications

The level in each storage tank is indicated on Units 1 and 2 main control boards and on a local panel in the area of the transfer pump. These level signals are received from electronic level transmitters which provide the signals for the annunciation in the main control room of low-low CST tank water level. Each tank is also equipped with side mounted displacement type level switches which provide signals for annunciation in the main control room of high-low CST tank water levels. The set points for these switches are set to alarm at points that are different from the low-low setpoint of the electronic level transmitter. Therefore, the electronic transmitter low-low setpoint is a backup for the displacement switch low level setpoint. Continuous tank level indication is provided locally at each tank.

9.2.7 Refueling Water Storage Tank

The refueling water storage tank (RWST) fulfills two basic requirements:

(1) It provides an adequate supply of borated water (boron concentration of minimum 2000 ppm) for use during refueling operations.

(2) It provides an adequate supply of borated water (boron concentration of minimum 2000 ppm) to the two charging pumps (CVCS), the two safety injection system (SIS) pumps, the two residual heat removal (RHR) pumps, and the two containment spray (CSS) pumps in the event of a loss-of-coolant accident (LOCA). During normal power operation, RWST water is valved to

the suction of the SIS pumps, RHR pumps, and the CSS pumps. The suction of the CVCS pumps is automatically valved to the RWST by a safety injection signal.

The following criteria are used to fulfill the above requirements; the size of the RWST is sufficient to contain the largest of the following:

(a) The amount of water required to fill the refueling cavity and fuel transfer tubes (350,000 gallons).

(b) The amount of water, in addition to that in the SIS accumulator tanks, RCS inventory, and ice melt, necessary to establish the emergency cooling recirculation mode following a LOCA (i.e., the depth of water provided in the Reactor Building will be sufficient to provide free flow to the containment sump and to provide adequate suction head for the CVCS, SIS, RHR, and CSS pumps), including holdup or unavailable water (reactor cavity, containment atmosphere, water remaining in the RWST).

(c) The amount of water necessary to supply the CVCS, SIS, RHR, and CSS for a period of time (10 minutes or more) sufficient to allow the operator to properly assess the situation and establish the recirculation mode following a LOCA.

The design parameters of the RWST are as follows:

Quantity	1
Design pressure	atmospheric
Normal operating pressure	atmospheric
Tank design temperature	200°F
Operating temperature, EF (water-min)	60
Volume, gal (to overflow)	380,000
Minimum operating volume, gal	370,000
Boron concentration, ppm (nominal)	2,050
Outside diameter, ft	43-1/2
Straight Side height, ft	36
Material of construction	Austenitic stainless steel
Number of heaters	4
Capacity of each heater, kW	12

The RWST instrumentation is discussed in Chapter 7. Overflow routing is discussed in Section 11.2.

The vent at the top of the RWST is 28" in diameter and is fabricated from 1/4" thick type 304 stainless steel. The rain hood is fabricated from 3/16" thick 304 stainless steel. A protective screen having 3/4" openings and an effective area almost three times the cross sectional area of the 28" vent stack is fitted over windows near the top of the 28" stack but beneath and inside the rain hood. This screen guards against intrusion of foreign objects, yet is sufficiently open to minimize vent plugging by ice buildup. Additionally, to prevent freezing, the exterior surfaces of the vent stack and rain hood will be insulated with 3" of external grade insulation, suitably supported. Since the vent is located at the top of the RWST, and is approximately 36 feet from ground level, it is clear of normal debris (plastic sheets, paper, etc.), but further assurance is afforded by the shielding of the screen by the rain hood, and the large screen area.

The RWST's vortex nozzle assemblies were not radiographed. ASME Section III, Subsection NC, paragraph NC-5282.6 (1974 Edition, and Winter 1975 Addenda) requires butt joints in atmospheric storage tanks be fully radiographed.

TVA has issued CAQR's WBP890317 and WBP890318, for Units 1 & 2, respectively, for documentation of the problem. Calculation WBP-MTB-001 documents the basis for the acceptability of these welds.

9.2.7.1 ECCS Pumps Net Positive Suction Head (NPSH)

The straight side height of the RWST is 36 feet, and the overflow pipe inlet is 411 inches above the bottom of the tank, which is at Elevation 729.08. The inside diameter is 43.45 feet, with a capacity of 925 gal/in of depth. The normal fill is 375,000 gallons. The minimum operating level is 370,000 gallons. Makeup will be made should the level drop to the minimum operating level. Further emergency condition data is tabulated below:

Pump	Pump Centerline Elevation, ft	Minimum Water Level Used in NPSH Analysis
RHRS	678.59	0"
CVCS	695.92	0"
SIS	694.60	0"
CSS	679.00	0"

Using the minimum RWST volume of 370,000 gallons at the start of ECCS pumping, sufficient water will have been pumped into the Reactor Building in just over 10 minutes (maximum flowrates), to cause the low level auto switchover alarm to be actuated signaling the switchover sequencing. The switchover sequence from injection to recirculation mode is completed in accordance with Table 6.3-3.

The RHR pumps are automatically aligned to the containment sump. The ECCS and CS pumps have injected approximately 224,000 gallons of water into the Reactor Building at this time. The low-low level alarm is actuated after approximately 320,000 gallons have been injected, signaling the operator to shut off the CSS pumps. These are the last pumps to be shut down after all pumps have been switched to recirculation modes.

Analysis of RHR and containment spray pump NPSH considers the effects of the sump with its screens and all associated suction piping and valves. Assumptions made in the analysis are conservative and include:

(1) water temperature, 190°F

(2) normal containment atmospheric pressure

(3) all pumps operating at maximum rated flow and

(4) Containment sump level at containment floor elevation.

The screens were assumed to consist of circular orifices with only 50% open area and the pressure loss was calculated using Darcy's equation. Pipe, fittings, valves and entrance losses were calculated for the maximum loss paths by use of L/D equivalent from Crane: Flow of Fluid.

Based on the above, the ECCS and CSS pumps NPSH data is tabulated in Table 9.2-3.

All of the ECCS pumps will be preoperationally tested under conditions that simulate limiting design basis conditions. Where accident limits can be more extreme than test conditions, calculations and/or extrapolations are made from the test data to show that the system performance will be satisfactory under accident conditions. For instance, all ECCS pumps are to be started and operated at maximum possible flow from the RWST into an open reactor vessel. Suction pressure data is taken and then corrected to reflect any difference between the level in the RSWT at the point where data is taken and the lowest level to exist in the tank under accident conditions. This number is then compared to required NPSH conditions to assure that acceptable margin exists. The containment spray pumps are also run during this test to determine their effect on the NPSH conditions at the ECCS pumps.

To verify acceptable discharge piping losses, each ECCS pump will be run individually at its maximum flow into an open reactor vessel. The safety injection and centrifugal charging pump flows will be limited and balanced through the use of manual valves in the injection lines going to the separate reactor coolant loops. Hence, these discharge line losses are set during the preoperational tests. The RHR pump discharge line losses are determined entirely by the installed piping system. The ECCS pump flowrates achieved during preoperational testing were evaluated to determine actual system resistance and the system resistance was confirmed to be acceptable.

All of the ECCS pumps are determined to be running in conformance with manufacturers test curves for total developed head. Test points for total developed head are also compared and determined to exceed the performance curves assumed in the ECCS analysis.

A 1:4 scale model study which demonstrates the acceptability of the revised sump, sump screen, and trash rack design has been performed. The report of the model study, and an NPSH evaluation were submitted by letter from J. E. Gilleland to S. A.

Varga, dated May 23, 1979. Additional detail, including a comparison of the final sump design with the provisions of Regulatory Guide 1.82, is provided in Section 6.3.2.

9.2.8 Raw Cooling Water System

9.2.8.1 Design Bases

The raw cooling water (RCW) system is designed to achieve the following objectives:

(1) Provide cooling water to the turbine-generator auxiliary equipment and miscellaneous cooling equipment within the Turbine Building.

(2) Serve as primary nonqualified source of cooling water for the ice condenser system.

(3) Provide cooling water to nonessential air conditioning equipment within the Auxiliary Building.

(4) Serve as a source for filling and maintaining pressurization of the raw service water (RSW) system.

(5) Serve as a source of makeup water to the condenser circulating water system.

(6) Provide raw water makeup to water treatment plant.

9.2.8.2 System Description

The flow, logic and control diagrams for this system are shown on Figures 9.2-32 through 9.2-39.

The RCW system is a non-safety related, shared system. Water is supplied by seven electric motor driven pumps located in the plant intake pumping station. The design data for these pumps is given in Table 9.2-12. Six of the pumps are capable of meeting the maximum normal system flow requirements and the seventh serves as an installed spare.

Water is supplied to the Turbine Building through two sectional legs of a single loop header. In the Turbine Building, the water is filtered to 1/32-inch particle size by four automatic backwashing strainers common to both units. Each strainer is designed to handle 1/3 of the maximum normal flow of both units.

After being strained, the water is directed to two loop headers within the Turbine Building, one for each unit. Water is then distributed from each loop header to the following equipment within the Turbine Building:

(1) Generator stator heat exchangers

(2) Generator hydrogen heat exchangers

(3) Generator exciter heat exchangers

(4) Generator main bus heat exchangers

(5) Generator seal oil heat exchanger

(6) Main turbine oil heat exchanges

(7) Turbine electro-hydraulic control fluid heat exchangers

(8) Feedwater pump turbine oil heat exchanger

(9) Condenser vacuum pump coolers

(10) Condensate booster pump heat exchangers

(11) No. 3 and No. 7 heater drain tank pump heat exchangers

(12) Turbine Building ventilation coolers

(13) Sample heat exchangers

(14) Standby main feedwater pump heat exchanger

(15) Heat exchangers 90-120 for radiation monitoring

(16) Auxiliary Boiler System Blowdown Tank

(17) Condensate Demineralizer Air Compressor

In addition, the system supplies raw water upon demand to the raw service water system and makeup to the water treatment plant from either unit.

The raw service water (RSW) system supplies water requirements for various air-conditioning loads and for maintenance, cleaning, and other miscellaneous, intermittent purposes throughout the Turbine, Service, and Office Buildings and plant yard. Refer to Figures 9.5-1 through 9.5-12 for the flow diagram showing the RSW system.

The RCW discharge from the heat exchangers and coolers located in the Turbine Building, with the exception of the sample heat exchangers which discharge to plant drainage, is directed to the cold water outlet flume of the condenser circulating water (CCW) cooling tower corresponding to the same unit. However, the Unit 1 RCW flow can be discharged into either the Unit 1 CCW cold water outlet flume, or the Unit 2 CCW cold water outlet flume to allow work to be performed on the CCW system while still maintaining RCW flow. As described in Section 10.4.5 this RCW discharge serves as a portion of the makeup water to the CCW system. A siphon break is provided on the RCW discharge of each unit to prevent flooding of the powerhouse by backflow of water from the CCW system in the event of a rupture of the RCW header rupture within the buildings.

Since the flow through major components within the RCW system is varied by temperature control valves which monitor the process side temperature in order to maintain a constant temperature of the cooled systems, the total system flow is decreased in the winter when the river temperature decreases. Subsequently, fewer than six pumps operate and less flow is available for CCW cooling tower makeup water. Therefore, to enable the RCW system to be utilized to the fullest extent as a makeup source to the CCW system, a bypass line with modulating valve is provided from the RCW supply to RCW discharge headers. This line permits that portion of the RCW system flow in excess of the RCW component requirements to bypass the Turbine Building and serve as additional makeup water to the CCW system on demand.

A connection to the Turbine Building loop header of both units provides a nonessential source of water to various equipment within the Auxiliary and Additional Equipment Buildings. This equipment includes the following:

(1) Auxiliary Building general ventilation system and coolers (nonsafety- related equipment)

(2) Additional Equipment Building ventilation coolers (for nonsafety-related equipment)

(3) Ice condenser system heat exchangers

(4) Post-operational chemical cleaning equipment

Since the RCW system is not designed to remain operational for a flood level in excess of plant grade (Elevation 728.0), provisions are made in the Auxiliary Building for an intertie with the essential raw cooling water (ERCW) supply which is to be installed as part of the plant flood preparations (refer to Sections 2.4.14 and 9.2.1) in order to supply flow to the ice condenser system heat exchangers. The flow through the ice condenser system is always discharged to the holding pond, whether supplied from RCW or ERCW. The ERCW intertie is used in flood conditions to maintain a cooling water supply to the ice machine refrigeration condensers. Refer to Section 6.7 for a detailed description of the ice condenser system.

For control of organic fouling, including slime and Asiatic clam infestation, see Section 9.2.1.6. Strainers in the supply headers and periodic backflushing of the strainers curtail large clams from entering the plant. Chemical treatment of the RCW is necessary during the clam spawning season to control Asiatic clam growth, which is approximately May to October.

9.2.8.3 Safety Evaluation

Since this system has no safety-related functions, it is not required to be designed to remain operable through an earthquake, tornado, flood-above- plant-grade, or other such natural phenomena. The RCW system is designed such that none of its components can adversely affect the function of any safety-related system.

Within the intake pumping station, the RCW pumps and piping are located in a completely separate area from any safety-related equipment. The RCW piping in the electrical equipment room is supported to the extent required to prevent falling on safety-related cables and cable trays (pressure boundary integrity is not required).

The RCW system piping within the Auxiliary and Additional Equipment Buildings is seismically qualified (Seismic Category I(L)) to the extent required to ensure that a safe shutdown earthquake in combination with normal operating conditions will not cause flooding, water impingement, or damage due to falling on safety related equipment. This degree of seismic qualification is accomplished by supporting the piping in all areas so as to prevent its falling. In areas where safety-related equipment is located, either further support is provided to ensure the integrity of the RCW piping pressure boundary, or the safety-related equipment is sealed or shielded from water spray.

An isolation valve is provided in the seismically qualified portion of the RCW supply line from the Turbine Building to the Auxiliary Building. This prevents the loss of water from the ERCW system to the nonqualified portion of the RCW system whenever the flood mode intertie to the ERCW system is made.

9.2.8.4 Tests and Inspection

The RCW system is hydrostatically or in-service leak tested and performance tested prior to plant operation to ensure adequacy of the system to meet the operational requirements. Once the plant is operational, routine visual inspection of all the system components is sufficient to verify functionability.

Table 9.2-1 ESSENTIAL RAW COOLING WATER SYSTEM PUMP DESIGN DATA

Essential Raw Cooling Water Pumps	
Quantity	8
Type	Vertical, wet pit centrifugal type
Rated capacity, gpm (each)	11,800

Table 9.2-1 ESSENTIAL RAW COOLING WATER SYSTEM PUMP DESIGN DATA

Rated head, ft	210 (See Note 1)
Motor horsepower, hp (each)	800
Submergence required, ft	5.75
Submergence available (minimum), ft	12.07
Screen Wash Pumps	
Quantity	4
Type	Vertical turbine
Rated capacity, gpm (each)	270
Rated head, ft	350
Motor horsepower, hp (each)	40
NPSH required, ft	10.35
NPSH available (minimum), ft	42.35
Traveling Water Screens	
Quantity	4
Motor Horsepower, hp (each)	3

Note:

1. During the performance of the Preop test program, ERCW pump performance did not match the original performance curves supplied by the vendor. Reanalysis of the ERCW System flow requirements determined that the ERCW Pumps could perform at 72% of the original vendor supplied performance curve and still meet the ERCW System design requirements for Unit 1 only operation. Therefore, the performance of the ERCW Pumps has been determined to be acceptable for Unit 1 only operation.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 1 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
1.	ERCW PumpsA-A B-A C-A D-A E-B F-B G-B H-B	Operate.	Any one pump either fails to start or stops operating.	Electrical or mechanical failure.	Status lights 0-HS-67-28A, 32A, 36A, 40A, 47A, 51A, 55A, 59A, respectively, and low header pressure alarms 0-PA-67-18 and 17 for Trains A and B, respectively.	None. Any two of four pumps on either Train A or Train B are capable of providing full ERCW flow.	None.	
2.	Screen Wash Pumps 1A-A 2A-A 1B-B 2B-B	Operate.	Any one either fails to start or stops operating.	Electrical or mechanical failure.	Status lights 1-HS-67-431a, 2-HS-67-437A, 1-HS-67-440A, 2-HS-67-447A, respectively.	None. Any one of the two screens for either Train A or Train B intakes is capable of screening full ERCW flow.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 2 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
3.	Traveling Water Screen 1A-A 1B-B 2A-A 2B-B	Operate. Start automatically on high pressure in wash line.	Any one either fails to start or stops operating.	Electrical or mechanical failure.	Motor indication 1-XI-67-434, 445, 2-XI-67-439, 451, respectively.	None. Any one of the two screens on either train A or Train B intake is capable of screening full ERCW flow.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 3 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
4.	ERCW Pump Disch Check Valves 0-67-503A 0-67-503B 0-67-503C 0-67-503D 0-67-503E 0-67-503F 0-67-503G 0-67-503H	Open to provide flow path when respective pump starts.	Fails to open.	Mechanically stuck closed.	High pressure alarms 0-PA-67-29, 33, 37, 41, 48, 52, 56, 60, respectively.	None. Any other two of the remaining three pumps in the affected train or any two of the four pumps in the other train can be started.	None.	
		Close to prevent backflow when respective pump stops.	Fails to close.	Mechanically stuck open.	Low flow alarms 1,2-FA-67-61 for Headers 1A,2A respectively and low pressure alarm 0-PA-67-18 for Train A manifold. Low flow alarms 1,2-FA-67-62, for Headers 1B,2B, respectively and low pressure alarm 0-PA-67-17 for Train B manifold.	None. Respective pump train discharge valves 1,2-FCV-67-22 in Train A or 1,2-FCV-67-24 in Train B can be closed to isolate affected pump train from supply headers and supply ERCW from other pump train.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 4 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
5.	ERCW Pump Disch Hdr Butterfly Valves. 1-FCV-67-22 1-FCV-67-24 2-FCV-67-22 2-FCV-67-24	ERCW flow path to headers 1A, 1B, 2A, 2B, respectively.	Any one of four closes.	Inadvertent actuation or mechanical failure.	Low flow alarms 1-FA-67-61, 62 2-FA-67-61, 62, respectively.	None. Three of four headers are available to ensure either headers !A and 2A or headers 1B and 2B will be in service to meet all plant require-ments.	None.	Administratively locked in open position with breakers open.
6.	DG 1A-A Clr Inlet B'fly Valves 1-FCV-67-66 1-FCV-67-68	ERCW supply flow path from headers 1A and 2B, respectively.	1-FCV-67-66 fails to remain open, or 1-FCV-67-68 fails to open on demand.	Electrical or me-chanical failure Inadvertent actua-tion or mechanical failure.	Status lights 1-HS-67-68A	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve.	None.	1-FCV-67-66 is administratively locked open with breaker open.
7.	DG 2A-A Clr Inlet B'fly Valves 2-FCV-67-66 2-FCV-67-68	ERCW supply flow path from headers 1A and 2B, respectively.	2-FCV-67-66 fails to remain open, or 2-FCV-67-68 fails to open on demand. .	Electrical or me-chanical failure. Inadvertent actua-tion or mechanical failure	Status lights 2-HS-67-68A	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve.	None.	2-FCV-67-66 is administratively locked open with breaker open.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 5 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
8.	DG 1B-B Clr Inlet B'fly Valves 1-FCV-67-67 1-FCV-67-65	ERCW supply flow path from headers 1B and 2A, respectively	1-FCV-67-67 fails to remain open, or 1-FCV-67-65 fails to open on demand.	Electrical or me-chanical failure Inadvertent actua-tion or mechanical failure.	Status lights 1-HS-67-65A	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve.	None.	1-FCV-67-67 is administartively locked open with breaker open.
9	DG 2B-B Clr Inlet B'fly Valves 2-FCV-67-67 2-FCV-67-65	ERCW supply flow path from headers 1B and 2A, respectively.	2-FCV-67-67 fails to remain open, or 2-FCV-67-65 fails to open on demand.	Electrical or me-chanical failure. Inadvertent actua-tion or mechanical failure.	Status lights 2-HS-67-65A	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve.	None.	2-FCV-67-67 is administratively locked open with breaker open.
10.	ADG Clr Inlet B'fly Valves 1-FCV-67-72 2-FCV-67-73	ERCW supply flow path from headers 2A/2B and 1A/2B re-spectively.	Either one of two fails to open or recloses.	Electrical or me-chanical failure. Inadvertent actua-tion or mechanical failure.	Status lights 1-HS-67-72A, 2-HS-67-73A, respectively.	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 6 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
11.	DG 1A-A Clr Inlet Check Valves 1-67-508A 1-67-513A	ERCW supply flow path from header 1A and 2B, respectively, backflow protection.	Either one of two fails to open. or fails to close on reverse flow.	Mechanical failure or stuck closed. Mechanical fail-ures or stuck open.	No direct MCR in-dications available.	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve. None. Normally closed valves 1-FCV-67-66, 68, respectively, prevents backflow.	None.	
12.	DG 2A-A Clr Inlet Check Valves 2-67-508A 2-67-513A	ERCW supply flow path from header 1A and 2B, respectively, backflow protection.	Either one of two fails to open or fails to close on reverse flow	Mechanical failure or stuck closed. Mechanical fail-ures or stuck open.	No direct MCR in-dications available.	None. Each valve provides full flow capacity. Flow supplied via unaffected valve. None. Normally closed valves 2-FCV-67-66, 68, respectively, prevents backflow.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 7 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
13.	DG 1B-B Clr Inlet Check Valves 1-67-508B 1-67-513B	ERCW supply flow path from header 1B and 2A, respectively, backflow protection.	Either one of two fails to open. or fails to close on reverse flow.	Mechanical failure or stuck open.	No direct MCR indications available.	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve. None. Normally closed valves 1-FCV-67-67, 65, respectively, prevents backflow.	None.	
14.	DG 2B-B Clr Inlet Check Valves 2-67-508-B 2-67-513-B	ERCW supply flow path from header 1B and 2A, respectively, backflow protection.	Either one of two fails to open. or Fails to close on reverse flow.	Mechanical failure or stuck closed. Mechanical failure or stuck open.	No direct MCR indications available.	None. Each valve provides full flow capacity. ERCW supplied via unaffected valve. None. Normally closed valves 2-FCV-67-67, 65, respectively, prevents backflow.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 8 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
15.	ADG Clr Check Supply Valves 0-67-508-A 0-67-508-B 0-67-513-A 0-67-513-B	ERCW supply flow path from header 2A, 2B, 1A and 1B, respectively, backflow protection.	Any one of four fails to open or Fails to close on reverse flow	Mechanical failure or stuck closed. Mechanical failure or stuck open.	No direct MCR indications available	None. Each valve provides full flow capacity. ERCW supplied from any one of the unafected valves. None. Normally closed valves 1-FCV-67-72, 2-FCV-67-73 provide backup backflow for 508, 513 check valves, respectively.	None.	
16.	ADG Clr Outlet Check Valves 0-67-517A 0-67-512A	ERCW return flow path to header A and B, respectively, back flow protection.	Either one of two fails to open. or Fails to close on reverse flow.	Mechanical failure or stuck closed. Mechanical failure or stuck open.	No direct MCR indications available.	None. Each valve provides full flow capacity. ERCW return via unaffected valve. None. Check valves 0-67-508A, B and 0-67-513A, B will stop backflow.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 9 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
17.	Screen Wash Prop Disch Check Valves 1-67-940A 2-67-935B	Pump 1A-A and 2B-B discharge flow path to screens 1A-A and 2B-B, re-spectively, backflow protection when cross connect is open.	Either one of two fails to open. or Fails to close on reverse flow.	Mechanical failure or stuck closed. Mechanical failure or stuck open.	Pump ON indicated by position of hand switch 1, 2-HS-67-431A, 447, respec-tively, and screen mo-tors NOT ON by status indicating light 1, 2-XI-61-434, 451, respectively, indicates pressure switch 1, 2-PS-67-434, 451, respectively, did not reach setpoint and allow screen motor to run. No direct MCR in-dications available.	None. Pumps 2A-A and 1B-B and screens 2A-A and 1B-B, respectively, provide full capacity backup.	None.	
18.	Main Discharge Hdr A, B B'fly Valves FCV-67-360 FCV-67-362	ERCW to Cooling Tower 2 and 1 basin isolation, respectively.	Either one of two fails to close or reopens.	Electrical or mechanical failure. Inadvertent actuation or electrical failure.	Status Lights 0-HS-67-360A, 362A, respectively.	None. Alternate route to emergency pond thru overflow weir is always open without any obstruction for water discharge.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 10 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
19.	ERCW Pump Discharge Strainers 1 A-A 1 B-B 2 A-A 2 B-B	Operate.	Any one of four fails to start or stops operating.	Electrical or mechanical failure.	High differential pressure alarms 1-PDA-67-9, 10, 2-PDA-67-9, 10, respectively.	None. Both strainers on either Train A or B pump discharges are capable of full ERCW flow capacity. Shut down affected header and operate on other train.	None.	
20.	Screen Wash Pump 1 B-B, 2 B-B, 1A-A, 2 A-A Prelube Check Valves 1-67-934B 2-67-934B 1-67-938A 2-67-938A	Open to provide flow path to flush pump bearings. Close to prevent backflow.	Any one of four fails to open. or Fails to close on reverse flow.	Mechanical failure or stuck closed. Mechanical failure or stuck open.	No direct MCR indications available.	None. Either one of two pump and screen sets in each train is capable of screening full ERCW flow. None. Shut down pump with failed valve and operate other pump/screen set in train.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 11 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
21.	Deleted by Amendment 89							
22.	ERCW Pump Prelube Check Valves 0-67-507A 0-67-507B 0-67-507C 0-67-507D 0-67-507E 0-67-507F 0-67-507G 0-67-507H	Open to provide flush path to flush bearings of pumps A-A, B-A, C-A, D-A, E-B, F-B, G-B, H-B, respectively, to prolong life of the bearings and stuffing box.	Any one of eight fails to open. or Any one of eight fails to close on reverse flow.	Mechanical failure or stuck closed. Mechanical failure or stuck open.	High bearing temp logs T3110A and T3111A for A and C, T3112A and T3113A for B and D, T3114A and 3115A for E and G, T3116A and T3117A for F and H. No direct MCR indications available.	None. Operate pumps on unaffected train. None. Operate pumps on unaffected train.	None. None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 12 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
23.	ERCW Vac Brkr (Air Release Valves) 0-67-502A 0-67-502B 0-67-502C 0-67-502D 0-67-502E 0-67-502F 0-67-502G 0-67-502H	Close when Pumps A-A, B-A, C-A, D-A, E-B, F-B, G-B, H-B, respectively, are started and air is evacuated from pump discharge column. Open when respective pump is stopped to break vacuum in column.	Any one of eight valves fails to close. Any one of eight valves fails to open.	Mechanical failure or stuck open. Mechanical failure or stuck closed.	No direct MCR indications available.	None. Two of four pumps on each Train A or B can furnish full ERCW flow. None. Two of four pumps in each Train A or B can furnish full ERCW flow.	None. None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 13 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
24.	Stainer Flush Valves 1-FCV-67-9B 2-FCV-67-9B 1-FCV-67-10B 2-FCV-67-10B	Cycle intermit-tently to provide ERCW flow to flush stainer 1A-A, 2A-A, 1B-B, 2B-B, respectively.	Any one of four fails to operate correctly.	Electrical or me-chanical failure.	High differential pressure alarms 1, 2-PDA-67-9, 1, 2-PDA-67-10, respectively.	None. Respective strainer will clog reducing flow to Header 1A, 2A, 1B, 2B, respectively. Either one of two header sets of 1A and 2A or 1B and 2B above can furnish full ERCW flow.	None.	
25.	Strainer Backwash Valves 1-FCV-67-9A 2-FCV-67-9A 1-FCV-67-10A 2-FCV-67-10A	Cycle intermi-tently to provide ERCW flow to backwash strainer 1A-A, 2A-A, 1B-B, 2B-B, respec-tively.	Any one of four fails to operate correctly.	Electrical or me-chanical failure.	High differential pressure alarms 1, 2-PDA-67-9 1, 2-PDA-67-10, respectively.	None. Respective strainer will clog reducing ERCW flow to Header 1A, 2A, 1B, 2B, respective-ly. Either one of two header sets of 1A and 2A or 1B and 2B alone can furnish full ERCW flow.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 14 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
26.	Aux. Bldg. Supply Header Section Valves 1-FCV-67-81 1-FCV-67-82 2-FCV-67-81 2-FCV-67-82	ERCW supply flow path to Aux. Bldg. for headers 1A, 1B, 2A, 2B, respectively.	Any one of four fails closed.	Mechanical failure.	No direct MCR indication available. See remarks.	None. Interrupt ERCW supply to Aux. Bldg. via respect-ive header. Either one of two header sets of 1A and 2A or 1B and 2B can furnish full ERCW flow.	None.	Administratively locked in open position with breaker open.
27.	Header 1B and 2A Section Valves 1-FCV-67-223 2-FCV-67-223	Remain open to provide flow to CCS HX A.	Either one of two fails closed.	Mechanical failure.	Flow indicator 2-FI-67-222.	None. ERCW header 2B still supplies redundant CCS HX C.	None.	Administratively locked in open position with breaker open.
28.	CCS HX A Inlet B'fly 1-FCV-67-478	Remain open for ERCW flow path.	Fails closed.	Mechanical failure.	Flow indicator 2-FI-67-222.	Interrupts flow to HX. ERCW flow provided to redundant CCS HX C by Train B via Header 2B.	None. CCS HX C provides 100% backup service.	Administratively locked in open position with breaker open.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 15 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
29.	CCS HX A Outlet B'fly and Bypass 1-FCV-67-146 1-FCV-67-143	Remain closed, or open to two intermediate positions or full open if not using 1-FCV-67-143 modulate, respectively, to control ERCW flow through HX. See remarks.	Either one does not operate properly.	Electrical or mechanical failure.	Flow indicator 1-FI-67-222.	Depending on failure position of valves, disrupts system balance or interrupts proper flow to HX. ERCW flow provided to redundant CCS HX C by Train B via Header 2B.	None. CCS HX C provides 100% backup service.	Both valves do not simultaneously operate. Valve 1-FCV-67-146 is normally closed with power removal.
30.	CCS HX B Outlet B'fly and Bypass 2-FCV-67-146	Remains closed.	None. See remarks.	Not applicable.	Not applicable.	None.	None. CCS HX B serves Unit 2 only.	Administratively locked in closed position with breaker open.
	2-FCV-67-143	None. See remarks.	Not applicable. See remarks.	Not applicable.	Not applicable.	None.	None.	This valve serves Unit 2 only.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 16 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
31.	CCS HX C Inlet Bfly's 1-FCV-67-147 2-FCV-67-147	(1) isolates Header 1A from 2B. (2) provides ERCW flow path from Header B.	None for (1). See remarks. (2) fails closed.	Not applicable. Mechanical failure due to disc-stem slip.	Not applicable. Flow indicator 1-FI-67-226.	Not applicable. None.	Not applicable. None. CCS HX A provides 100% service.	Administratively locked in closed and open position, respectively, with breakers open.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 17 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
32.	CCS HX C Outlet Bfly's and Bypass							
	0-PCV-67-152	Opens to low flow position to provide ERCW discharge.	None. See remarks.	Not applicable.	Not applicable.	None.	None.	CCS HX C is back-up for CCS HX A. A failure related to HX A precludes a second failure related to HX C.
	0-FCV-67-151	None for 151.	None. See remarks.	Not applicable.	Not applicable.	None.	None.	Administratively locked in closed position with breaker open.
	0-PCV-67-144	None for 144.	None. See remarks.	Not applicable	Not applicable	None. See remarks.	None.	Used during normal operation. During DBE does not affect ERCW safety function.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS
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Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
33.	CSS HX 1A, 1B Inlet Bfly's 1-FCV-67-125 1-FCV-67-123	Open to provide ERCW flow.	Either one fails to open. or Recloses.	Electrical or mechanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-125A, 123A, respectively, and flow indicators 1-FI-67-136, 122, respectively.	None.	None. Only one of two HXs required for safe shutdown.	
34.	CCS HX 1A, 1B Outlet Bfly's 1-FCV-67-126 1-FCV-67-124	Open to provide ERCW flow.	Either one fails to open. or Recloses	Electrical or me-chanical failure. Electrical or me-chanical failure or inadvertent actuation.	Status lights 1-HS-67-126A, 124A, respectively, and flow indicators 1-FI-67-136, 122, respectively.	None.	None. Only one of two HXs required for safe shutdown.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 19 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
35.	Shutdown BD RM A/C Wtr Chiller A-A, B-B Inlet 1-TCV-67-158 2-TCV-67-158	Remain open to provide ERCW flow to Chillers A-A, B-B, respectively.	Either one of two fails closed.	Electrical or me-chanical failure or inadvertent actuation.	No direct MCR indication available.	None.	None. Either one of two chillers provides 100% cooling.	
36.	Train 1A, 2A A/C Equip and Service Air Compressor Supply B'fly 1-FCV-67-127 2-FCV-67-127	Remain open to provide ERCW flow to Train 1A and 2A A/C equipment and SA compressor, respectively.	Either one of two fails closed.	Mechanical failure by disc stem slippage.	No direct MCR ind-ication available.	None.	None. Either one of two trains 1A or 1B provides 100% cooling. Unit 2 equipment not required for Unit 1.	Administratively locked in open position with breaker open.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 20 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
37.	Train 1B, 2B A/C Equip and Service Air Compressor Supply B'fly 1-FCV-67-128 2-FCV-67-128	Remain open to provide ERCW flow to Train 1B and 2B A/C equipment and SA compressor, respectively.	Either one of two fails closed.	Mechanical failure by disc stem slippage.	No direct MCR indication available.	None.	None. Either one of two trains 1A or 1B provides 100% cooling. Unit 2 equipment not required for Unit 1.	Administratively locked in open position with breaker open.
38.	Instr Rm Wtr Chlrs 1A & 1B Inlet 1-TCV-67-115 1-TCV-67-118	Modulate to provide ERCW flow to Chillers 1A, 1B, respectively.	Fails closed	Electrical or me-chanical failure or inadvertent actuation.	No direct MCR indication available.	None. Either one of two coolers provides 100% service.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 21 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
39.	Upper Containment Vent Clrs 1A, 1C, 1B, 1D Supply Control Valves 1-TCV-67-129 1-TCV-67-132 1-TCV-67-137 1-TCV-67-140	Piping system integrity.	Not applicable. See remarks.	Not applicable.	Status lights 1-ZS-67-129, 132, 137, 140, respectively.	None.	None.	ERCW flow to containment will be isolated.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 22 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
40.	Upper Containment Vent Clrs 1A, 1C, 1B, 1D Supply Cont Isol Valves 1-FCV-67-130 (Penet X-69) 1-FCV-67-133 (Penet X-75) 1-FCV-67-138 (Penet X-74) 1-FCV-67-141 (Penet X-68)	Close for containment isolation.	Fails to close or Reopens	Mechanical or electrical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-130, 133, 138, 141, respectively.	None. Check valves 580A, 580C, 580B, 580D, respectively, provide containment isolation backup.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 23 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
41.	Upper Containment Vent Clrs 1A, 1C, 1B & 1D Supply Cont Iso Check Valves 1-67-580A (Penet X-69) 1-67-580C (Penet X-75) 1-67-580B (Penet X-74) 1-67-580D (Penet X-68)	Close to provide containment isolation backup for valves 1-FCV-67-130, 133, 138, 141, respectively.	Any one of four fails to close.	Mechanical failure or stuck open.	No direct MCR indication available.	None. Containment isolation valves fulfill containment isolation function.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS
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Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
42.	Upper Containment Vent Coolers 1A, 1C, 1B, 1D Return Inboard Cont Iso Valves 1-FCV-67-295 (Penet X-73) 1-FCV-67-296 (Penet X-71) 1-FCV-67-297 (Penet X-70) 1-FCV-67-298 (Penet X-72)	Close for containment isolation.	Any one of four fails to close. or Reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-295A, 296A, 297A, 298A, respectively.	None. Outboard containment isolation valves 1-FCV-67-131, 134, 139, 142, respect-ively, provide backup isolation.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 25 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
43.	Upper Containment Vent Clrs 1A, 1C, 1B & 1D Return Pressure Relief Cont Iso Check Valves 1-67-585A (Penet X-73) 1-67-585C (Penet X-71) 1-67-585B (Penet X-70) 1-67-585D (Penet X-72)	Close to provide containment isolation backup for valves 1-FCV-67-131, 134, 139, 142, respectively.	Any one of four fails to close. See remarks.	Mechanical failure or stuck open.	No direct MCR indication available.	None. Respective containment isolation valves fulfill isolation function.	None.	Primary function is thermal pressure relief of liquid trapped between isolation valves. Failure to open is not considered credible.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 26 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
44.	Upper Containment Vent Clr 1A, 1C, 1B, 1D Return Outboard Cont Iso Valves 1-FCV-67-131 (Penet X-73) 1-FCV-67-134 (Penet X-71) 1-FCV-67-139 (Penet X-70) 1-FCV-67-142 (Penet X-72)	Close for containment isolation.	Any one of four fails to close. or reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-131A, 134A, 139A, 142A, respectively.	None. Inboard containment isolation valves 1-FCV-67-295, 296, 297, 298 and check valves 585A, 585C, 585B, 585D, respectively, provide backup isolation.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 27 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
45.	Lower Containment Vent Clr 1A, 1C, 1B, 1D Supply Outboard Cont Iso Valves 1-FCV-67-83 (Penet X-58A) 1-FCV-67-91 (Penet X-62A) 1-FCV-67-99 (Penet X-60A) 1-FCV-67-107 (Penet X-56A)	Close for containment isolation.	Any one of four fails to close. or reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-83A, 91A, 99A, 107A, respectively.	None. Check Valves 562A, 562C, 562B, 562D, respectively, provide isolation backup.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 28 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
46.	Lower Containment Vent Clr 1A, 1C, 1B, 1D Supply Inboard Cont Iso Valves 1-FCV-67-89 (Penet X-58A) 1-FCV-67-97 (Penet X-62A) 1-FCV-67-105 (Penet X-60A) 1-FCV-67-113 (Penet X-56A)	Close for containment isolation.	Any one of four fails to close. or reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-89A, 97A, 105A, 113A, respectively.	None. Valves 1-FCV-67-83, 91, 99, 107, respectively, provide backup isolation function.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS
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Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
47.	Lower Containment Vent Clr 1A, 1C, 1B, 1D Supply Pressure Relief Cont Iso Valves 1-67-1054A 1-67-1054C 1-67-1054B 1-67-1054D	Close to provide backup containment isolation for valves 1-FCV-67-83, 91, 99, 107, respectively. See remarks.	Anyone of four fails to close.	Mechanical failure or stuck open.	No direct MCR indication available.	None. Respective containment isolation valve will fulfill isolation function.	None.	Primary function is thermal pressure relief of liquid trapped between isolation valves. Failure to open is not considered credible.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 30 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
48.	Lower Containment Vent Clrs 1A, 1C, 1B, 1D Temperature Control Valves 1-TCV-67-84 1-TCV-67-92 1-TCV-67-100 1-TCV-67-108	None.	Not applicable.	Not applicable.	Not applicable.	None.	None.	These valves are isolated from ERCW flow by containment isolation valves.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 31 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
49	RC Pump Motor 1, 3, 2, 4 Clrs Temperature Control Valves 1-TCV-67-86 1-TCV-67-94 1-TCV-67-102 1-TCV-67-110	None	Not applicable	Not applicable	Not applicable	None	None	These valves are isolated from ERCW flow by containment isolation valves.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 32 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
50.	Control Rod Drive Units 1A, 1C, 1B, 1D Temperature Control Valves 1-TCV-67-85 1-TCV-67-93 1-TCV-67-101 1-TCV-67-109	None.	Not applicable.	Not applicable.	Not applicable.	None.	None.	These valves are isolated from ERCW flow by containment isolation valves.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 33 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
51.	Lower Containment Vent Clrs 1A, 1C, 1B, 1D Check Valves 1-67-565A 1-67-565C 1-67-565B 1-67-565D	None.	Not applicable.	Not applicable.	Not applicable.	None.	None.	These valves are isolated from ERCW flow by containment isolation valves.
52.	RC Pump Motor 1, 3, 2, 4 Clrs Check Valves 1-67-571A 1-67-571C 1-67-571B 1-67-571D	None.	Not applicable.	Not applicable.	Not applicable.	None.	None.	These valves are isolated from ERCW flow by containment isolation valves.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 34 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection		Effect on System	Effect on Plant	Remarks
53.	Control Rod Drive Vent Clrs 1A, 1C, 1B, 1D Check Valves 1-67-568A 1-67-568C 1-67-568B 1-67-568D	None.	Not applicable.	Not applicable.	Not applicabl e.		None.	None.	These valves are isolated from ERCW flow by containment isolation valves.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS
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Item	Component	Function	Failure Mode	Potential Cause	Method of Detection		Effect on System	Effect on Plant	Remarks
54.	Lower Containment Vent Clrs 1A, 1C, 1B, 1D Return Inboard Cont Iso Valves 1-FCV-67-87 (Penet X-59A) 1-FCV-67-95 (Penet X-63A) 1-FCV-67-103 (Penet X-61A) 1-FCV-67-111 (Penet X-57A)	Close for containment isolation.	Any one of four fails to close. or reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-87A, 95A, 103A, 111A, respectively.		None. Valves 1-FCV-67-88, 96, 104, 112, respectively, provide backup isolation function.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 36 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
55.	Lower Containment Vent Clrs 1A, 1C, 1B, 1D Return Pressure Relief Cont Iso Check Valves 575A (Penet X-59A) 575C (Penet X-63A) 575B (Penet X-61A) 575D (Penet X-57A)	Close for containment isolation backup for valves 1-FCV-67-88, 96, 104, 112, respectively.	Any one of four fails open.	Mechanical failure or stuck open.	No direct MCR indication available.	None. Containment isolation valves fulfill isolation function.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 37 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
56.	Lower Containment Vent Clrs 1A, 1C, 1B, 1D Return Outboard Cont Iso Valves 1-FCV-67-88 (Penet X-59A) 1-FCV-67-96 (Penet X-63A) 1-FCV-67-104 (Penet X-61A) 1-FCV-67-112 (Penet X-57A)	Close for containment isolation.	Any one of four fails to close. or reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-HS-67-88A, 96A, 104A, 112A, respectively.	None. Inboard containment isolation valves 1-FCV-67-87, 95, 103, 111 and check valves 575A, 575C, 575B, 575D, respectively, provide backup isolation.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 38 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
57.	Spent Fuel Pit Pump & TB Booster Pump Space Clr 1A, 1B Supply Valves 1-FCV-67-213 1-FCV-67-215	Open for ERCW flow to Coolers 1A, 1B, respectively.	Either one of two fails to open. or either one of two recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-213A, 215A, respectively. No indication for disc-stem connection failure. None.		None. Either one of two coolers provides 100% service.	
58.	CCS Pump & Aux FW Pump Space Clr 1A, 1B Supply Valves 1-FCV-67-162 1-FCV-67-164	Open for ERCW flow to Coolers 1A, 1B, respectively.	Either one of two fails to open or either one of two recloses	Electrical or me-chanical failure Mechanical failure or inadvertent actuation	Status lights 1-ZS-67-162A, 164A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provides 100% service.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 39 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
59.	Centrif Charging Pump Rm Clr 1A, 1B Supply Valves 1-FCV-67-168 1-FCV-67-170	ERCW flow to Coolers 1A, 1B, respectively.	Either one of two closes.	Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-168A, 170A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provides 100% service.	
60.	Recip Charging Pump Rm Clr 1C Supply Valves 1-FCV-67-172	None.	None. See remarks.	Not applicable.	Not applicable.	None.	None.	During DBE does not effect ERCW safety function.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 40 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
61.	SIS Pump RM Clr 1A, 1B Supply Valves 1-FCV-67-176 1-FCV-67-182	Open for ERCW flow to Coolers 1A, 1B, respectively.	Either one of two fails to open. or Either one of two recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-176A, 182A, respectively. No indication for disc-stem connection failure	None.	None. Either one of two coolers provide 100% service.	
62.	CS Pump Rm Clr 1A-A, 1B-B Supply Valves 1-FCV-67-184 1-FCV-67-186	Open for ERCW flow to Coolers 1A, 1B, respectively.	Either one of two fails to open. or Either one of two recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-184A, 186A, respectively. No indication for disc-stem connection failure	None.	None. Either one of two coolers provide 100% service.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 41 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
63.	RHR Pump Rm Clr 1A-A, 1B-B Supply Valves 1-FCV-67-188 1-FCV-67-190	ERCW flow path to Coolers 1A-A, 1B-B, respectively.	Either one of two closes.	Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-188A, 190A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provide 100% service.	
64.	Penet Rm Elev 692 ft Crs 1A1, 1B1 Supply Valves 1-FCV-67-346 1-FCV-67-348	Open for ERCW flow to Coolers 1A1, 1B1, respectively.	Either one of two fails to open. or Either one of two recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-346A, 348A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provide 100% service.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 42 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
65.	Penet Rm Elev 713 ft Clrs 1A2, 1B2 Supply Valves 1-FCV-67-350 1-FCV-67-352	Open for ERCW flow to Coolers 1A2, 1B2, respectively.	Either one of two fails to open. or Either one of two recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-350A, 352A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provides 100% service.	
66.	Penet Rm Elev 737 ft Clrs 1A3, 1B3, 2A3, 2B3 Supply Valves 1-FCV-67-354 1-FCV-67-356 2-FCV-67-354 2-FCV-67-356	Open for ERCW flow to Coolers 1A3, 1B3, 2A3, 2B3, respectively.	Either one of four fails to open. or Either one of four recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-354A, 356A, 2-ZS-67-354A, 356A, respectively. No indication for disc-stem connection failure.	None.	None. Either pair of coolers 1A3 and 2A3 or 1B3 and 2B3 provide 100% service.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 43 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
67.	Pipe Chase Clr 1A, 1B Supply Valves 1-FCV-67-342 1-FCV-67-344	Open for ERCW flow to Coolers 1A, 1B, respectively.	Either one of two fails to open. or Either one of two recloses.	Electrical or me-chanical failure Mechanical failure or inadvertent actuation	Status lights 1-ZS-67-342A, 344A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provides 100% required capacity.	
68.	Emerg Gas treatment Rm Clr 2A, 2B Supply Valves 2-FCV-67-336 2-FCV-67-338	Open for ERCW flow to Coolers 2A, 2B, respectively.	Either one of two fails to open or Either one of two recloses.	Electrical or me-chanical failure Mechanical failure or inadvertent actuation	Status lights 1-ZS-67-336A, 338A, respectively. No indication for disc-stem connection failure.	None.	None. Either one of two coolers provides 100% required capacity.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 44 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
69.	BA Transf Pump & Aux FW Pump Space Clr 2A, 2B Supply Valves 2-FCV-67-217 2-FCV-67-219	Open for ERCW flow to Coolers 2A, 2B, respectively.	Either one of two fails to open. or Either one of two recloses.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 1-ZS-67-217A, 219A, respectively. No indication for disc-stem connection failure.	None	None. Either one of two coolers provides 100% required capacity.	
70.	TB Supply Header 1A, 1B, Iso Bfly 0-FCV-67-205 0-FCV-67-208	Close on high flow and low pressure to isolate non-essential portion of ERCW system piping.	Either one of two fails to close or Either one of two reopens.	Electrical or me-chanical failure. Mechanical failure or inadvertent actuation.	Status lights 0-HS-67-205A, 208A, respectively.	None. Shut down train with failed valve. Operate other train.	None.	

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 45 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
71.	Penet Rm Clrs 2A1, 2B1, 2A2, 2B2, 2A3, 2B3, Supply Valves 2-FCV-67-346 2-FCV-67-348 2-FCV-67-350 2-FCV-67-352	None	None	Not Applicable	Not Appplicable	None	None	Unit 2 requirements not considered for Unit 1 FMEA
72.	Pipe Chase Clrs 2A, 2B Supply Valves 2-FCV-67-342 2-FCV-67-344	None	None	Not Applicable	Not Applicable	None	None	Unit 2 requirements not considered for Unit 1 FMEA

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 46 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
73.	CSS HX 2A, 2B Inlet Bfly (Unit 2) 2-FCV-67-125 2-FCV-67-123	Isolate HX 2A, 2B, respectively, from ERCW supply.	None.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Administratively locked in closed position with breakers open.
74.	CSS HX 2A, 2B Outlet Bfly (Unit 2) 2-FCV-67-126 2-FCV-67-124	Isolate HX 2A, 2B, respectively, from ERCW supply.	None.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Administratively locked in closed position with breakers open.
75.	Header 1B to CCS HX A Supply Bfly 1-FCV-67-458	Isolate ERCW header 1B from 2A.	Fails open.	Mechanical failure.	1-FI-67-222 flow indication.	Provides flow to CCS HX A. ERCW flow provided to CCS HX C via Header 2B.	None.	Administratively locked in closed position with breaker open.

Table 9.2-2 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 47 of 47)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
76.	Emergency Power to Train A, B	Provide power to Train A, B ERCW system pumps, screens, strainer motors and valve actuators, respectively.	Either one of two fails.	Diesel generator 1A-A, 1B-B, respectively, me-chanically failure or shutdown board failure.	MCR indication.	Loss of ERCW system Train A, B, respectively.	None. Other train has 100% ERCW system capability.	Only one of two Trains A or B required to mitigate DBE.
77.	Passive failure of any one piping system pressure boundary component (i.e., valve body, disc, pump casing, HX lube or shell, etc.) in either Train A or B.	Pressure boundary integrity.	Ruptures, leakage, component pressure boundary breaches, etc.	Mechanical failures.	No direct MCR indication available, however various process parameters such as temperature, pressure, flow, etc., will permit monitoring of system performance.	System capability for respective train diminished.	None. Other train has 100% ERCW system capability.	Only one of two Trains a or B required to mitigate DBE.

Table 9.2-3 AVAILABLE NPSH DURING ECCS OPERATION

Pump	Flow (gpm)	Supply	$NPSH_R$(ft)	$NPSH_A$(ft)	Margin (ft)
Injection - two of each pump in operation					
CCP 1	420	RWST	22	57.3	35.3
CCP 2	420	RWST	22	57.4	35.4
SIP 1	425	RWST	18	59.3	41.3
SIP 2	425	RWST	18	59.0	41.0
RHRP 1	2820	RWST	11	62.7	51.7
RHRP 2	2820	RWST	11	63.4	52.4
Injection - one of each pump in operation					
CCP 1	550	RWST	28	58.3	30.3
SIP 2	660	RWST	25	54.5	29.5
RHRP 1	5000	RWST	21	60.8	39.8
Recirculation with both trains operating					
RHRP 1	5000(1)	Sump	21	22.7	1.7
RHRP 2	5000(1)	Sump	21	23.3	2.3

Note: (1) A containment spray pump flow rate of 4650 gpm was assumed in the common piping section.

Table 9.2-4 Deleted by Amendment 66

Table 9.2-5 Deleted by Amendment 66

Table 9.2-6 Deleted by Amendment 66

Table 9.2-7 Deleted by Amendment 66

Table 9.2-8 COMPONENT COOLING SYSTEM COMPONENT DESIGN DATA

Component Cooling Pumps	
Quantity	5, 2 per unit, 1 shared
Type	Horizontal centrifugal
Rated capacity, gpm, each	6000 gpm*
Rated head, ft water	190*
Motor horsepower, hp	350
Casing material	Cast steel
Design pressure, psig	150
Design temperature, °F	200
Thermal Barrier Booster Pumps	
Quantity	2 (per unit)
Type	Horizontal centrifugal
Rated Capacity, gpm, each	160*
Rated head, ft water	130*
Motor horsepower, hp	10
Casing material	Cast steel (SS 316)
Design pressure, psig	200
Design temperature, °F	200
Surge Tanks	
Number	2, 1 per unit
Design presssure	
Internal, psig	33 psig
External, psig	vacuum breaker provided
Design temperature, °F	200
Total volume, gal	12,000
Normal water volume, gal	6,900 (minimum)
Fluid	Component cooling water (Demineralized Water)
Material	Carbon steel
Heat Exchangers	
Quantity	3, 1 shared, 1 per unit
Type	Shell and tube
Heat transferred, BTU/hr, each; normal operating conditionm Unit 1	64.343×10^6
Shell side (component cooling water)	
Inlet temperature, °F	109.3
Outlet temperature, °F	95.0
Flow rate, lb/hr	4.5×10^6
Design temperature, °F	200
Design pressure, psig	150
Shell material	ASME SA 516 Grade 70
Tube side (essential raw cooling water)	
Inlet temperature, °F	85
Outlet temperature, °F	95.7

Table 9.2-8 COMPONENT COOLING SYSTEM COMPONENT DESIGN DATA

Seal Leakage Collection Station	
Quantity	1 Unit w/ 2 pumps (per plant)
Pump type	Regenerative turbine (horizontal)
Rated capacity, gpm, each	10
Rated head, ft water	150
Motor horsepower, hp	1.5
Pump casing material	Cast iron
Tank capacity, gal	180
Tank material	Carbon steel
Design pressure, psig	150
Design temperature, °F	200

*During preoperational testing of the component cooling system (CCS) pumps and thermal barrier booster pumps, the pumps did not meet vendor pump performance curves. This was due mainly to the instrument inaccuracies factored into both the flow and head measurements for the data points. A review of the CCS hydraulic losses calculation has determined that even with the instrument inaccuracies factored in, the CCS pumps will still exceed the CCS hydraulic performance requirements on the pumps.

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Page 1 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
A	CONTAINMENT	ISOLATION						
A-1	1·FCY·70·85	Containment Isolation Penetraion No. X-35	Fails to close	Mechanical failure	1-NS-70-85A status lights	Single failure	None. Inside containment is a slosed system	Containment integrity is maintained. Valve is normally closed.
A-2	1-FCV-70-143	Containment Isolation Penetraion No. X-53	Fails to close	Power, supply electric or mechanical failure	1-HS-70-143A status lights	Single failure	None. Inside containment is a clsed system	Containment integrity is maintained. Valve is normally closed.
A-3	1-RFV-70-703	Relieve high pressure in ppg. to and from Excess Letdown HX inside containment due to tube leakage or failure of CVCS isolation valves	See “Effect on System” Column	Mechanical failure	None	None. Tube leakage or CVCS iso. valve failure constitutes the single failure. 1-RFV-70-703 will lift on overpressure	None	
A-4	1FCV-70-87	Containment Isolation Penetration No. X-50A	Failes to close	Power supply, electric or mechanical failure	1-HS-70-87A status lights	Single failure	Non. Isolation will be achieved by redundant valve 1-FCV-70-87	Containment integrity is maintained

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 2 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
A-5	1-FCV-70-90	Containment Isolation Penetration No. X-50A	Fails to close	Power supply, electric or mechanical failure	1-HS-70-90A status lights	Single failure	Non. Isolation will be achieved by redundant valve 1-FCV-70-87	Containment integrity is maintained
A-6	1-CKV-70-687	Containment Isolation Penetraion No. X-50A	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-90	Containment integrity is maintained
A-7	1-FCV-70-89	Containment Isolation Penetration No. X-50A	Fails to close	Power supply, electric or mechanical failure	1-HS-70-89A status lights	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-92	Containment integrity is maintained
A-8	1-FCV-70-92	Containment Isolation Penetration No. X-29	Fails to close	Power supply, electric or mechanical failure	1-HS-70-92A status lights	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-89	Containment integrity is maintained
A-9	1-CKV-70-698	Containment Isolation Penetration No. X-29	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-92	Containment integrity is maintained (See Note 1)
A-10	1-FCV-70-100	Containment Isolation Penetration No. X-52	Fails to close	Power supply, electric or mechanical failure	1-HS-70-100A status lights	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-140	Containment integrity is maintained

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 3 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
A-11	1-FCV-70-140	Containment Isolation Penetration No. X-52	Fails to close	Power supply, electric or mechanical failure	1-HS-70-140A status lights	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-100	Containment integrity is maintained
A-12	1-CKV-70-790	Containment Isolation Penetration No. X-52	Fails to close	Mechanical Power	None	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-100	Containment integrity is maintained (See Note 1)
A-13	1-FCV-70-133	Prevention of inleakage of unborated CCS water into containment	Fails to close	Power supply, electric or mechanical failure	1-HS-70-133A status lights	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-134	
A-14	1-FCV-70-134	Containment Isolation Penetration No. X-50B and prevention of inleakage of unborated CCS water into containment	Fails to close	Power supply, electric or mechanical failure	1-HS-70-134A status lights	Single failure for both functions	None. Isolation will be maintained by redundant valve 1-CKV-70-679 and inleakage prevention will be achieved by redundant valve 1-FCV-70-133	Containment integrity is maintained
A-15	1-CKV-70-679	Containment Isolation Penetration No. X-50B	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant valve 1-FCV-70-134	Containment integrity is maintained

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 4 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
B	COOLING WATER TO EQUIPMENT FOR SAFE SHUTDOWN							
B-1	1-FCV-70-153	Supply water to RHR HX 1B-B	Fails to open	Power supply, mechanical or electrical failure	1-HS-70-153A status lights 1-FA-70-155 low flow alarm	Supply to HX 1B-B is stopped	None. Redundant RHR HX 1A-A will provide heat removal capability	Safe shutdown function is achieved with one HX
B-2	1-FCV-70-156	Supply water to RHR HX 1A-A	Fails to open	Power supply, mechanical or electrical failure	1-HS-70-156A status lights 1-FA-70-158 low flow alarm	Supply to HX 1A-A is stopped	None Redundant RHR HX 1B-B will provide heat removal capability	Safe shutdown function is achieved with one HX
B-3	0-FCV-70-194	Supply water to Spent Fuel Pit HX-B	Fails to open	Power supply, mechanical or electrical failure	0-HX-70-194A status lights 0-FA-70-6 low flow alarm	Supply to HX B is stopped	None. 0-FCV-70-197 will supply water to redundant Spent Fuel Pit HX A	Safe shutdown function is achieved with one HX
B-4	0-FCV-70-197	Supply water to Spent Fuel Pit HX-A	Fails to open	Power supply, mechanical or electrical failure	0-HX-70-197A status lights 0-FA-70-20 low flow alarm	Supply to HX A is stopped	None. 0-FCV-70-194 will supply water to redundant Spent Fuel Pit HX A (See Note 2)	Safe shutdown function is achieved with one HX
C	CCS PUMP							
C-1	CCS Pump 1A-A	Supply water to Train 1A	Fails to operate	Power supply, electrical or mechanical failure	1-HS-70-46A status lights 1-PA-70-24 low hdr. press. alarm	Flow from Pump 1A-A is lost	None. Redundant CCS Pump 1B-B will start on low pressure	Safe shutdown function is achieved from redundant pump

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued)
(Page 5 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
C-2	CCS Pump 1B-B	Supply water to Train 1A	Fails to operate	Power supply, electrical or mechanical failure	1-HZ-70-38A status lights 1-PA-70-24 low hrd. press.	Flow from Pump 1B-B is lost	None. Redundant CCS Pump 1A-A will start on low pressure	Safe shutdown function is achieved from redundant pump.
C-3	CCS Pump C-S	Supply water to Train 1B	Fails to operate	Power supply, electrical or mechanical failure	1-HS-70-51A status lights	Flow from Pump C-S is lost	None. Redundant CCS Pump 1B-B can supply water to Train B.(Seen Note 3)	Safe shutdown function is achieved from redundant pump
C-4	1-CKV-70-504A	Prevent backflow to CCS Pump 1A-A when pump is not operating	Fails to close	Mechanical failure	1-PA-70-24 kjiw hdr. press alarm	Train A header pressure may be low	None. Manual isolation valve 1-ISV-505A will be closed. Pump 1B-B or C-S will continue to operate.	Safe shutdown function is not affected.
C-5	1-CKV-70-504B	Prevent backflow to CCS Pump 1B-B when pump is not operating	Fails to close	Mechanical failure	1-PA-70-24low hdr. press alarm	Train A header pressure may be low	None. Manual isolation valve 0-ISV-505B will be closed. Pump 1A-A or C-S will continue to operate.	Shutdown function is not affected.

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 6 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
C-6	1-CKV-70-504	Prevent backflow to CCS PumpC-S when pump is not operating	Fails to close	Mechanical failure	None	Train B header pressure may be low	None. Manual isolation valve 0-ISV-505 will be closed. Pump 1A-A or 1B-B will continure to operate.	Shutdown function is not affected.
D	SAFETY/NONSAFETY ISOLATION							
D-1	1-FCV-70-183	Isolate break in class 'G' ppg. to Sample HX's and Chiller on high flow differ. from 1-FE-70-215A and B and/or low Surge Tk. level at 1-LT-70-63	Fails to close	Power supply, electrical or mechanical failure	1-HS-70-183A status lights 1-LA-70-63 and low level alarm	Loss of inventory form Train 1A portion of Surge Tank	None. Train 1B portion of the Surge Tank is still intact, supporting Train B of CCS	Safe shutdown is achieved by redundant Train B.
D-2	1-FCV-70-215	Isolate break in class 'G' ppg. to Sample HX's and Chiller on signal that valve 1-FCV-70-183 has closed	Fails to close	Power supply, electrical or mechanical failure	1-LA-70-63 low level alarm	Potential loss of inventory from Train 1A portion of the Surge tank	None. Train 1B portion of the Surge Tank is still intact, supporting Train B of CCS	Safe shutdown is achieved by redundant Train B

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 7 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
D-3	0-FCV-70-206	Isolate break in class ‘G’ or ‘H’ ppg from CDWE on low level in Surge Tank at 1-LT-70-99A or 2-LT-70-99A low pressure at 0-PS-70-210	Fails to close	Power supply, electrical or mechanical failure	0-HS-70-206A status lights	Potential loss of inventory from Train 1B portion of the Surge tank	None, loss of inventory via backflow will be prevented by check valve 0-CKV-70-753	Safe shutdown function is not affected.
D-4	0-CKV-70-753	Prevent potential inventory loss via backflow to CDWE	Fails to close	Mechanical failure	None	Potential loss of inventory from Train 1B portion of the Surge tank	None, loss of inventory via backflow will be prevented by check valve 0-FCV-70-206	Safe shutdown function is not affected
D-5	0-FCV-70-207	Isolate break in class ‘G’ on ‘H’ ppg. to and from CDWE on low level in Surge Tank at 1-LT-70-99A or 2-LT-70-99A or low pressure at 0-PS-70-210	Fails to close	Power supply, electrical or mechanical failure	0-HS-70-207A status lights 1-LS-70-99 low level alarm	Potential loss of inventory from Train 1B portion of the Surge tank	None, Train 1A portion of the Surge tank is still intact, supporting Train A of CCS	Safe shutdown is achieved by redundant Train A. However, it is also possible that isolationmay be achieved by closure of 0-FCV-70-208 upon low press. from 0-PS-70-209

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 8 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
D-6	0-FCV-70-208	Isolate break in class 'G' or 'H' ppg. to CDWE on low pressure at 0-PS-70-209	Fails to close	Power supply, electrical or mechanical failure	0-HS-70-208A status lights 1-LA-70-99 low level alarm	Potential loss of inventory from Train 1B portion of the Surge tank	None, Train 1A portion of the Surge tank is still intact, supporting Train A of CCS	Safe shutdown is achieved by redundant Train A. However, isolation is also possible by closure of 0-FCV-70-207. See item D-1.
E	HIGH PRESSURE PIPING ISOLATION							
E-1	1-CKV-70-681A	Prevent backflow of high pressure RCS fluid into low pressure CCS Piping (See Note4)	Fails to close	Mechanical failure	Nove	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-682A	
E-2	1-CKV-70-682A	Prevent backflow of high pressure RCS fluid into low pressure CCS Piping (See Note4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-681A	
E-3	1-CKV-70-681B	Prevent backflow of high pressure RCS fluid into low pressure CCS Piping (See Note4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-682B	

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 9 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
E-4	1-CKV-70-682B	Prevent backflow of high pressure RCS fluid into low pressure CCS Piping (See Note4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-681B	
E-5	1-CKV-70-681C	Prevent backflow of high pressure RCS fluid into low pressure CCS Piping (See Note4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-682C	
E-6	1-CKV-70-682C	Prevent backflow of high pressure RCS fluid into low pressure CCS Piping (See Note4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-681C	
E-7	1-CKV-70-681D	Preven backflow of high pressure RCS fluid into low pressure CCS Piping (See Note 4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-682D	

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued)
(Page 10 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
E-8	1-CKV-70-682D	Prven backflow of high pressure RCS fluid into low pressure CCS Piping (See Note 4)	Fails to close	Mechanical failure	None	Single failure	None. Isolation will be achieved by redundant chack valve 1-CKV-70-681D	
F	SURGE TANK MAKE-UP							
F-1	1-LCV-70-63	Isolate Surge Tank upon demineralized water line break	Fails to close	Mechanical failure	1-HS-70-63A status lights 1-LS-70-99 high level alarm.	Single failure	None. Backflow will be prevented by valve 1-CKV-70-541	Failure to close without a Demin. Water line break occuring would result in tank overflow to LWDS which would not affect safe shutdown function
		Provide make-up to CCS Surge Tank	Fails to open	Pneumatic or mechanical failure	1-HS-70-63A status lights 1-LA-70-99 1-LA-70-63 low level alarm	Make-up to Surge Tank is lost	None, CCS Pump C-S may take suction from Train 2B portion of Unit 2 Surge Tank.	
F-2	1-CKV-70-541	Prevent backflow of water from Surge Tank	Fails to close	Mechanical failure	None	Single failure	None. Backflow will be prevented by valve 1-LCV-70-63	
G	SURGE TANK RADIATION RELEASE							

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 11 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
G-1	1-FCV-70-66	Surge Tank Vent to isolate tank when radiation detected in system	See ‘Effect on System’ column	Mechanical failure	1-HS-70-66A status lights	None. Radiation detected in system caused by tube break constitutes the single failure 1-FCV-70-66 will close on detection of radiation	None	
		Surge Tank vent to atmosphere	Fails to open	Pneumatic or mechanical failure	1-HS-70-66A status lights	Surge tank may be pressurized. However, Relief Valve 1-RFV-70-538 protects the CCS from overpressure	None	
G-2	2-FCV-70-66	Surge Tank vent to isolate tank when radiation detected in system	See ‘Effect on System’ column	Mechanical failure	2-HS-70-66A status lights	None. Radiation detectec in system caused by tube break constitutes the single failure. 2-FCV-70-66 will close on detection of radiation.	None	

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 12 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
		Surge Tank Vent to atmosphere	Fails to open	Pneumatic or mechanical failure	2-HS-70-66A status lights	Surge tank may be pressurized. However, Relief Valve 2-RFV-70-538 protects the CCS from overpressure	None	
G-3	1-RFV-70-538	Relieve overpressure in the Suge Tank	See 'Effect on System' column	Mechanical failure	None	None. Over-pressurization in system caused by tube break constitutes the singel failure. 1-RFV-70-538 will relieve over-pressure in the Surge Tank	None	

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued)
(Page 13 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
G-4	2-RFV-70-538	Relieve over-pressure in the Surge Tank	See 'Effect on System' column	Mechanical failure	None	None. Over-pressurization in system caused by tube break constitutes the singel failure. 2-RFV-70-538 will relieve over-pressure in the Surge Tank	None	
G-5	CCS Equipment Various coolers		Passive failure tube leak	Mechanical failure	High level alarm from 1-LA-70-99 or 2-LA-70-99 or 1-LA-70-63 or 2-LA-70-63	Potential radiation present in the system and/or increase in system volume	None. The Surge Tank Vent valve -- FCV-70-66 will close, preventing radiation release to atmosphere	
H	EMERGENCY FAILURE							
H-1	Emergency Power to Train A	Provide power to pump A motor and all MOV's in Train A	Fails	Diesel generator shutdown board 1A-A failure	Control room indication	CCS Train 'A' is lost	None. Two 100% capacity trains are provided	Only one train is required to mitigate accident consequences. Equipment realignments are required

Table 9.2-9 ESSENTIAL RAW COOLING WATER SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Continued) (Page 14 of 14)

Item	Component	Function	Failure Mode	Potential Cause	Method of Detection	Effect on System	Effect on Plant	Remarks
H-2	Emergency Power to Train B	Provide power to pump B motor and all MOV's in Train B	Fails	Diesel generator shutdown board 1B-B failure	Control room indication	CCS Train 'B' is lost	None. Two 100% capacity trains are provided	Only one train is required to mitigate accident consequences. Equipment realignments are required
I	PASSIVE FAILURE							
I-1	Piping System (Valve body, disc, pump casing, HX shell, etc.)		Ruptures, leakages disc separation, etc.	Mechanical failure	Various process paramerters; pressure, temperature, flow, etc.	System capability diminished	None. Two 100% capacity trains are provided.	Only one train is required to mitigate the accident consequences.
NOTE 1: Primary function of valve is to relieve pressure generated by expanding liquid trapped between isolation valves. Failure of a check valve to open is not considered to be credible.								
NOTE 2: SFP HX 'B' is normally associated with Unit #2. However, until Unit #2 is in operation, CCS flow to SFP HX 'B' will be via CCS HX 'C'. Opening of locked closed valves 2-FCV-70-195 & 196 will be required.								
NOTE 3: If CCS Pump 18-8 is used to supply water to Train B, opening of locked closed valves 1-FCV-70-26, 27, 64 & 74 and closing of locked open valve 1-FCV-70-34 will be required.								
NOTE 4: This evaluation is based on the assumption that RCP thermal barrier tube break has occured causing the high pressure RCS to pressurize the low pressure CCS.								

Table 9.2-10 Deleted by Amendment 65

Table 9.2-11 COMPONENT COOLING SYSTEM CODE REQUIREMENTS

	TVA Class [1]	Design Code
Heat exchangers	C	ASME III, Class 3
Surge Tanks	C	ASME III, Class 3
Pumps	C	ASME III, Class 3
System piping	B&C	ASME III, Class 2 and Class 3
Valves	B&C	ASME III, Class 2 and Class 3
Seal leakage return unit (Excluding Pumps)	L	Unclassified
Piping to sample heat exchangers and sample chiller package	C&G	ASME III, Class 3 and ANSI B31.1
Seal leakage return pumps	G	Manufacturer's Standards
Sample Cooler/Chiller piping and valves	G	ANSI B31.1
Condensate Demineralizer Waste Evaporator Piping and Valves	G&H	ANSI B31.1

(1) TVA classes are defined in Section 3.2

Table 9.2-12 RAW COOLING WATER SYSTEM PUMP DESIGN DATA

Number of Pumps	7
Type	Vertical Turbine
Rated Capacity (gpm)	5135

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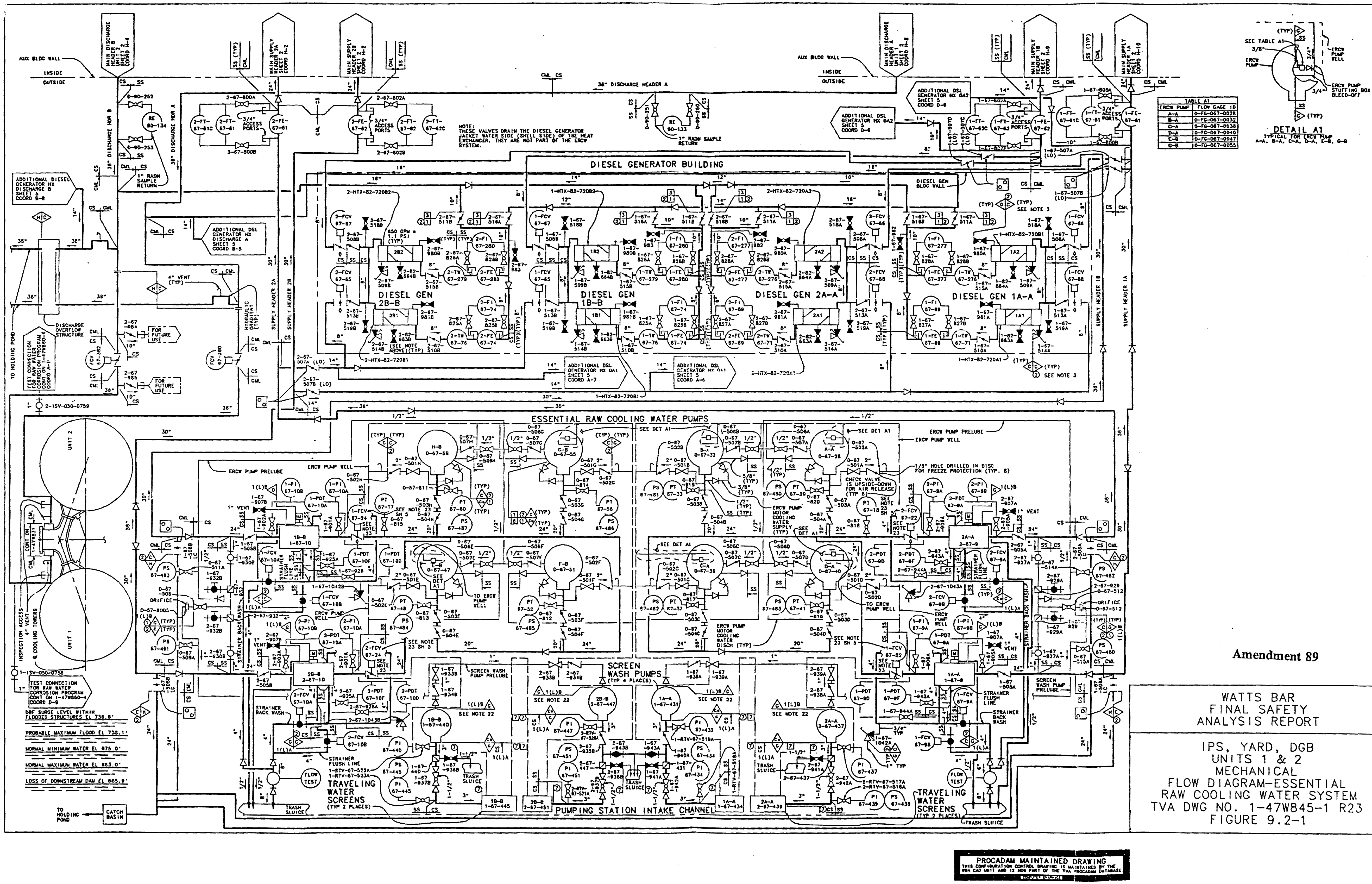

Figure 9.2-1 IPS, Yard, DGB Units 1 & 2 Flow Diagram for Essential Raw Cooling Water System Powerhouse and Auxiliary Building Flow Diagram for Essential Raw Cooling Water System

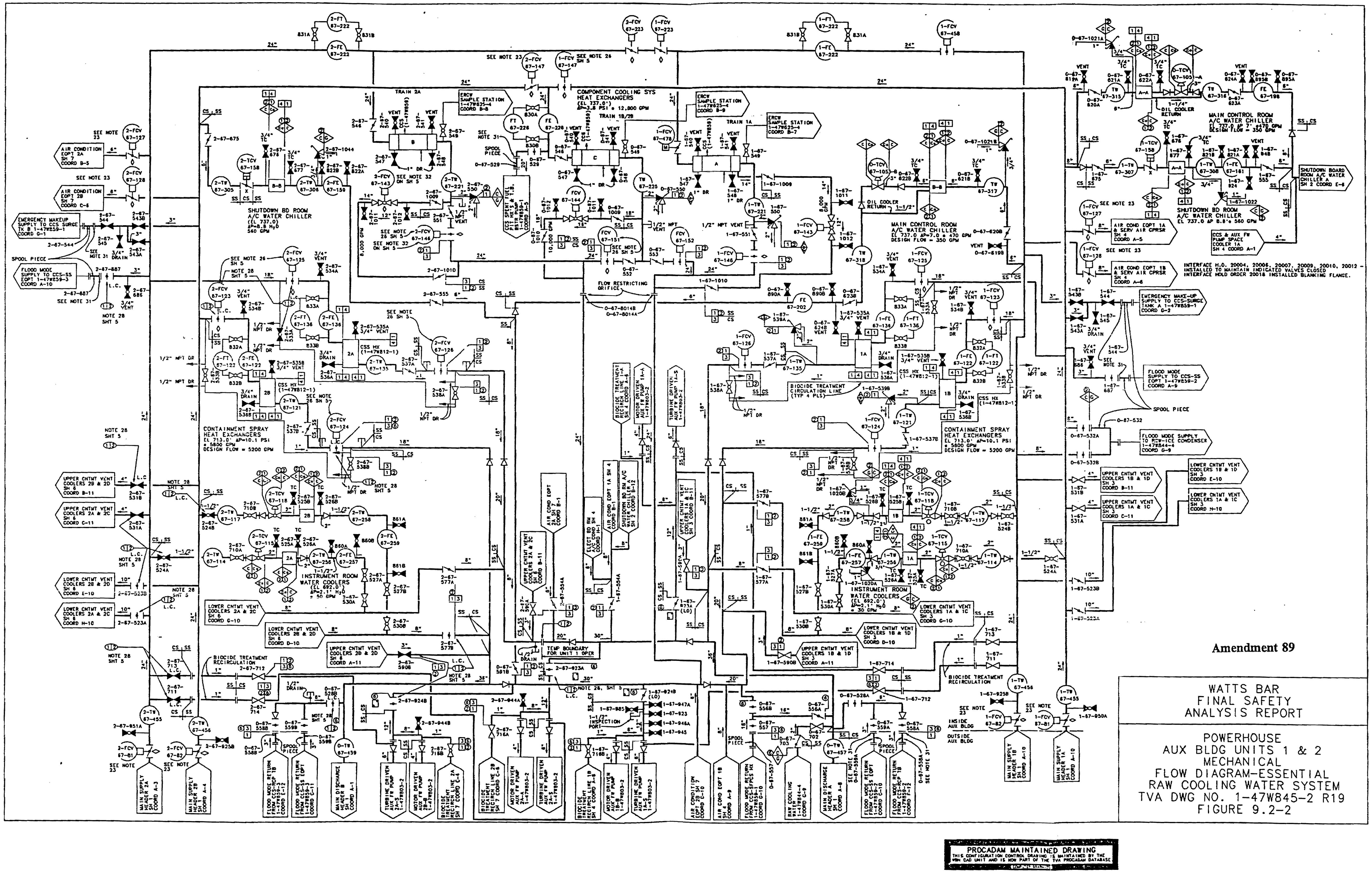

Figure 9.2-2 Powerhouse Aux Bldg Units 1 & 2 Mechanical Flow Diagram for Essential Raw Cooling Water System (Unit 1)

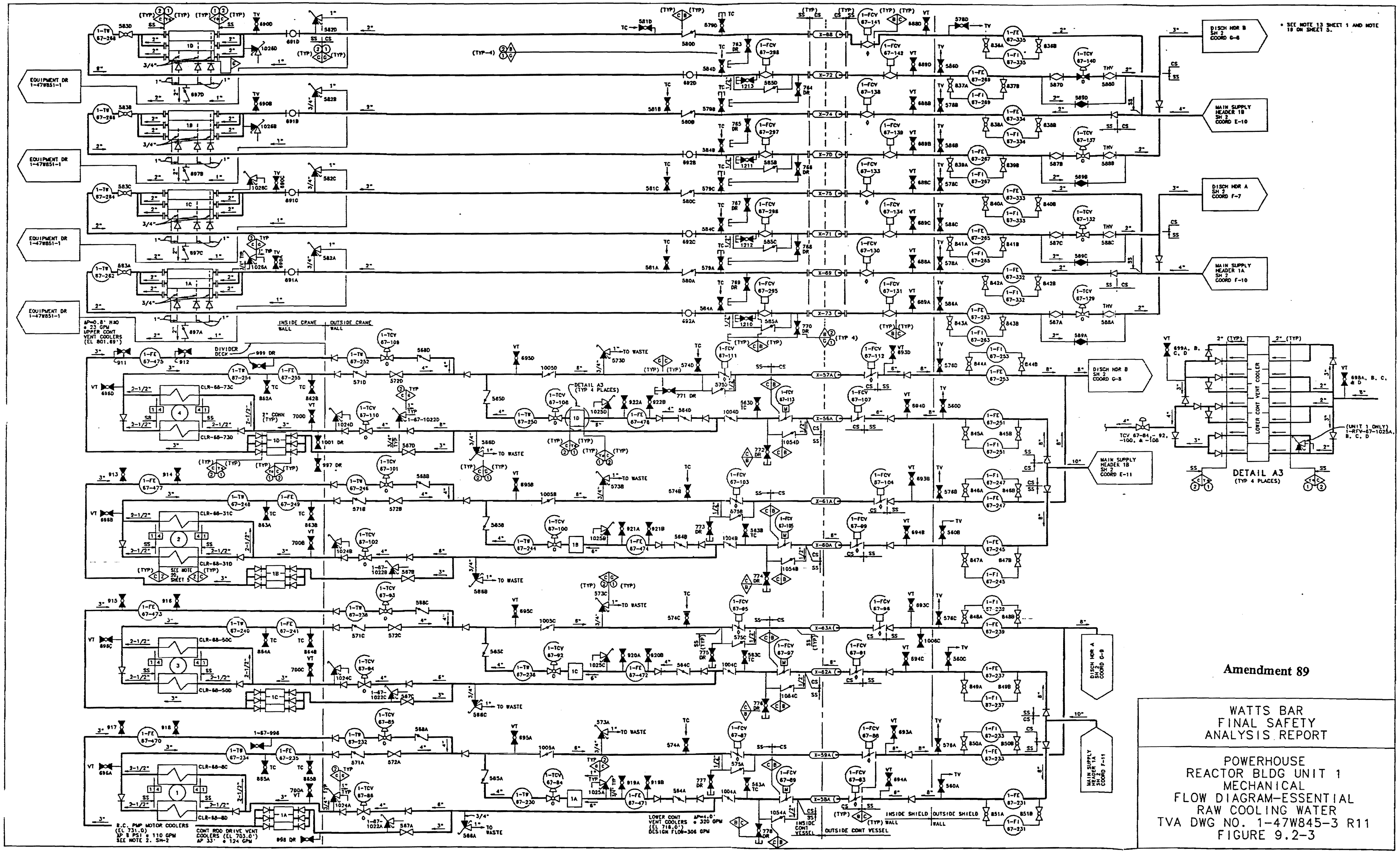

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Figure 9.2-3 Powerhouse Auxiliary and Control Buildings Flow Diagram for Essential Raw Cooling Water System (Unit 1)

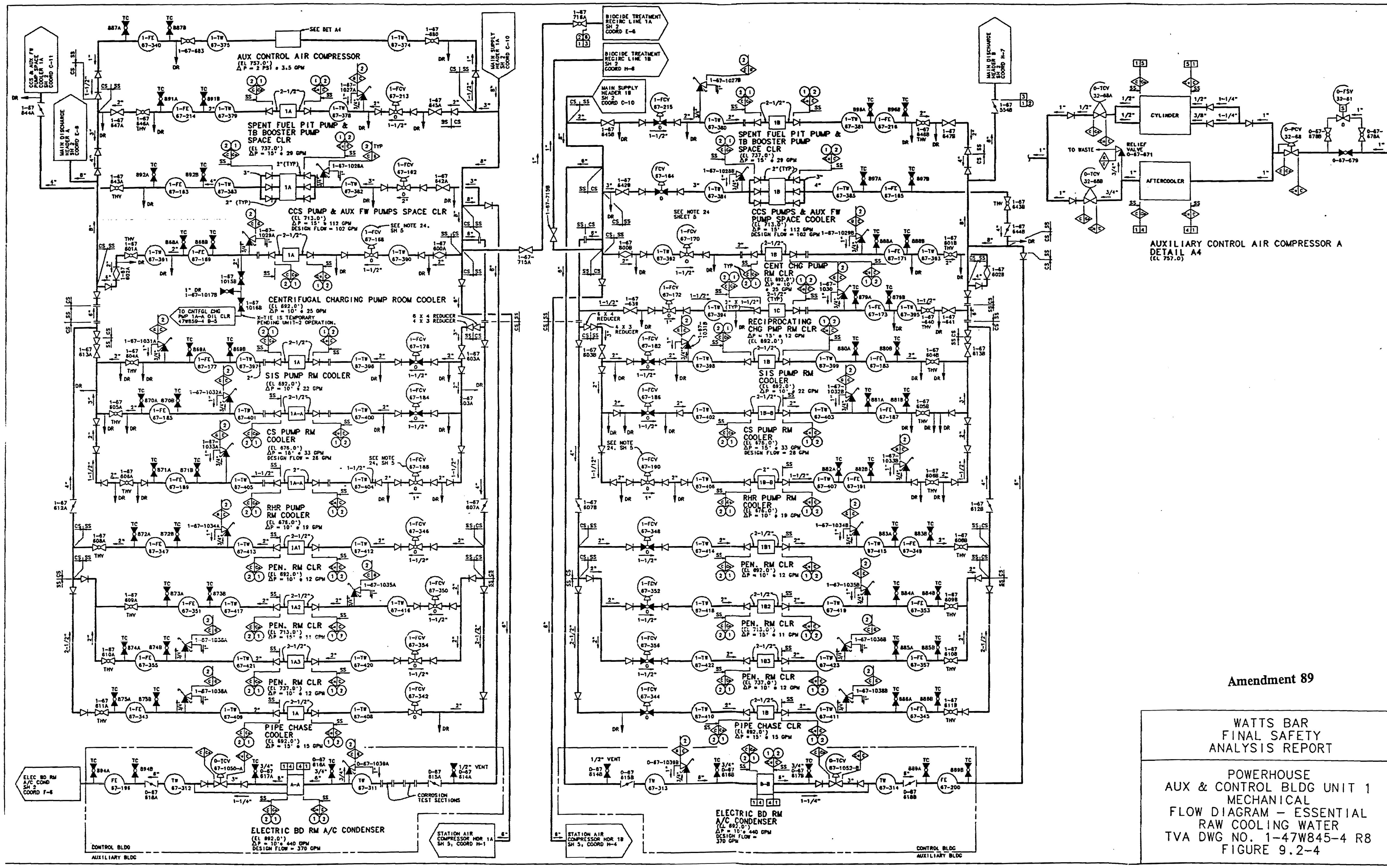

Figure 9.2-4 Powerhouse Aux & Control Bldg Unit 1 Mechancial Flow Diagram -Essential Raw Cooling Water

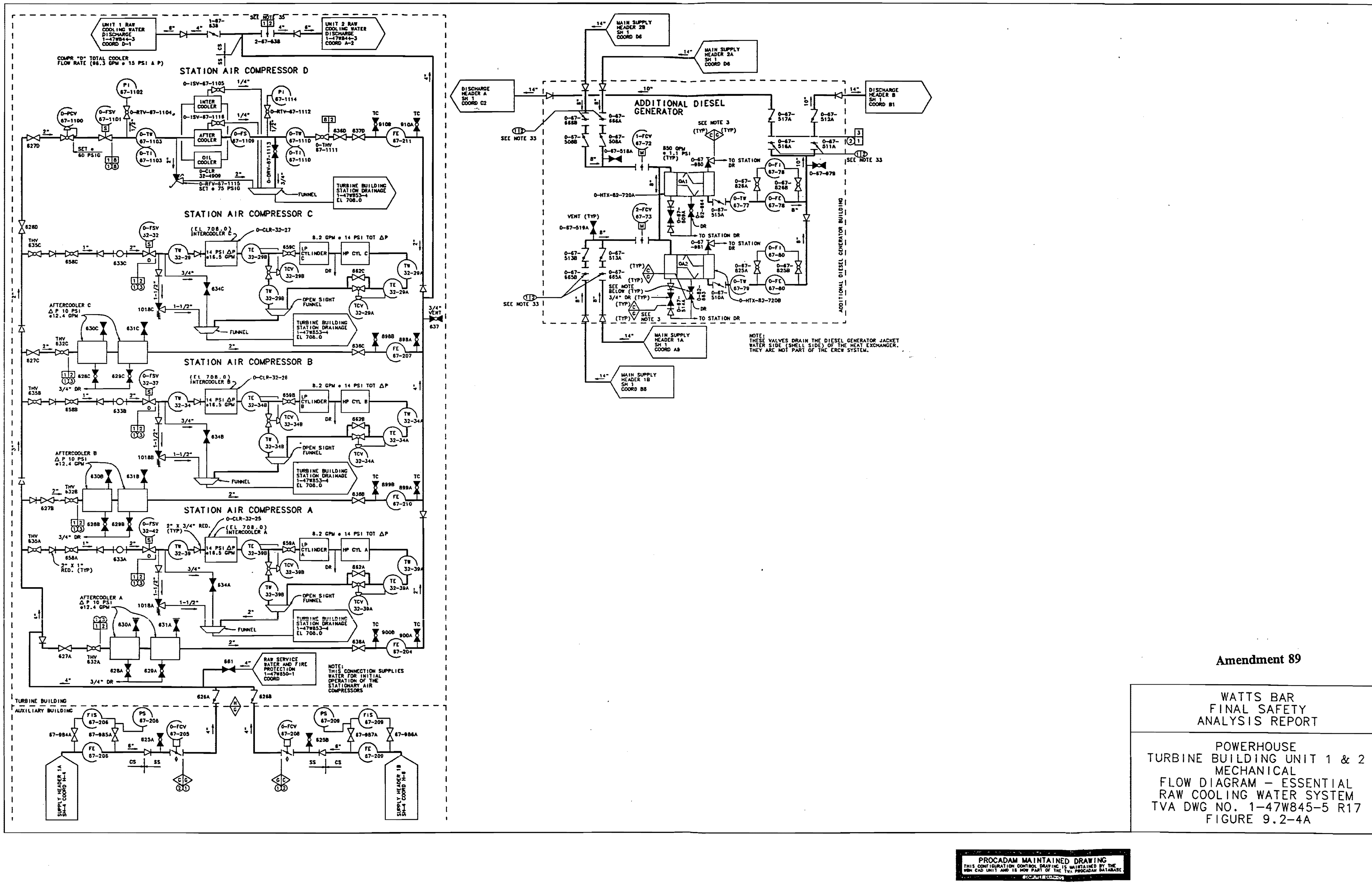

Figure 9.2-4a Powerhouse Turbine Building Units 1 & 2 Flow Diagram for Essential Raw Cooling Water System

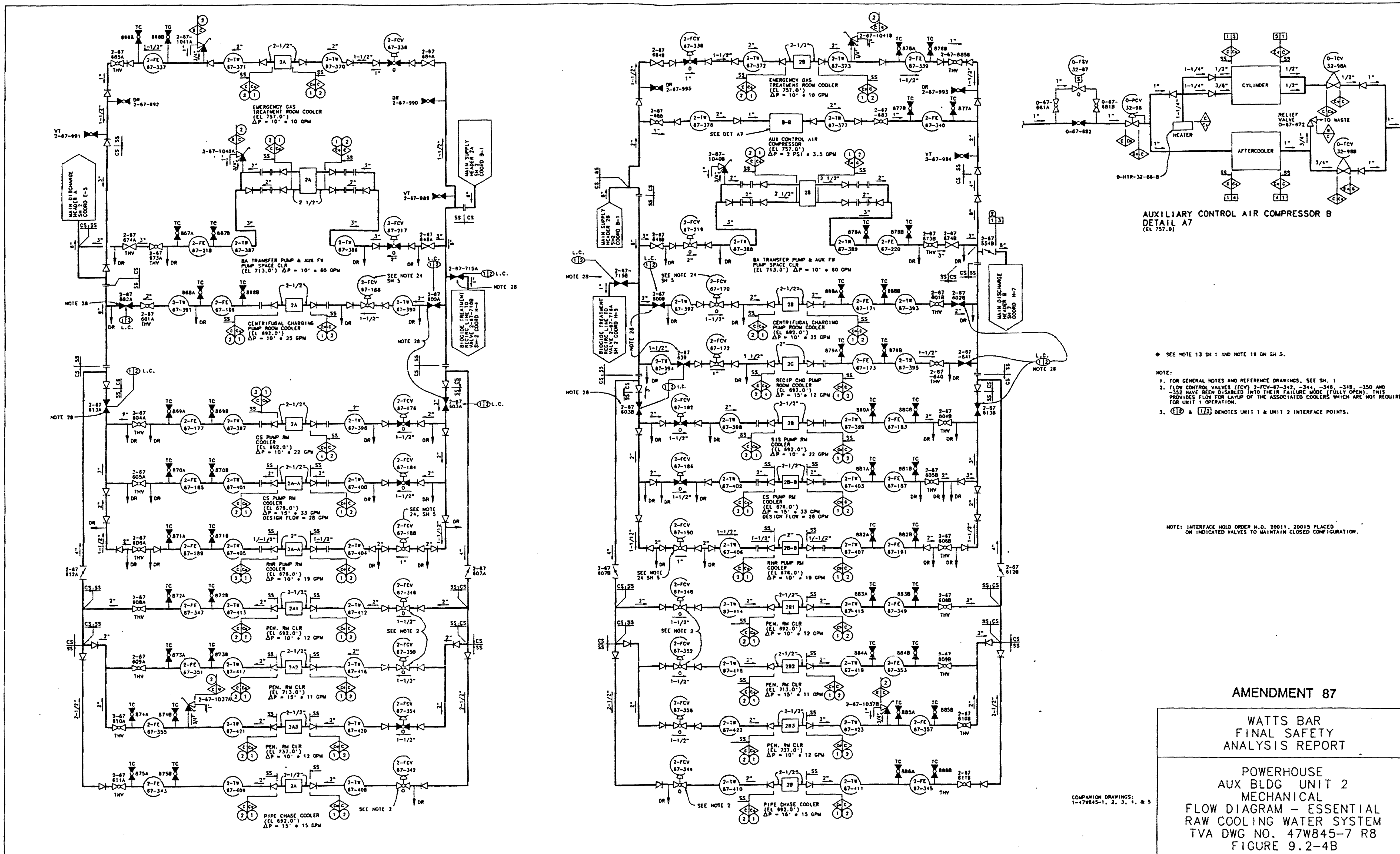

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Figure 9.2-4b Powerhouse Auxiliary Building Flow Diagram for Essential Raw Cooling Water System (Unit 2)

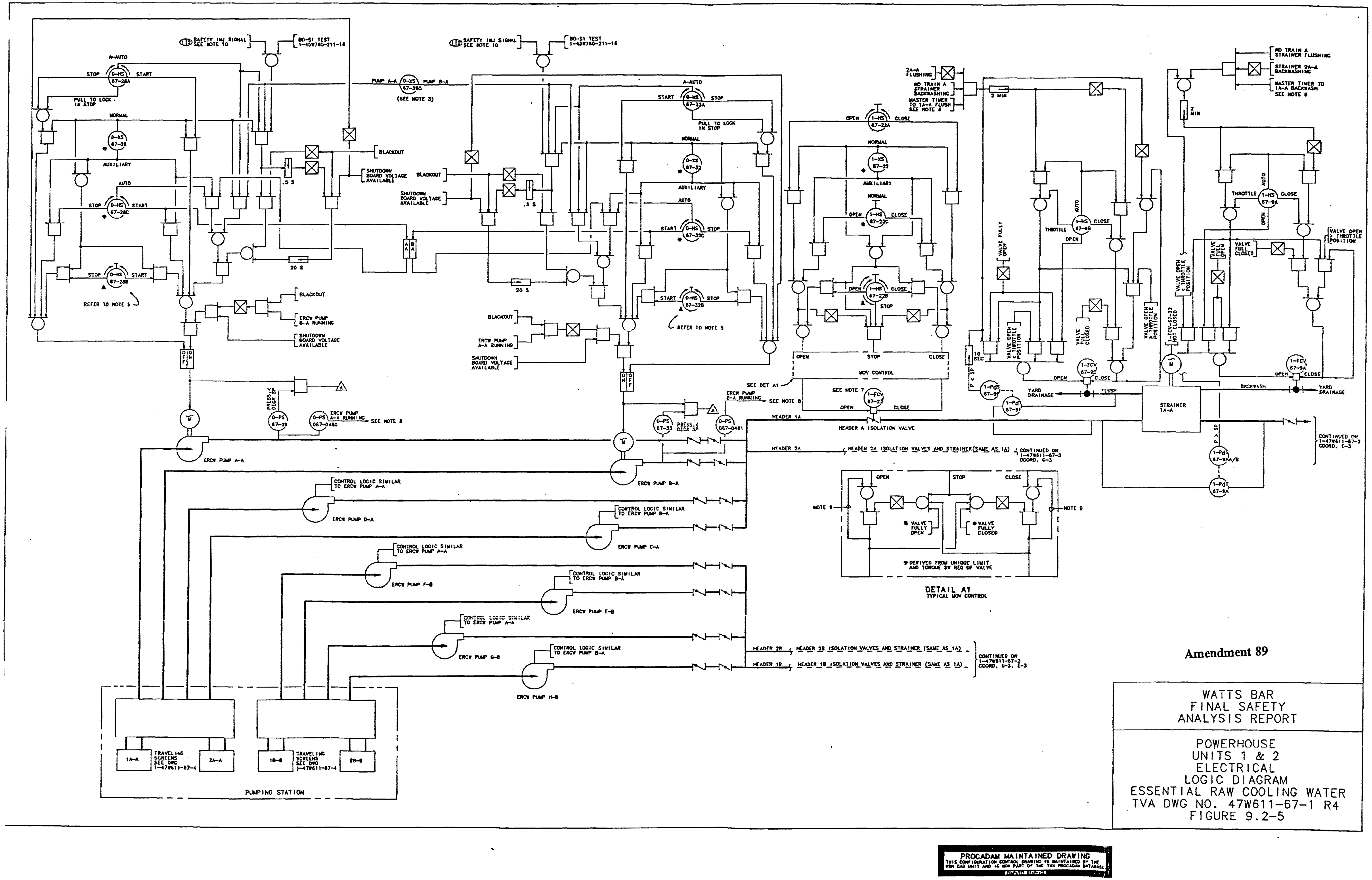

Figure 9.2-5 Powerhouse Units 1 & 2 Electrical Logic Diagram for Essential Raw Cooling Water System

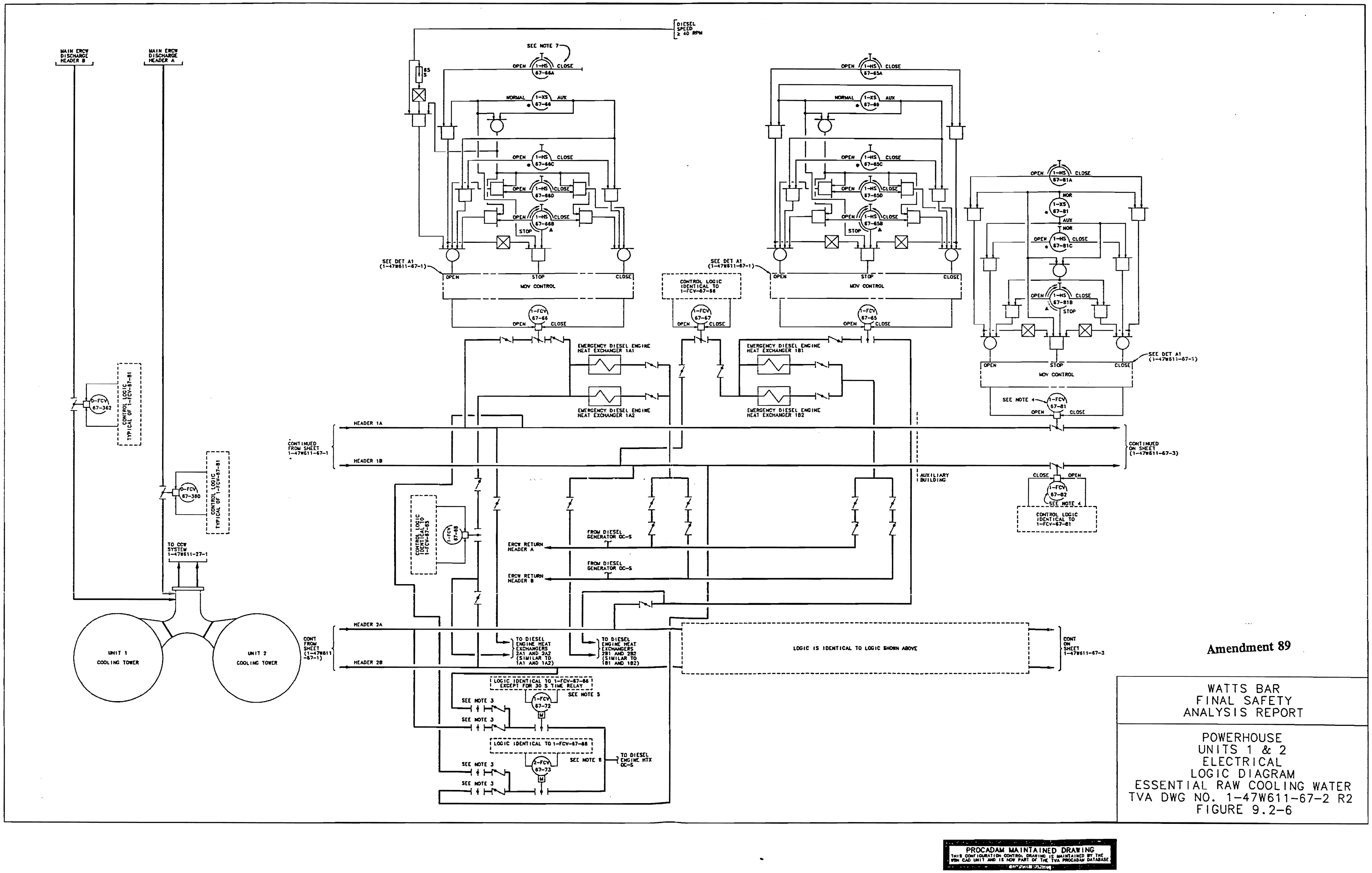

Figure 9.2-6 Powerhouse Units 1 & 2 Electrical Logic Diagram for Essential Raw Cooling Water System

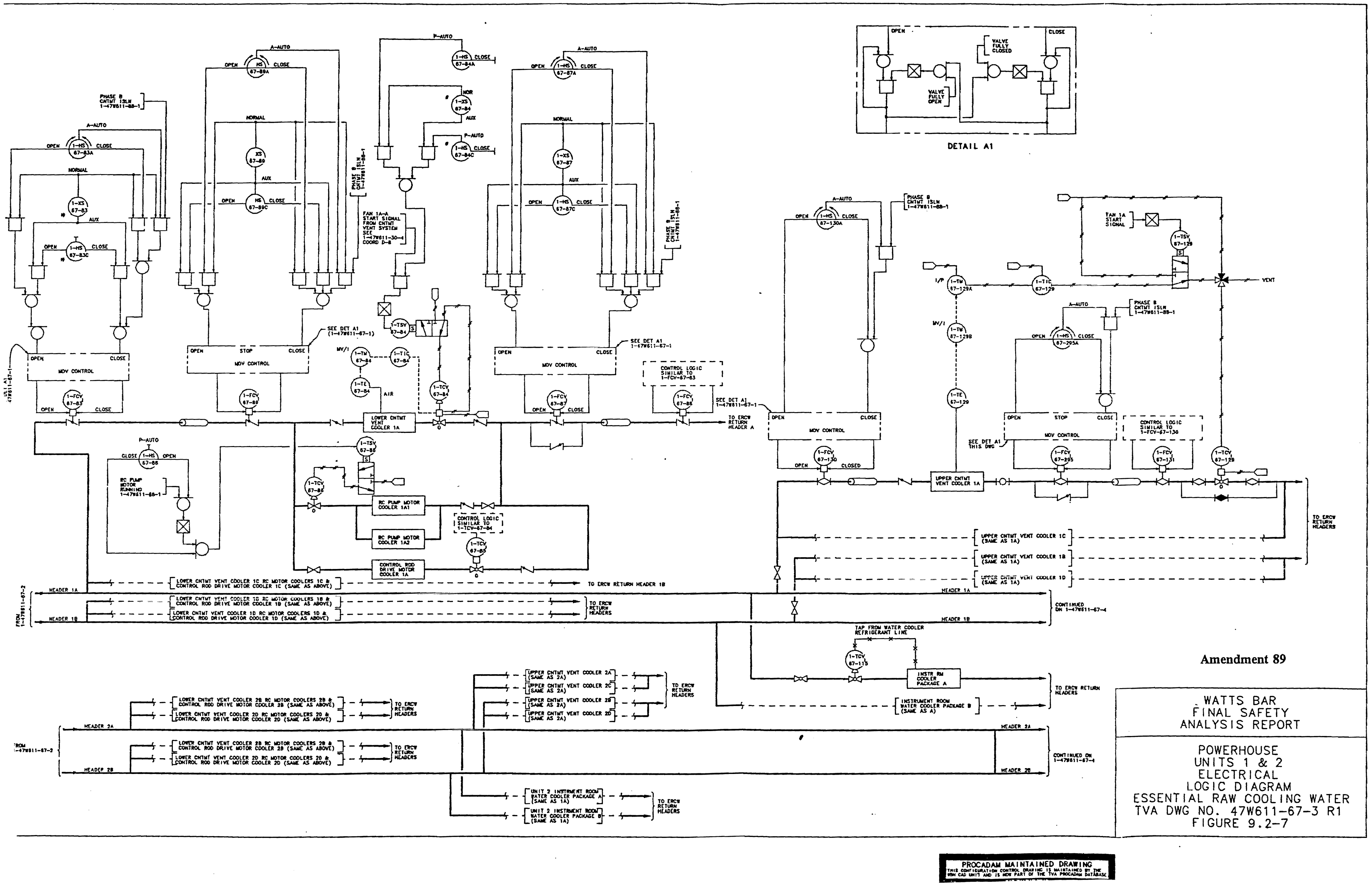

Figure 9.2-7 Logic Diagram for Essential Raw Cooling Water System

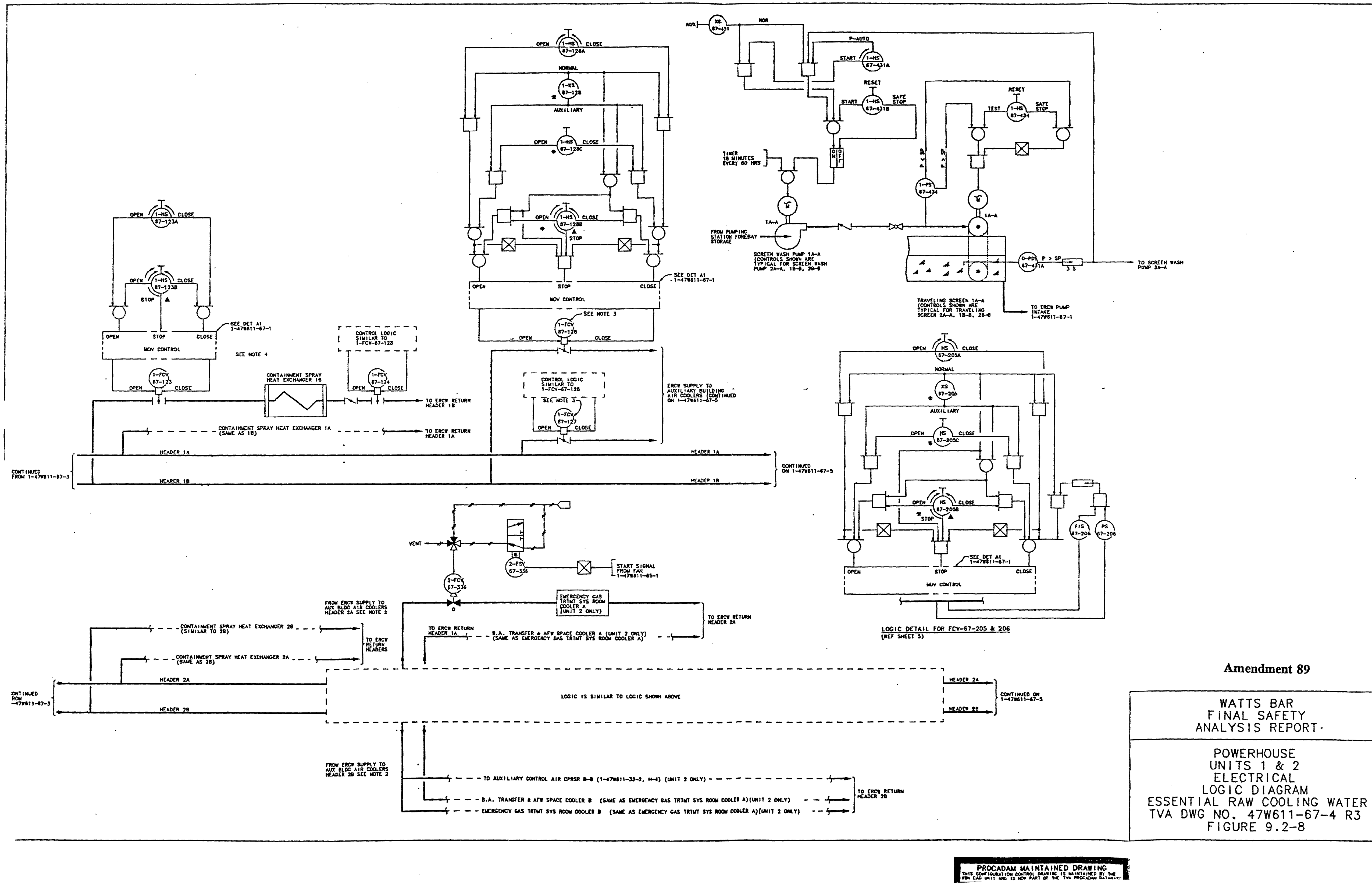

Figure 9.2-8 Powerhouse Units 1 & 2 Electrical Logic Diagram for Essential Raw Cooling Water System

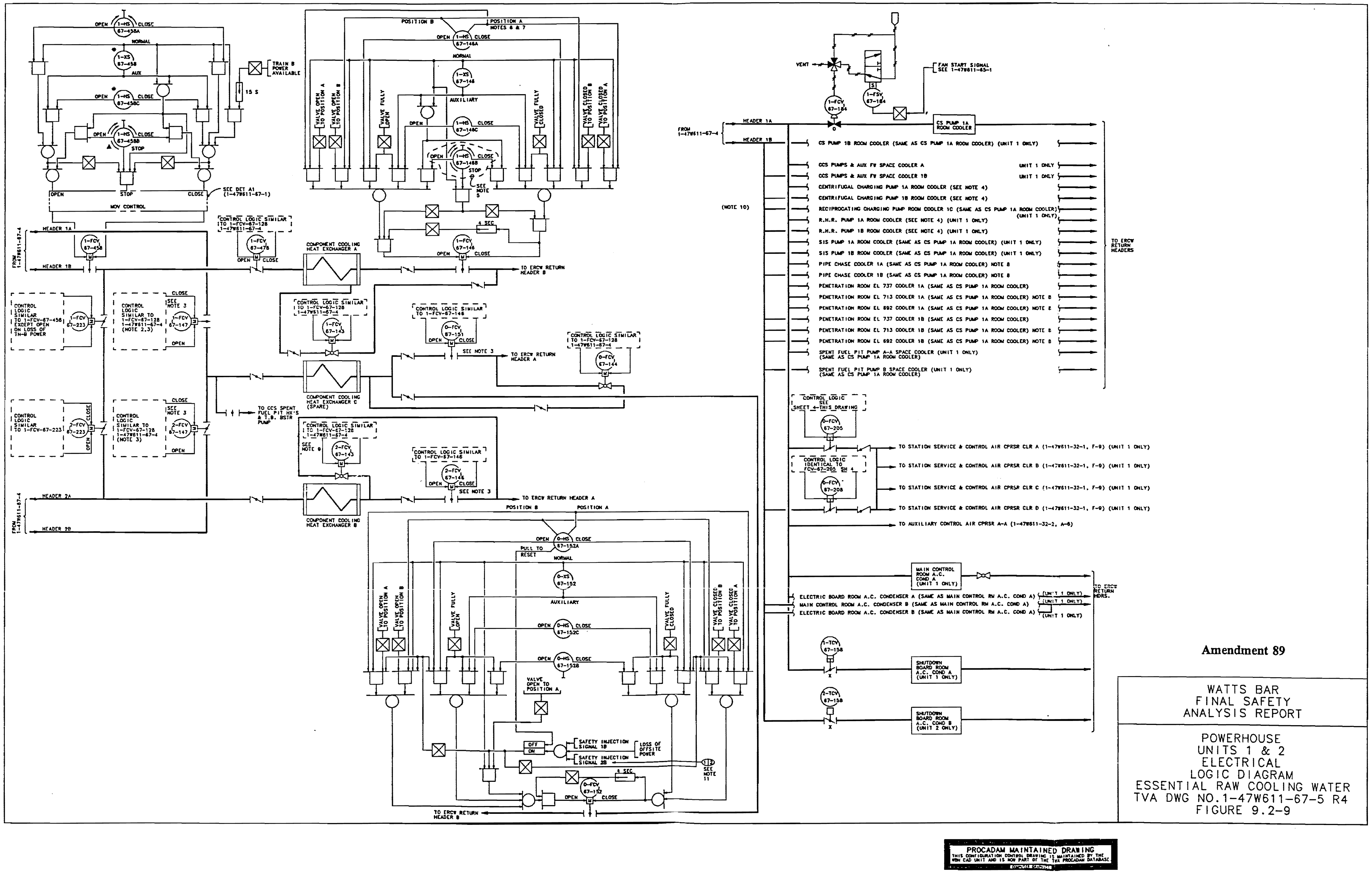

Figure 9.2-9 Powerhouse Units 1 & 2 Electrical Logic Diagram for Essential Raw Cooling Water System

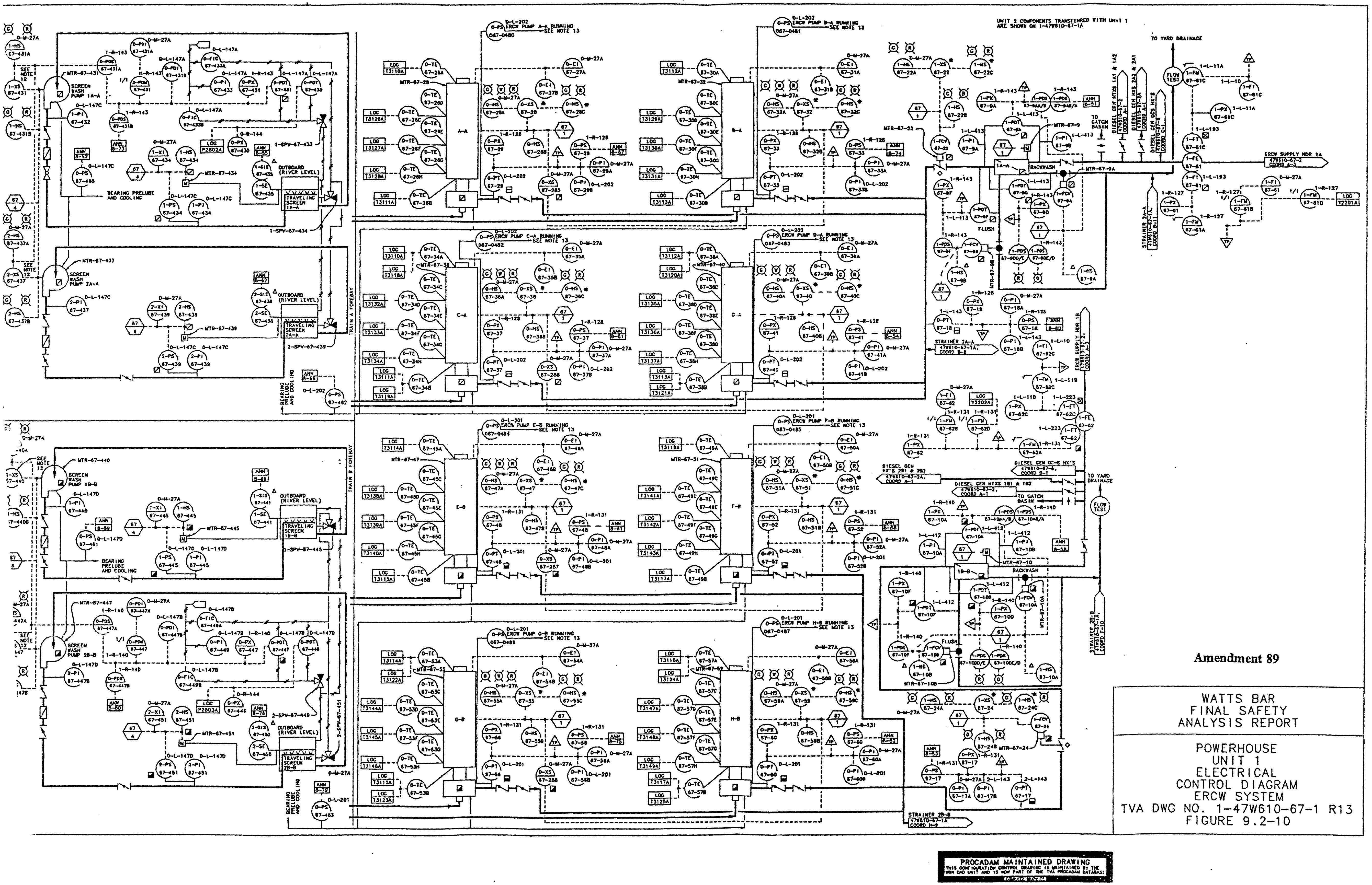

Figure 9.2-10 Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System (Unit 1)

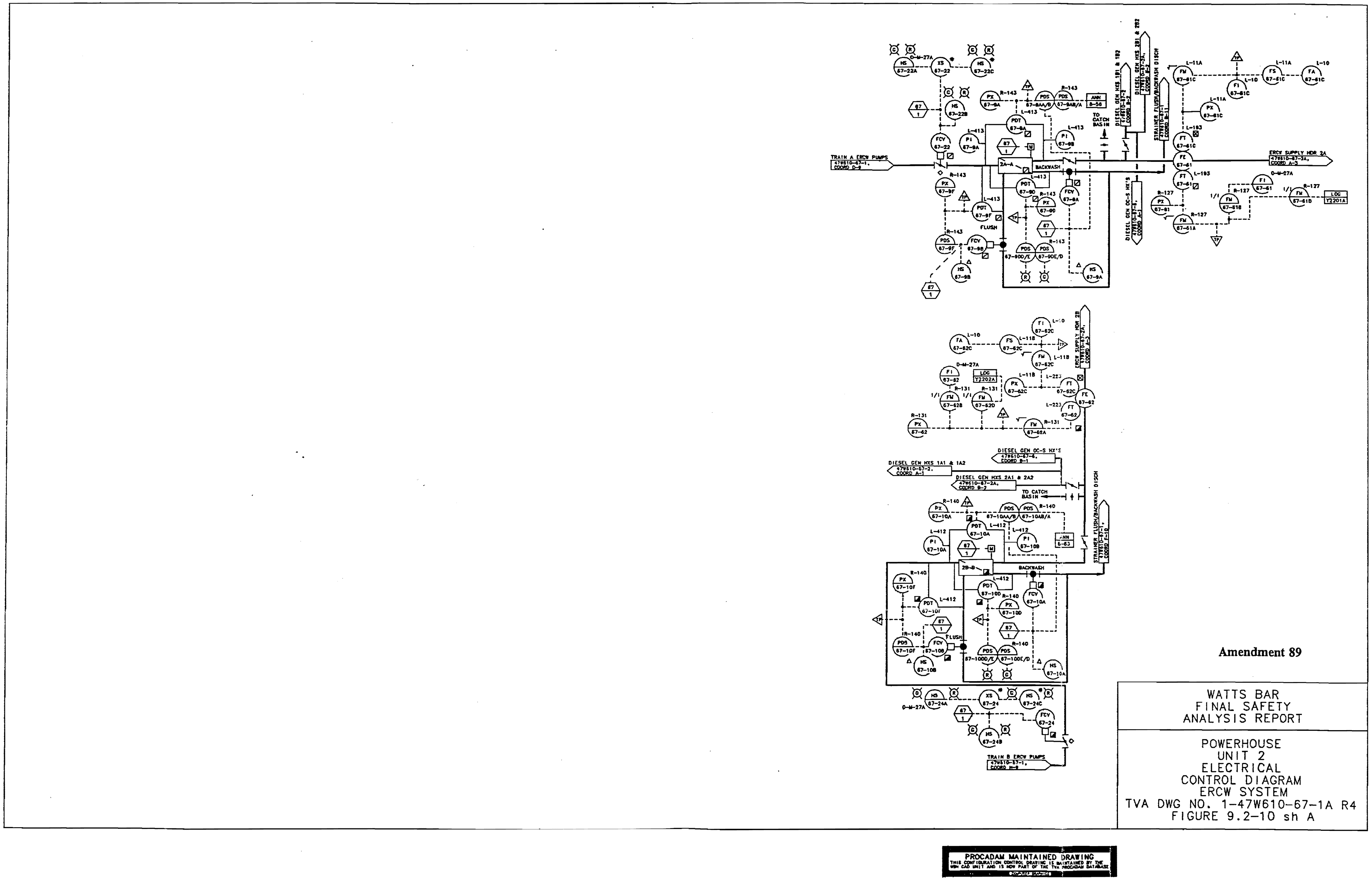

Figure 9.2-10a Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System (Unit 2)

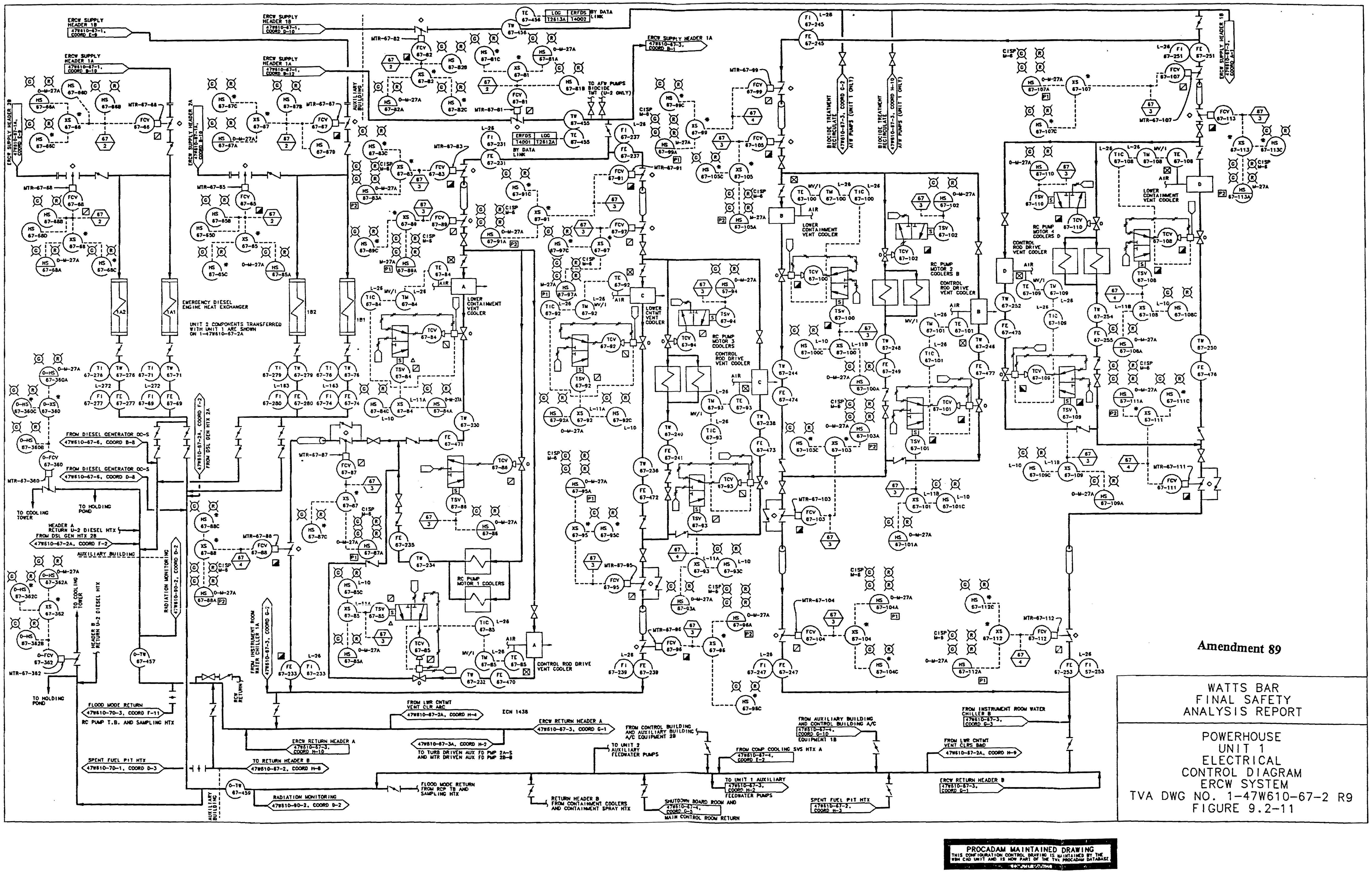

Figure 9.2-11 Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System (Unit 1)

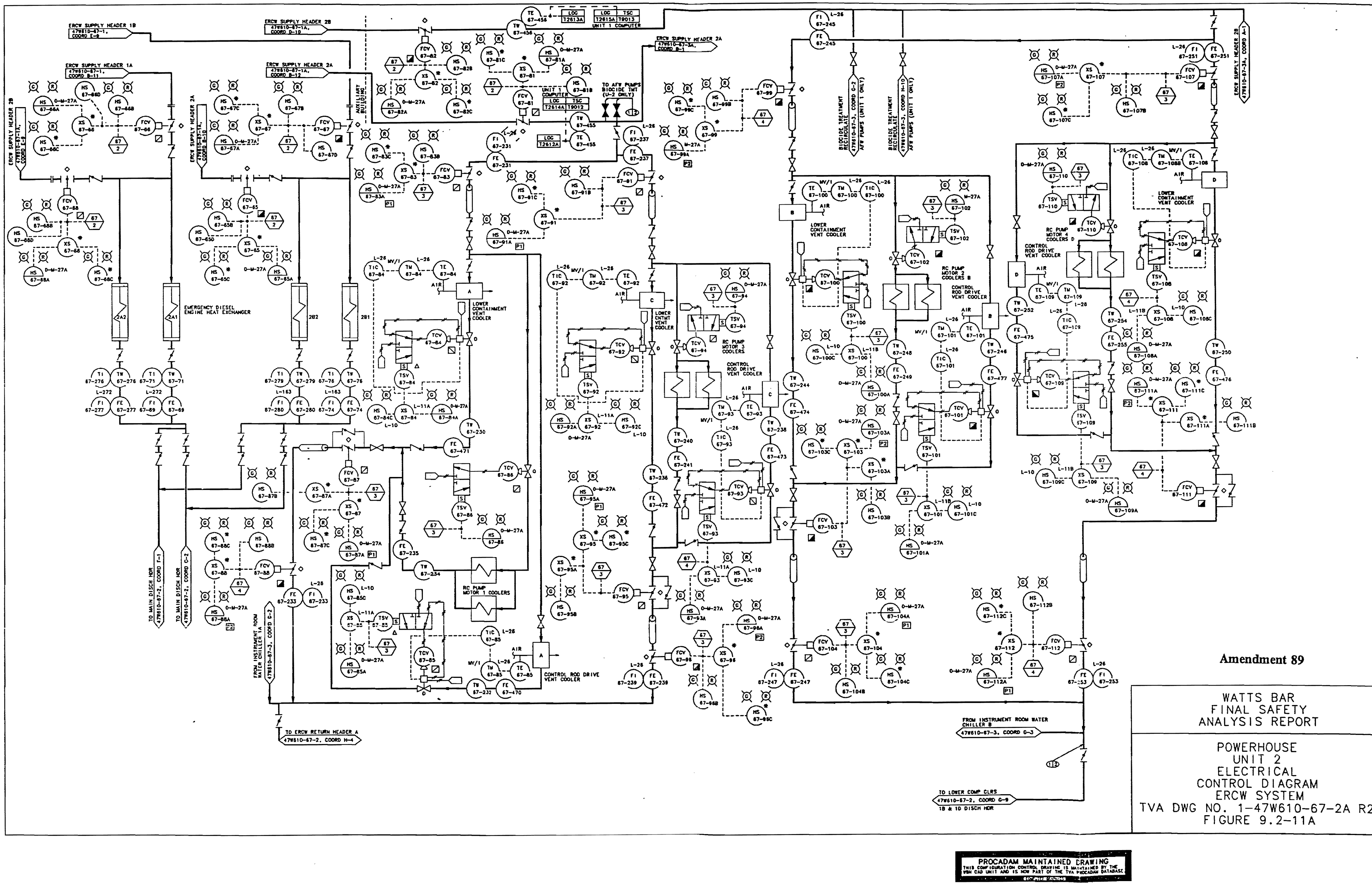

Figure 9.2-11a Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System (Unit 2)

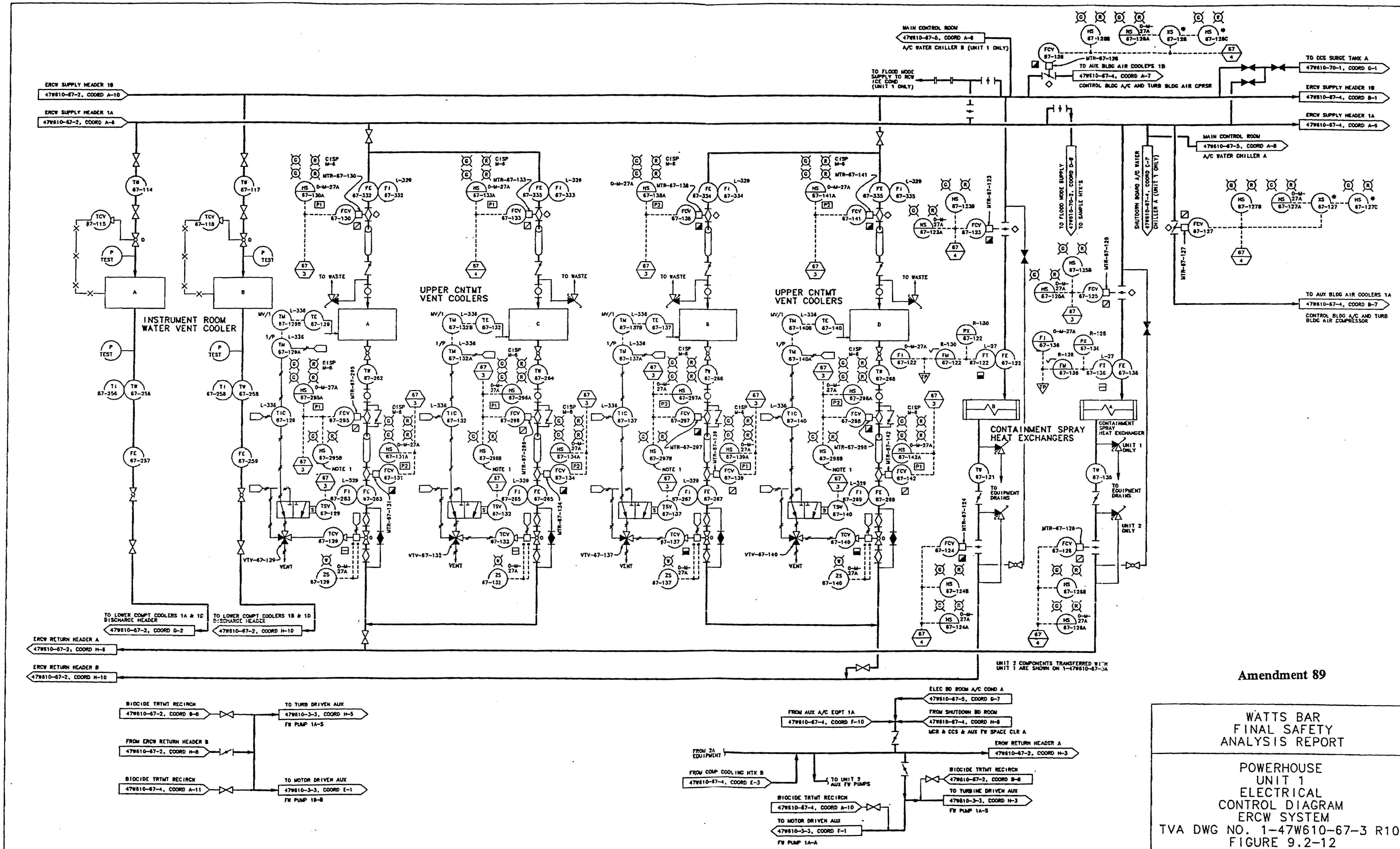

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Figure 9.2-12 Electrical Control Diagram for Essential Raw Cooling Water System (Unit 1)

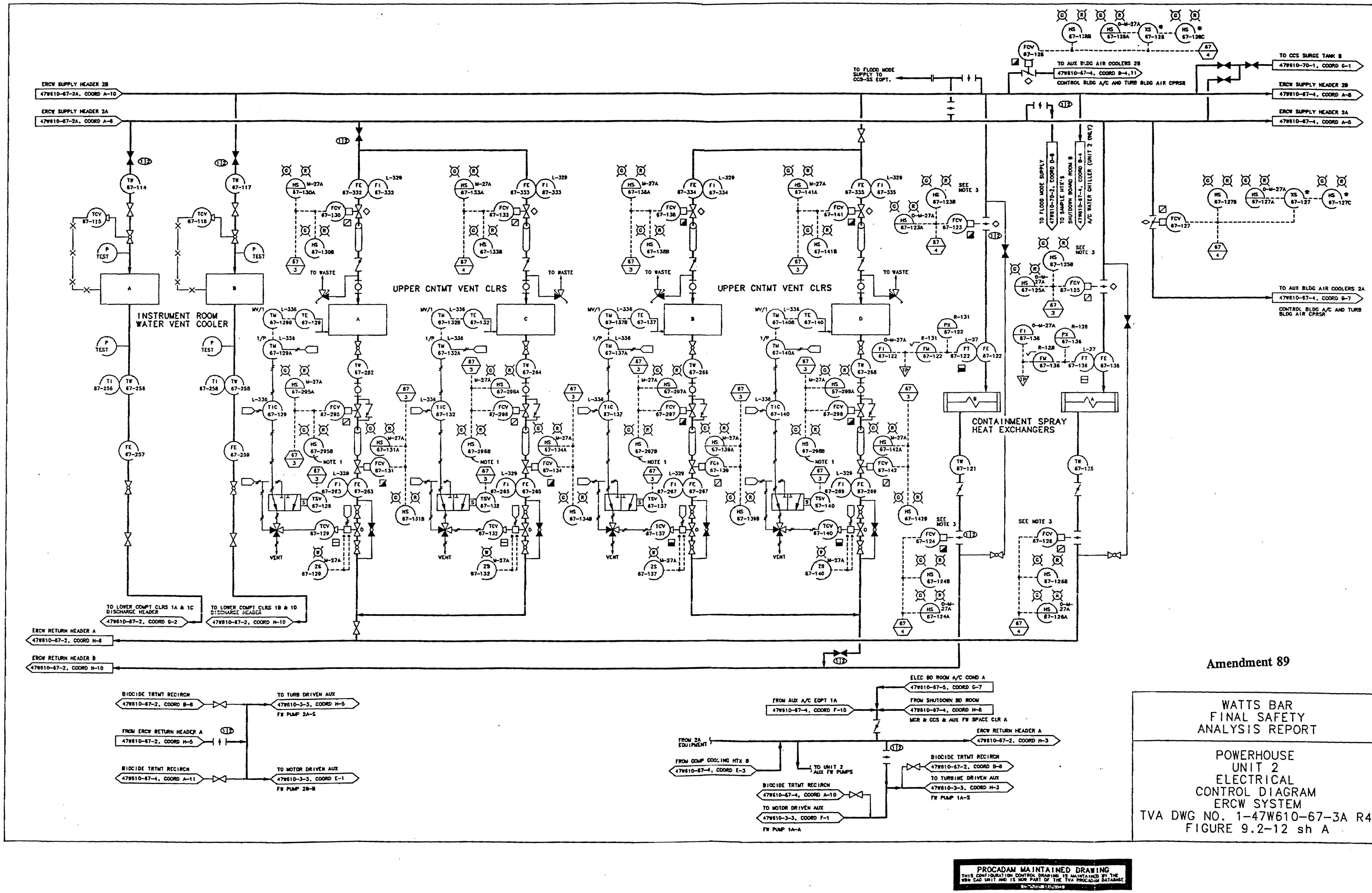

Figure 9.2-12 Electrical Control Diagram for Essential Raw Cooling Water System (Unit 2) (Sheet A)

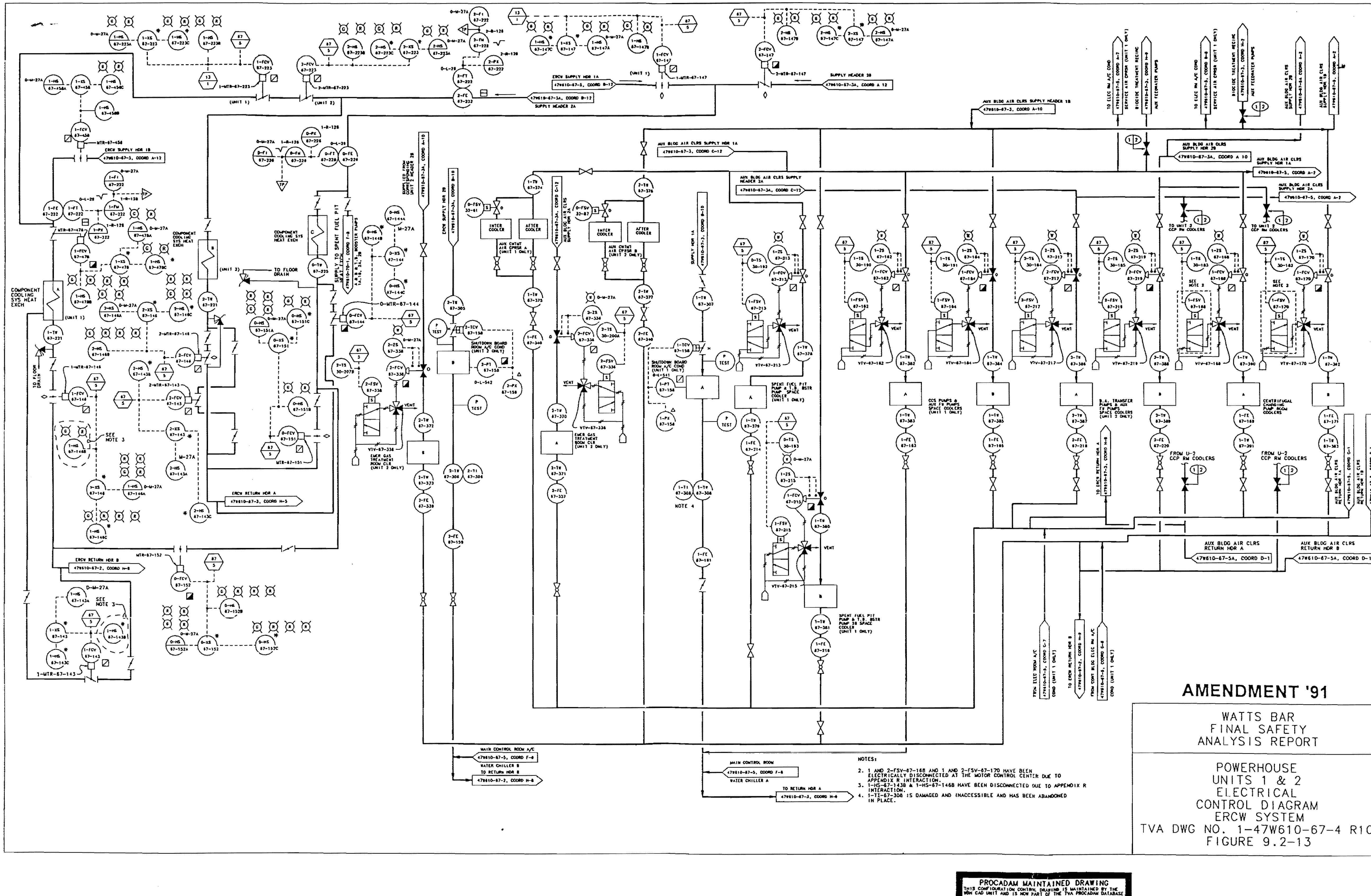

Figure 9.2-13 Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System

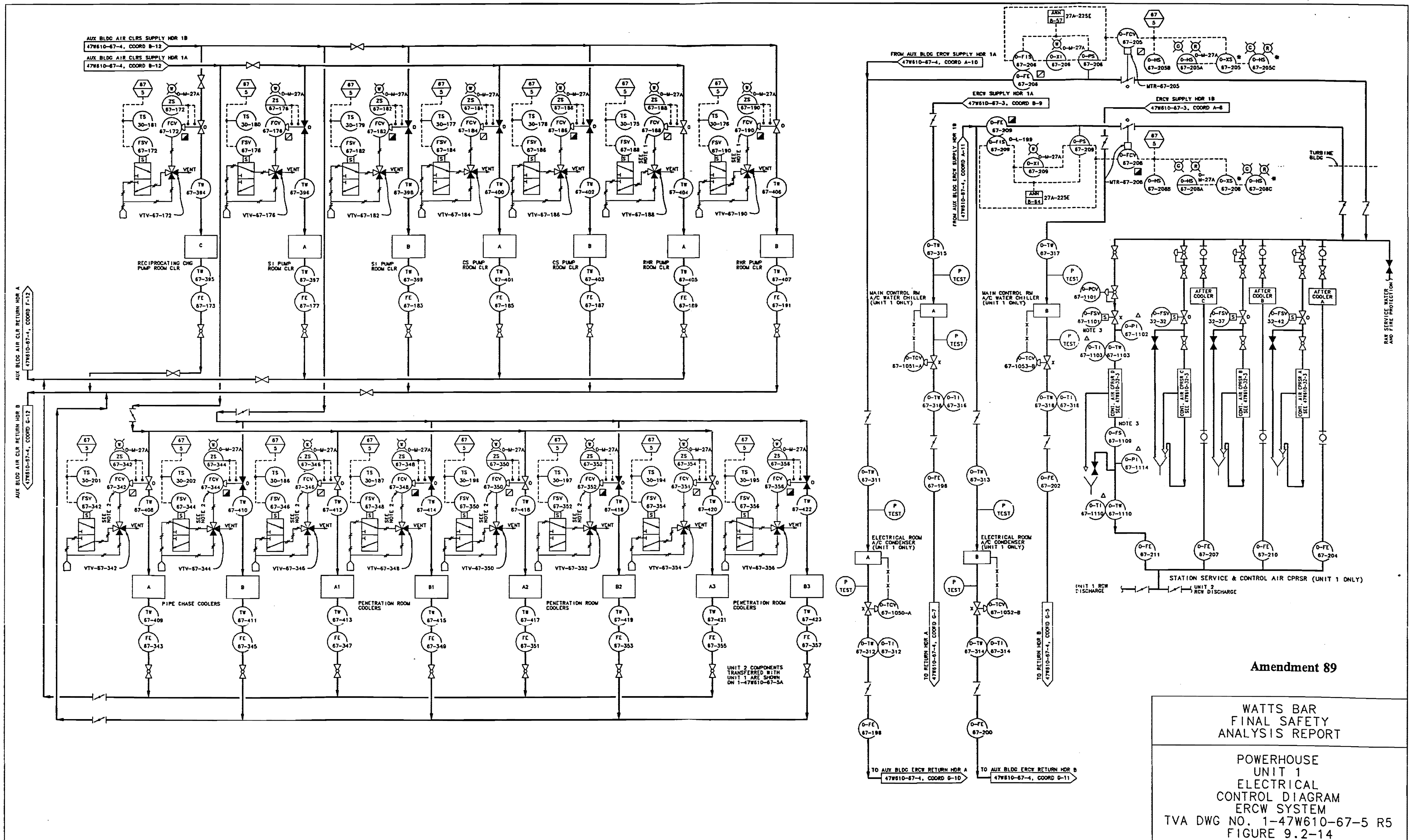

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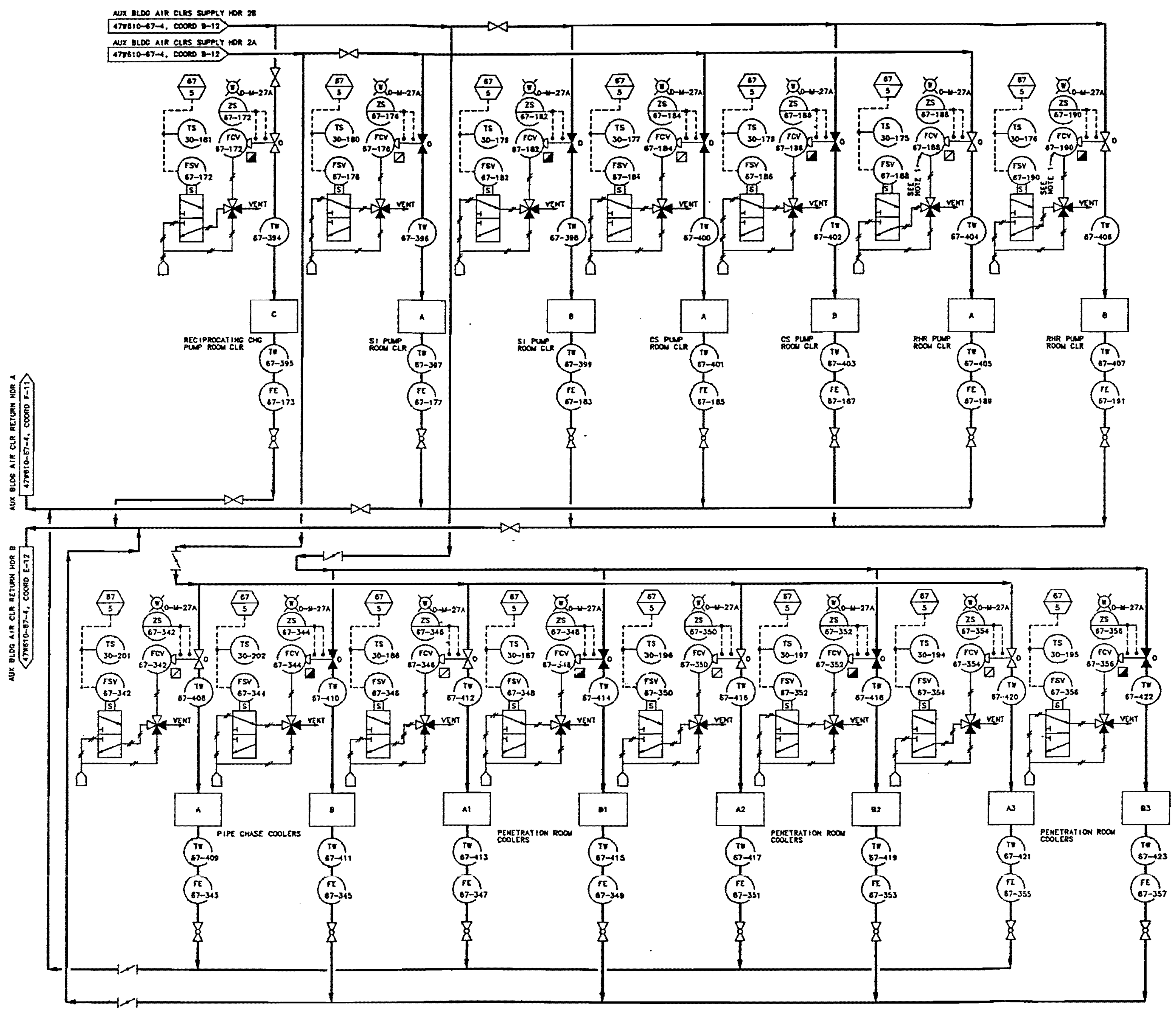
Figure 9.2-14 Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System (Unit 1)



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WATTS BAR
FINAL SAFETY
ANALYSIS REPORT

POWERHOUSE
UNIT 2
ELECTRICAL
CONTROL DIAGRAM
ERCW SYSTEM
TVA DWG NO. 1-47W610-67-5A R1
FIGURE 9.2-14 sh A

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Figure 9.2-14a Powerhouse Electrical Control Diagram for Essential Raw Cooling Water System (Unit 2)

Figure 9.2-15 Deleted by Amendment 87

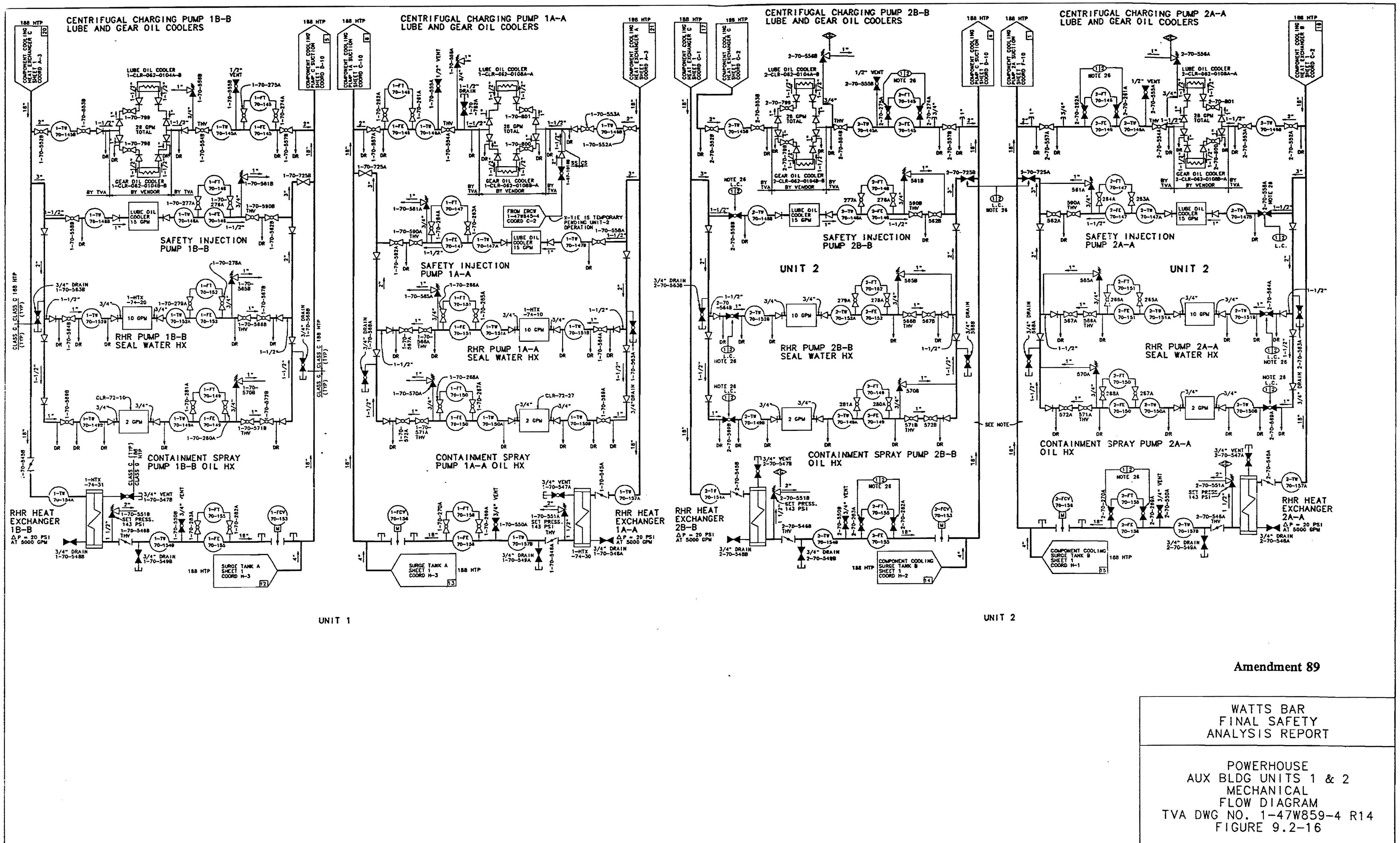

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Figure 9.2-16 Powerhouse, Auxiliary Building Flow Diagram for Component Cooling Water System

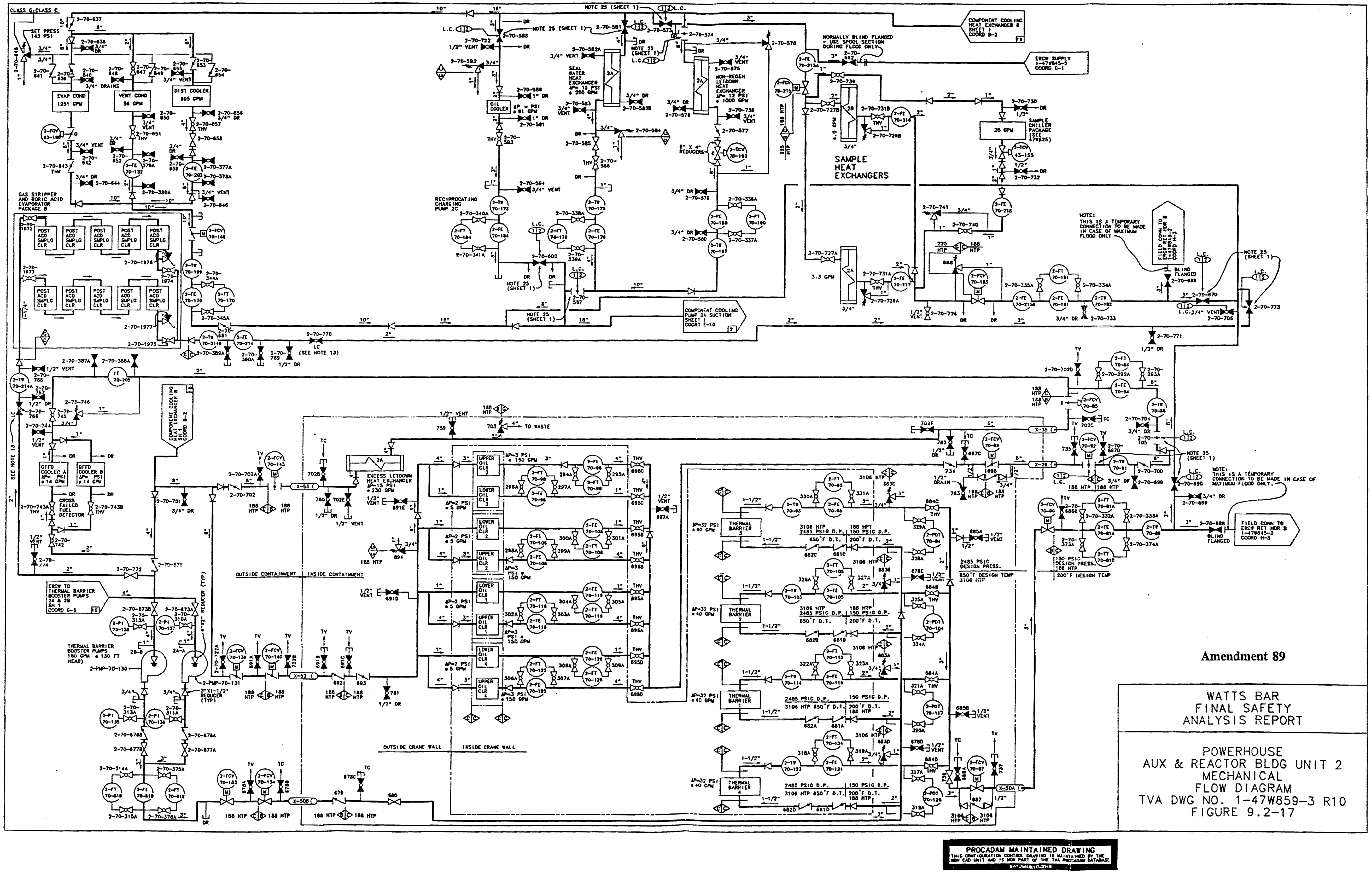

Figure 9.2-17 Powerhouse, Auxiliary and Reactor Building Flow Diagram for Component Cooling System (Unit 2)

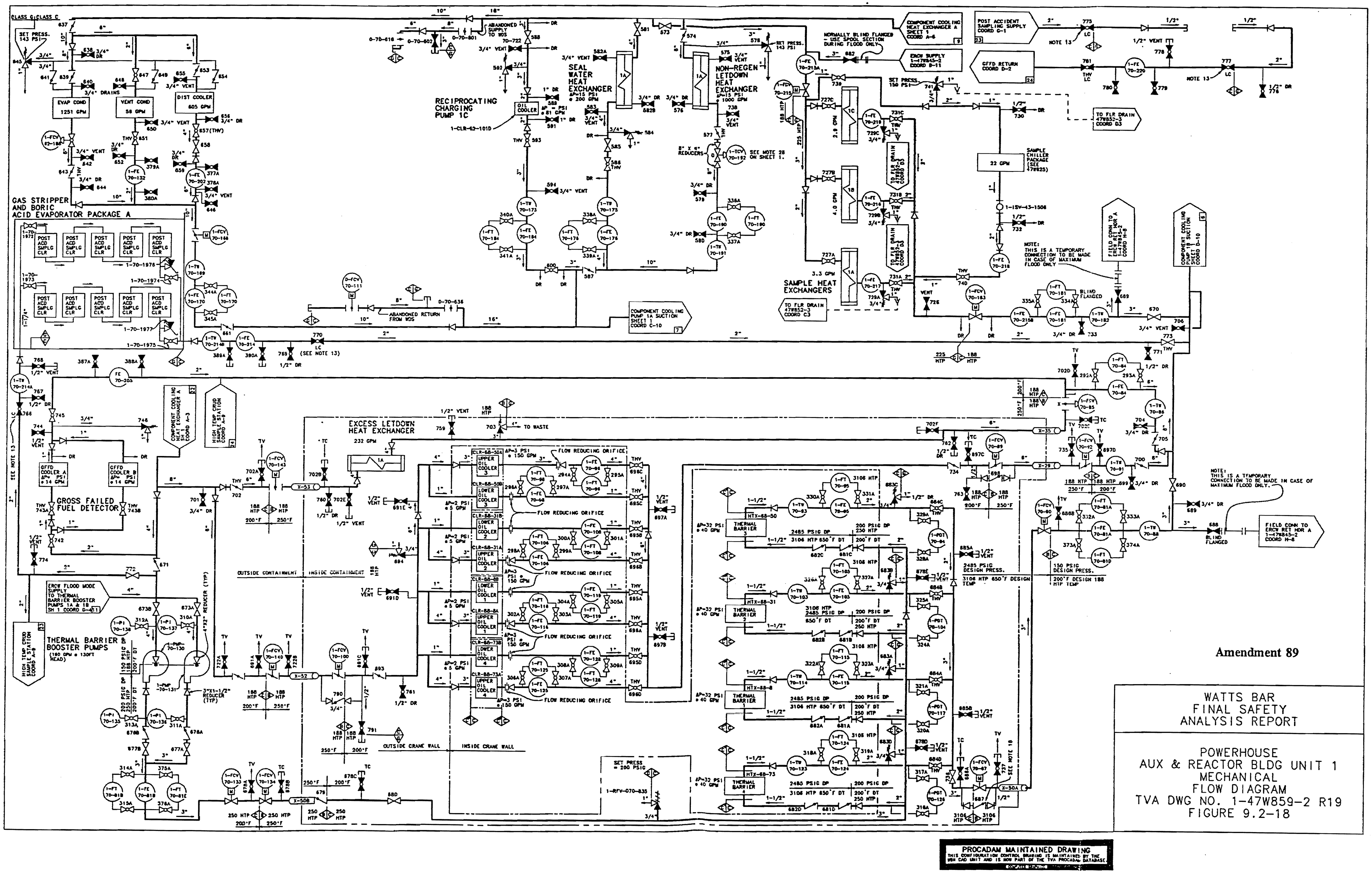

Figure 9.2-18 Powerhouse, Auxiliary and Reactor Building Flow Diagram for Component Cooling System (Unit 1)

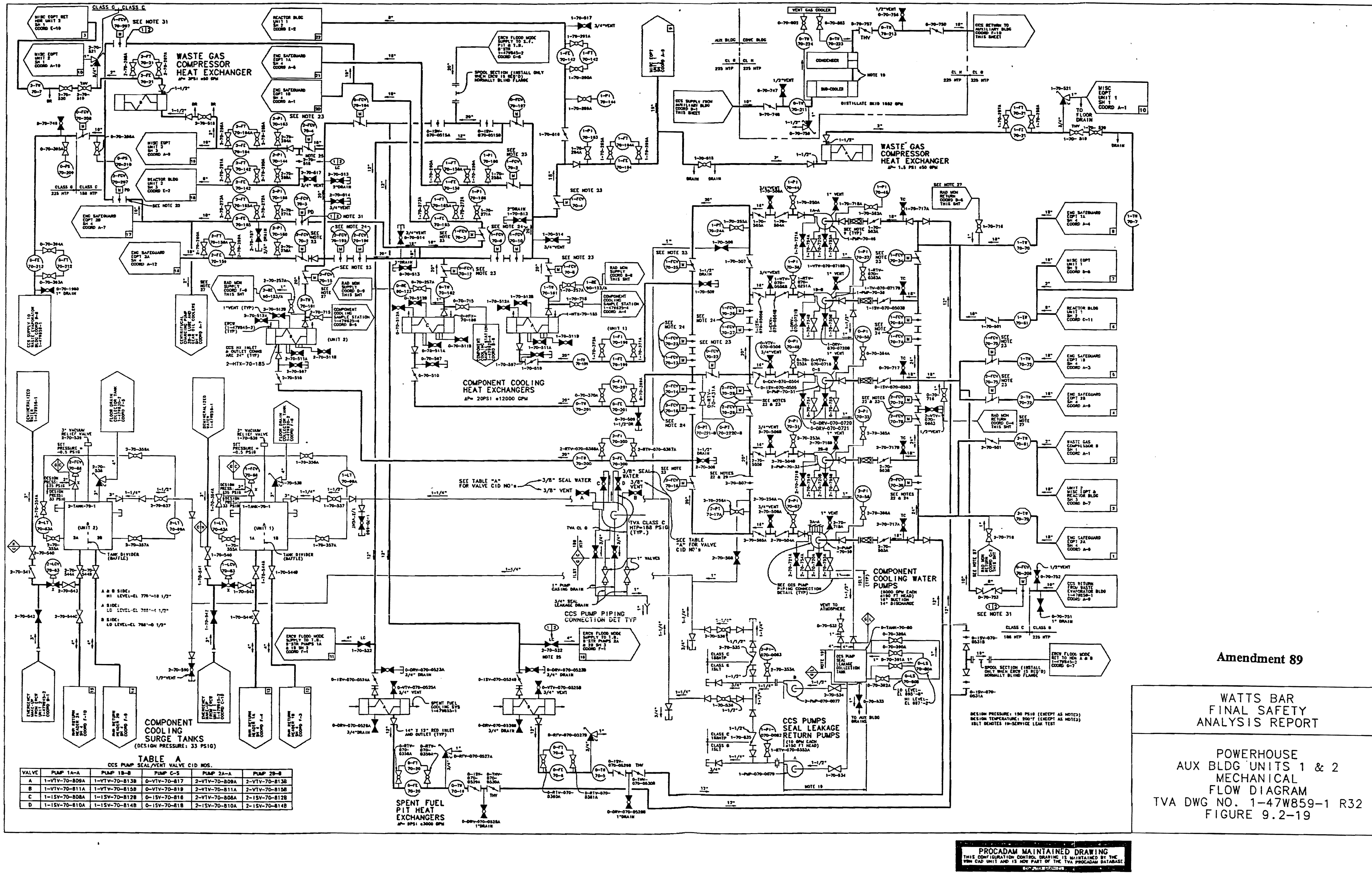

TABLE A

CCS PUMP SEAL/VENT VALVE CID NOS.

VALVE	PUMP 1A-A	PUMP 1B-B	PUMP C-S	PUMP 2A-A	PUMP 2B-B
A	1-VTV-70-809A	1-VTV-70-813B	0-VTV-70-817	2-VTV-70-809A	2-VTV-70-813B
B	1-VTV-70-811A	1-VTV-70-815B	0-VTV-70-819	2-VTV-70-811A	2-VTV-70-815B
C	1-ISV-70-808A	1-ISV-70-812B	0-ISV-70-816	2-VTV-70-808A	2-ISV-70-812B
D	1-ISV-70-810A	1-ISV-70-814B	0-ISV-70-818	2-ISV-70-810A	2-ISV-70-814B

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Figure 9.2-19 Powerhouse, Auxiliary Building Mechanical Flow Diagram (Units 1 and 2)

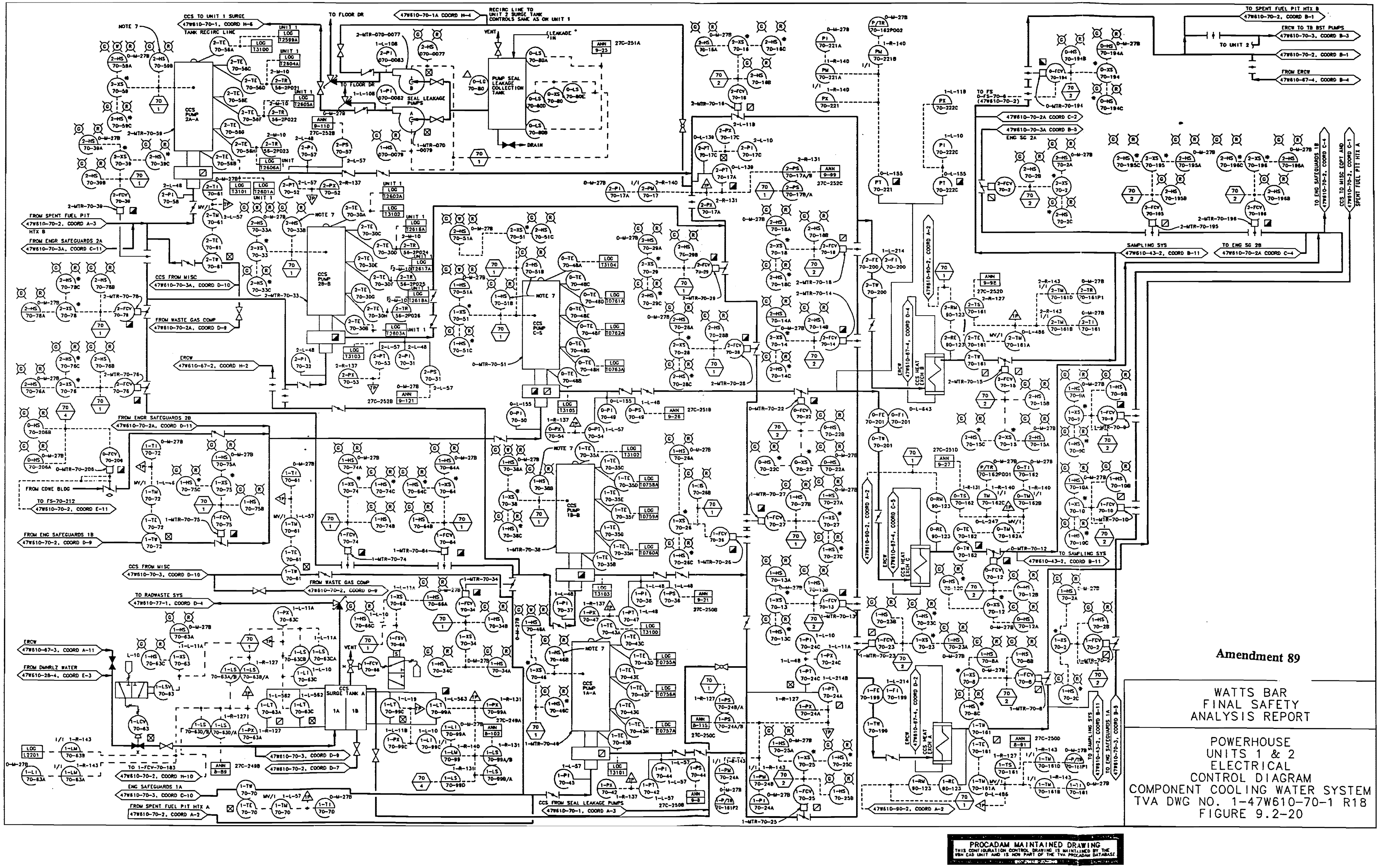
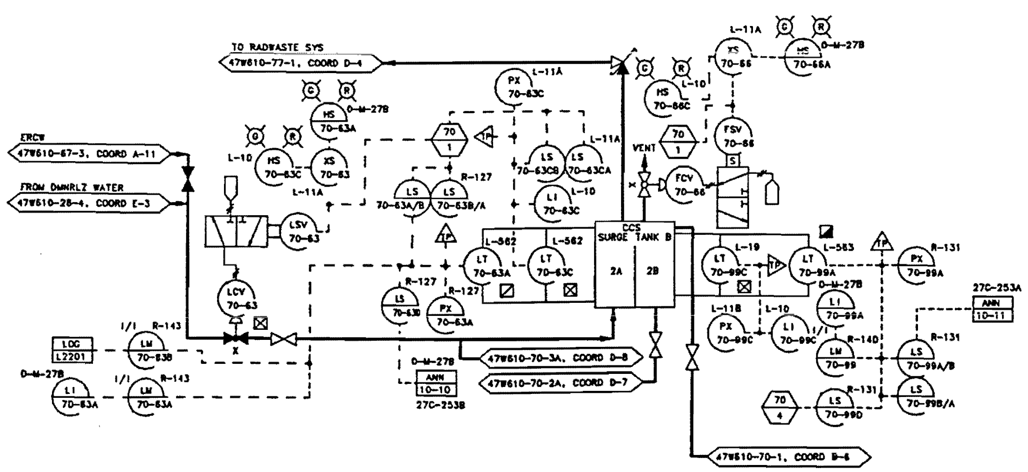


Figure 9.2-20 Powerhouse Electrical Control Diagram for Component Cooling Water System



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WATTS BAR
FINAL SAFETY
ANALYSIS REPORT

POWERHOUSE
UNIT 2
ELECTRICAL
CONTROL DIAGRAM
TVA DWG NO. 1-47W610-70-1A R5
FIGURE 9.2-20A

Figure 9.2-20a Powerhouse Unit 2 Electrical Control Diagram

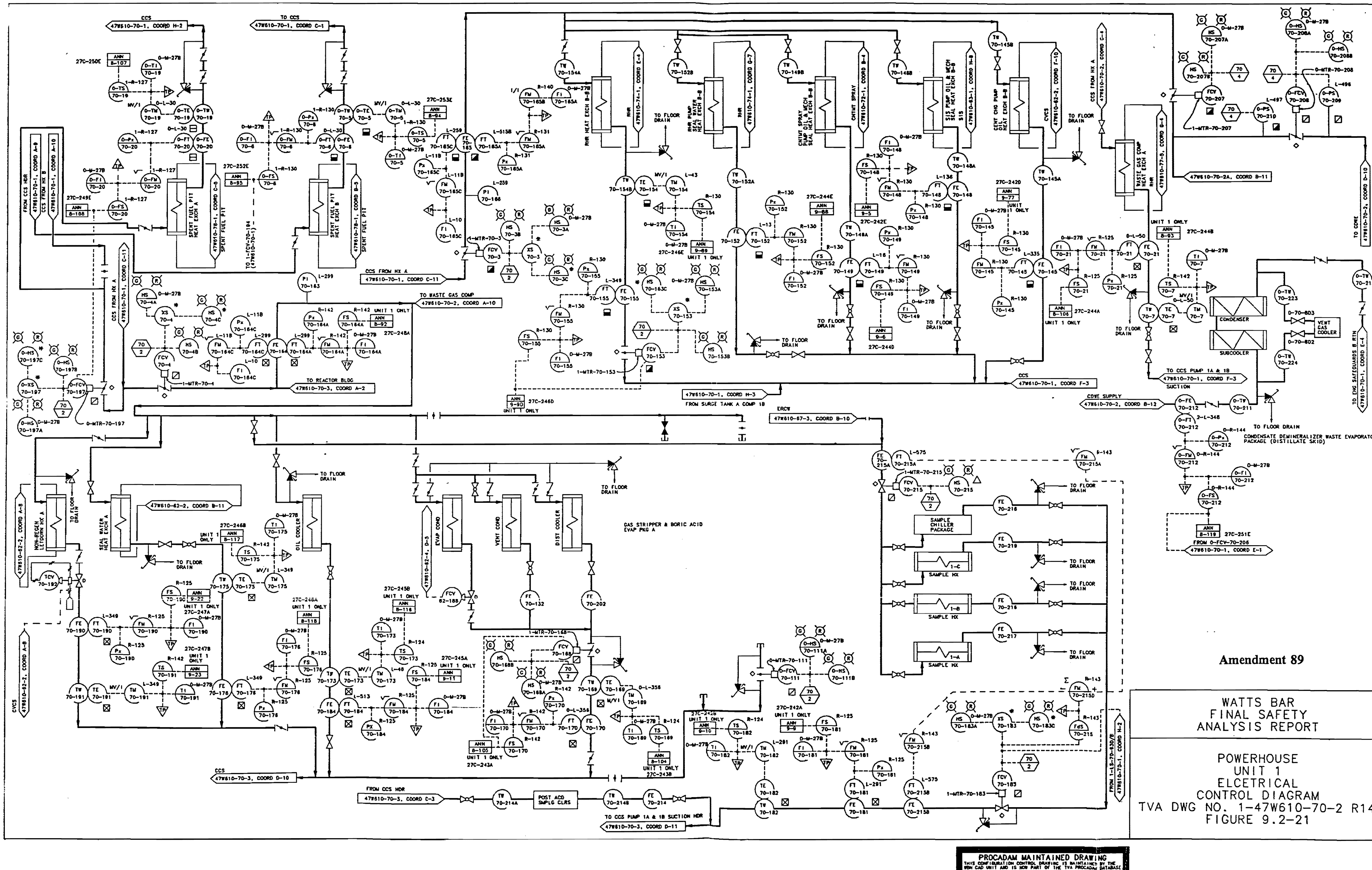

Figure 9.2-21 Powerhouse Electrical Control Diagram for Component Cooling Water S-ystem (Unit 1)

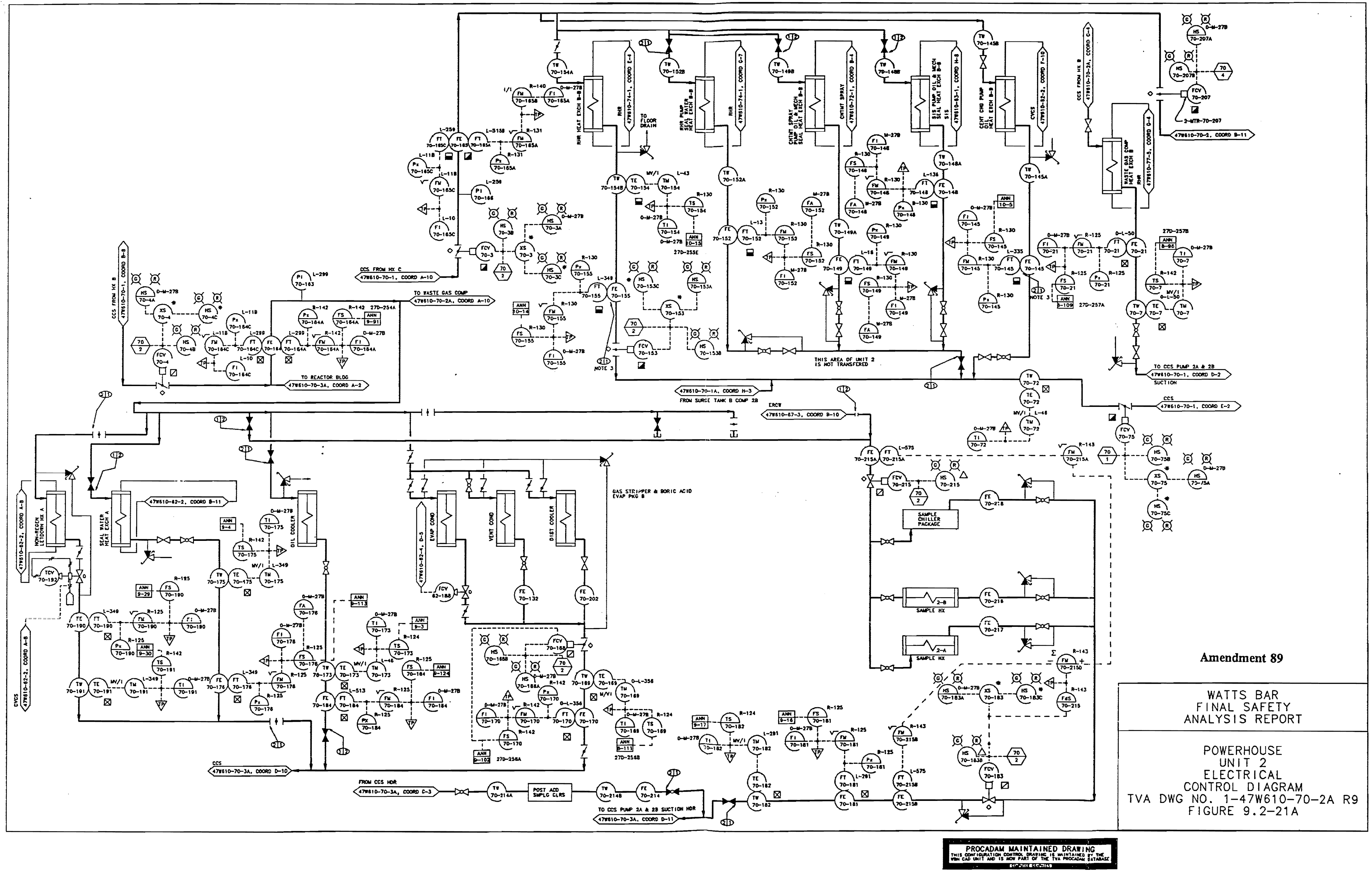

Figure 9.2-21a Powerhouse Unit 2 Electrical Control Diagram

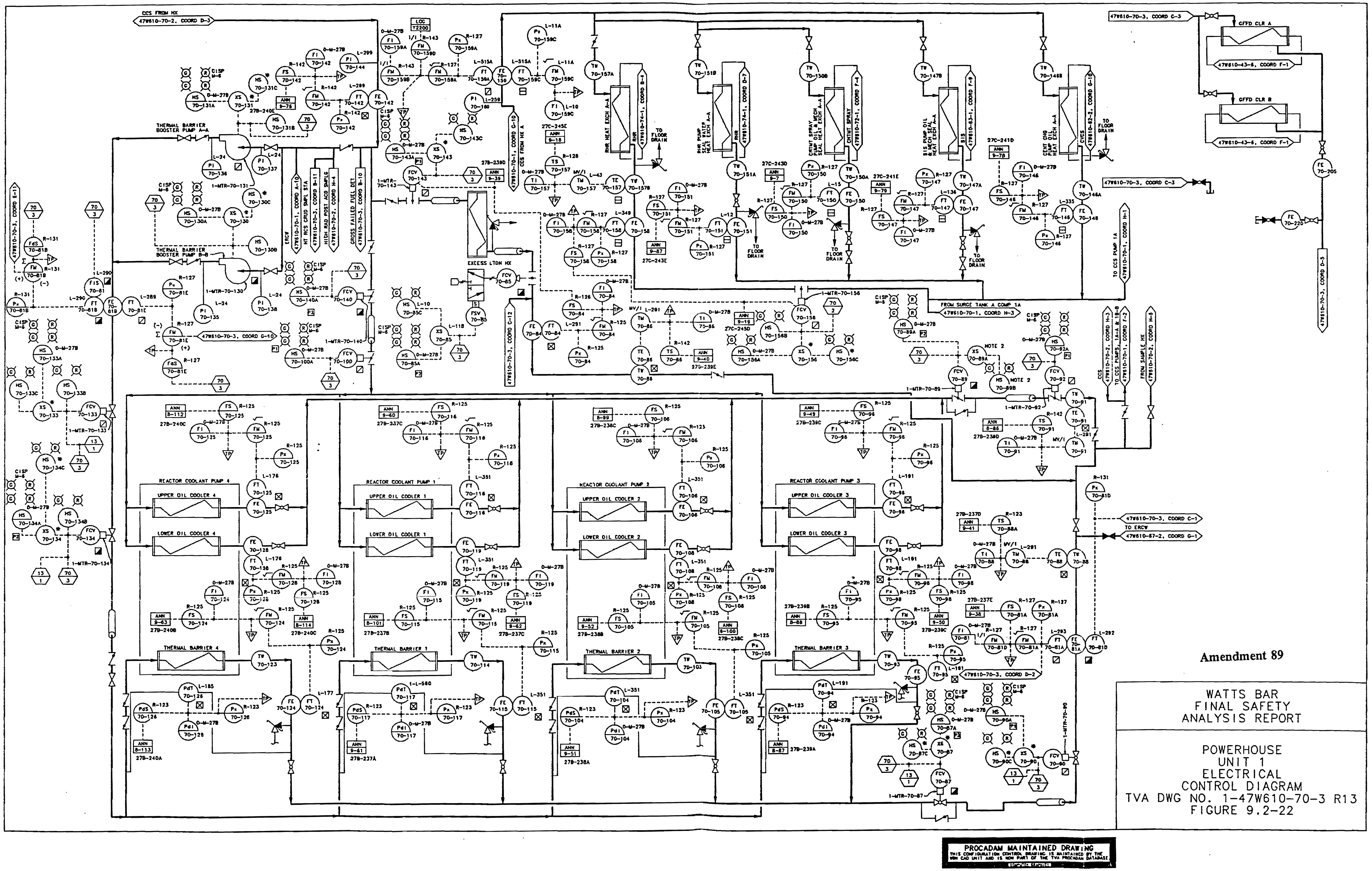

Figure 9.2-22 Powerhouse Unit 1 Electrical Control Diagram

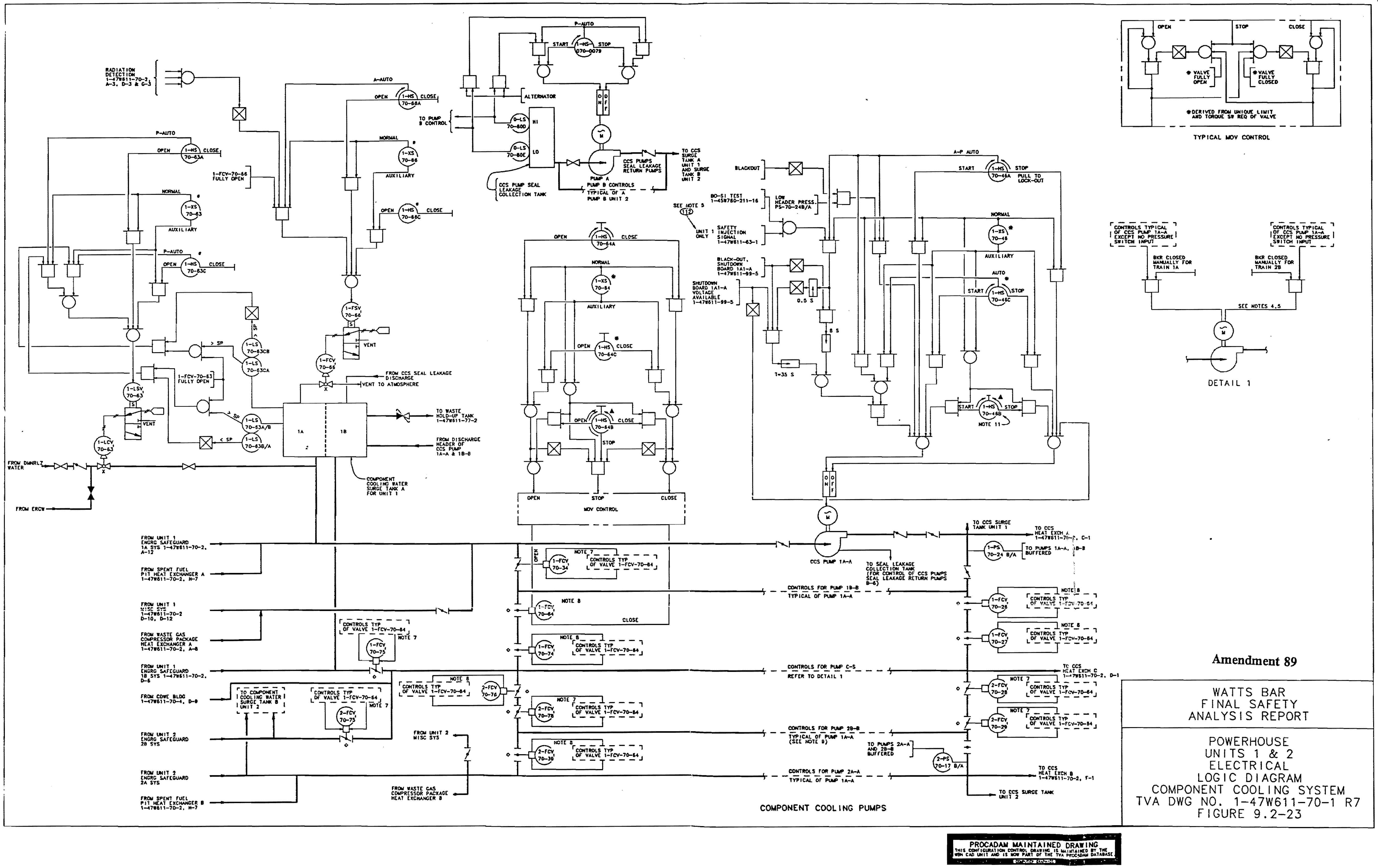

Figure 9.2-22a Powerhouse Unit 2 Electrical Control Diagram

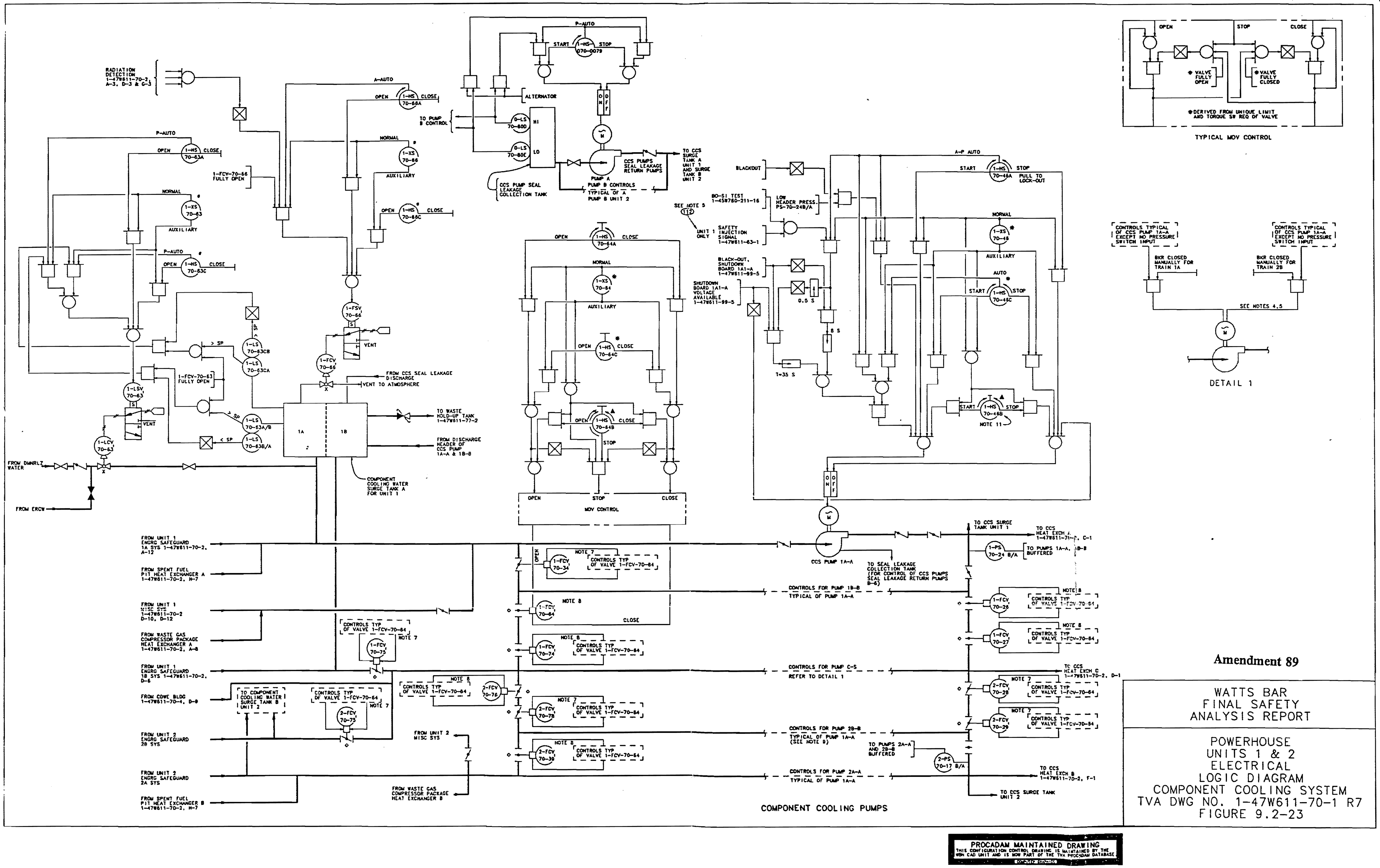

Figure 9.2-23 Powerhouse Units 1 & 2 Electrical Logic Diagram for Component Cooling System

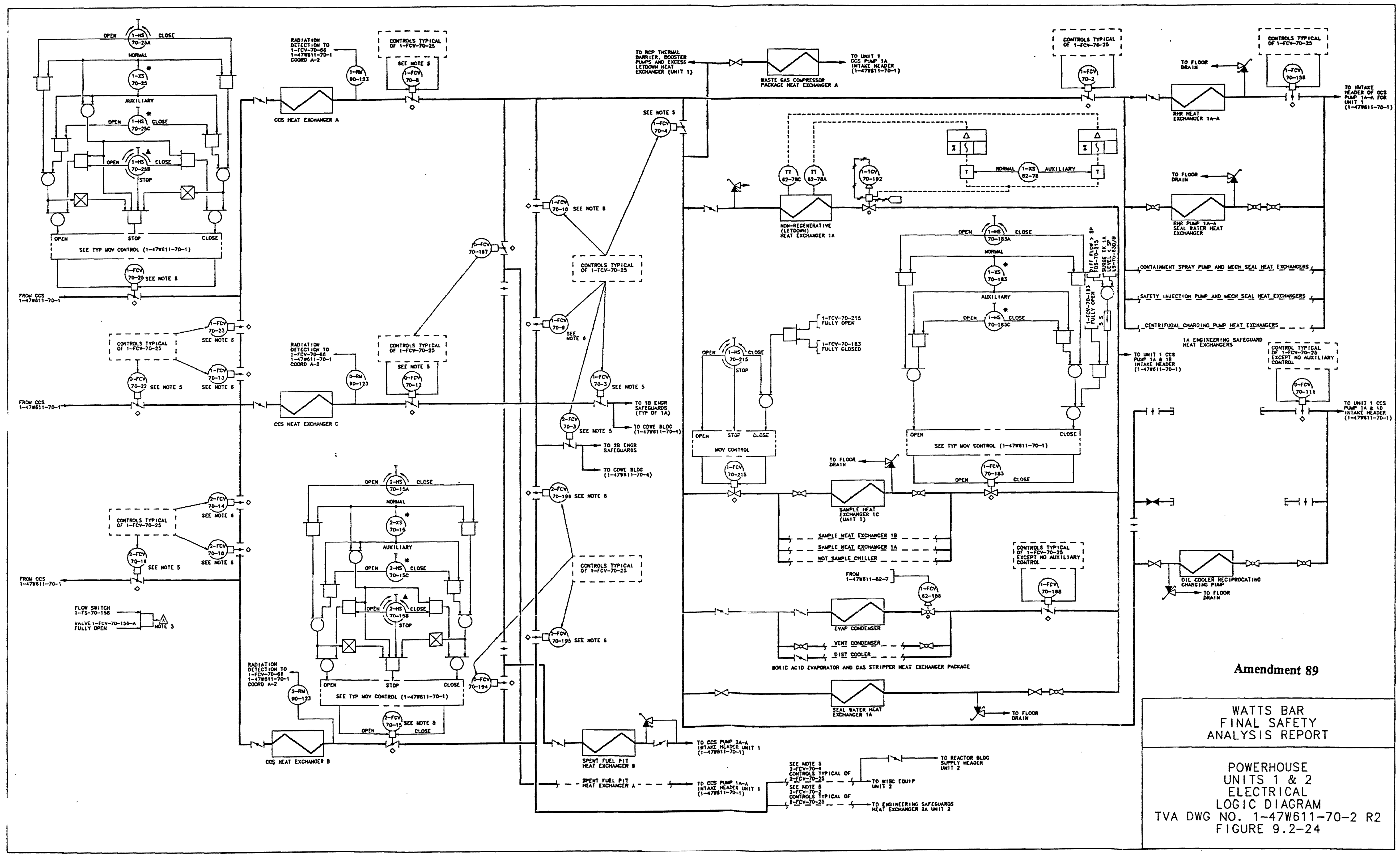

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Figure 9.2-24 Powerhouse Units 1 & 2 Electrical Logic Diagram for Component Cooling Water System

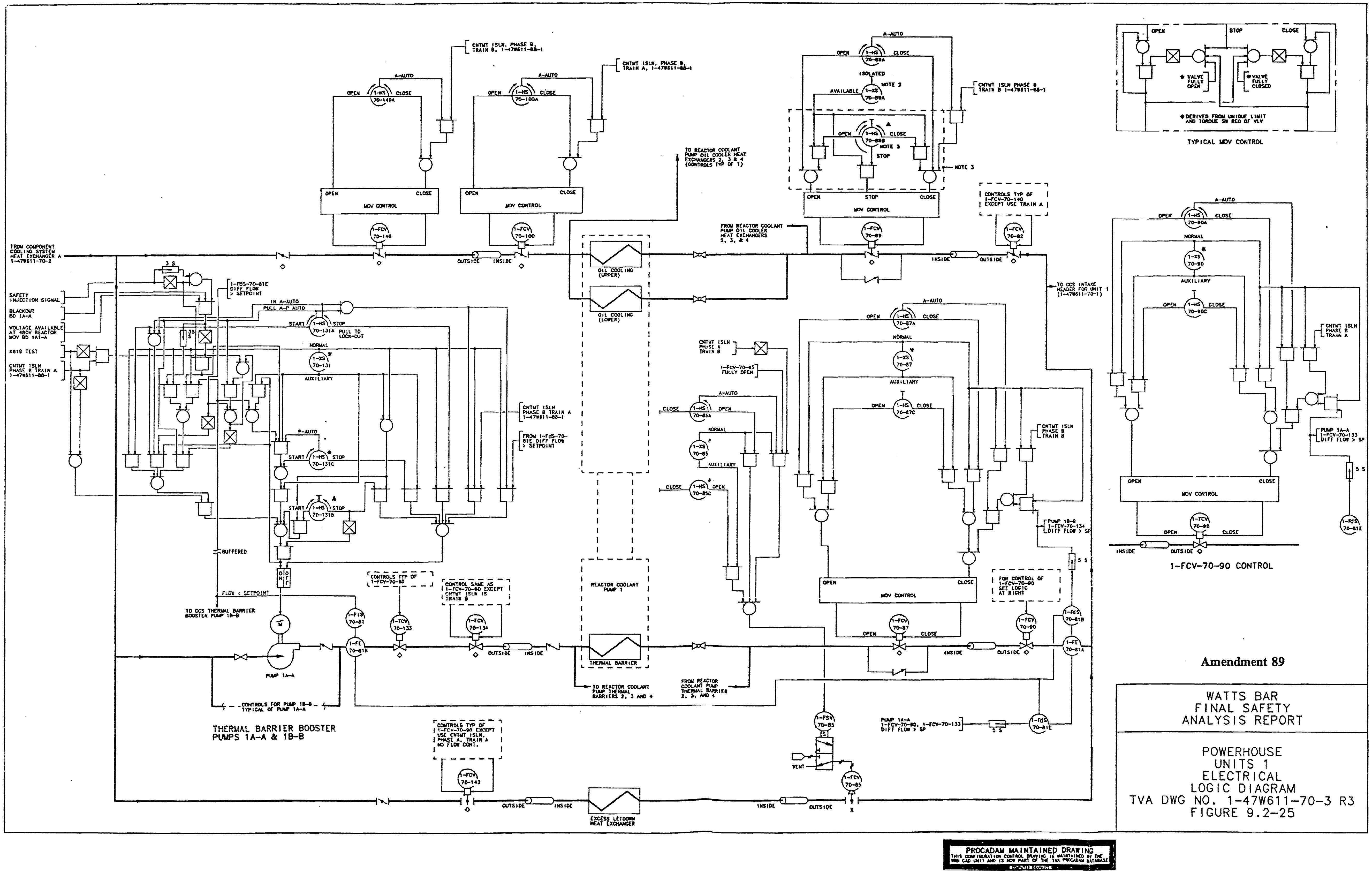

Figure 9.2-25 Powerhouse Unit 1 Electrical Logic Diagram

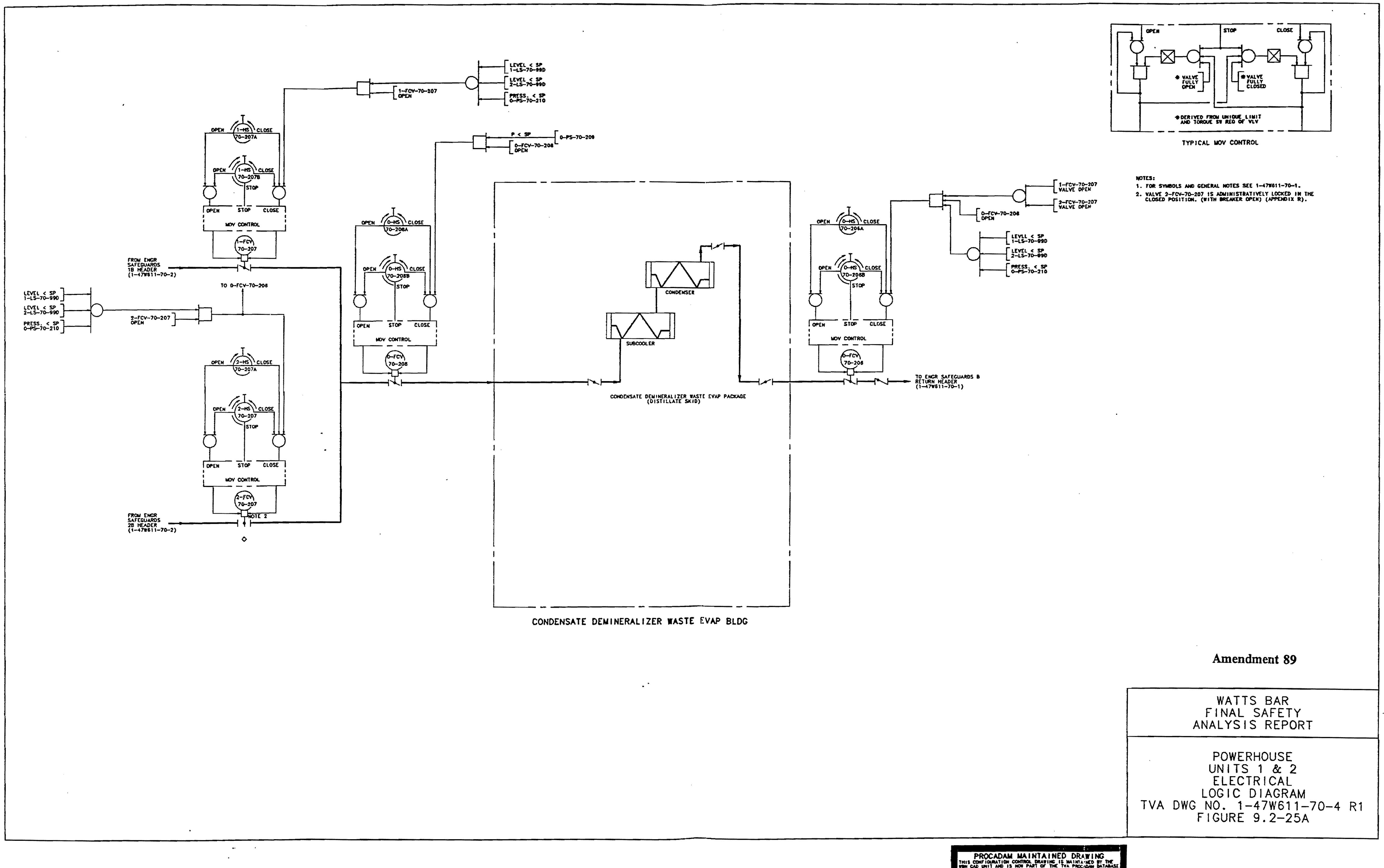

Figure 9.2-25a Powerhouse Units 1 & 2 Electrical Logic Diagram for Component Cooling System

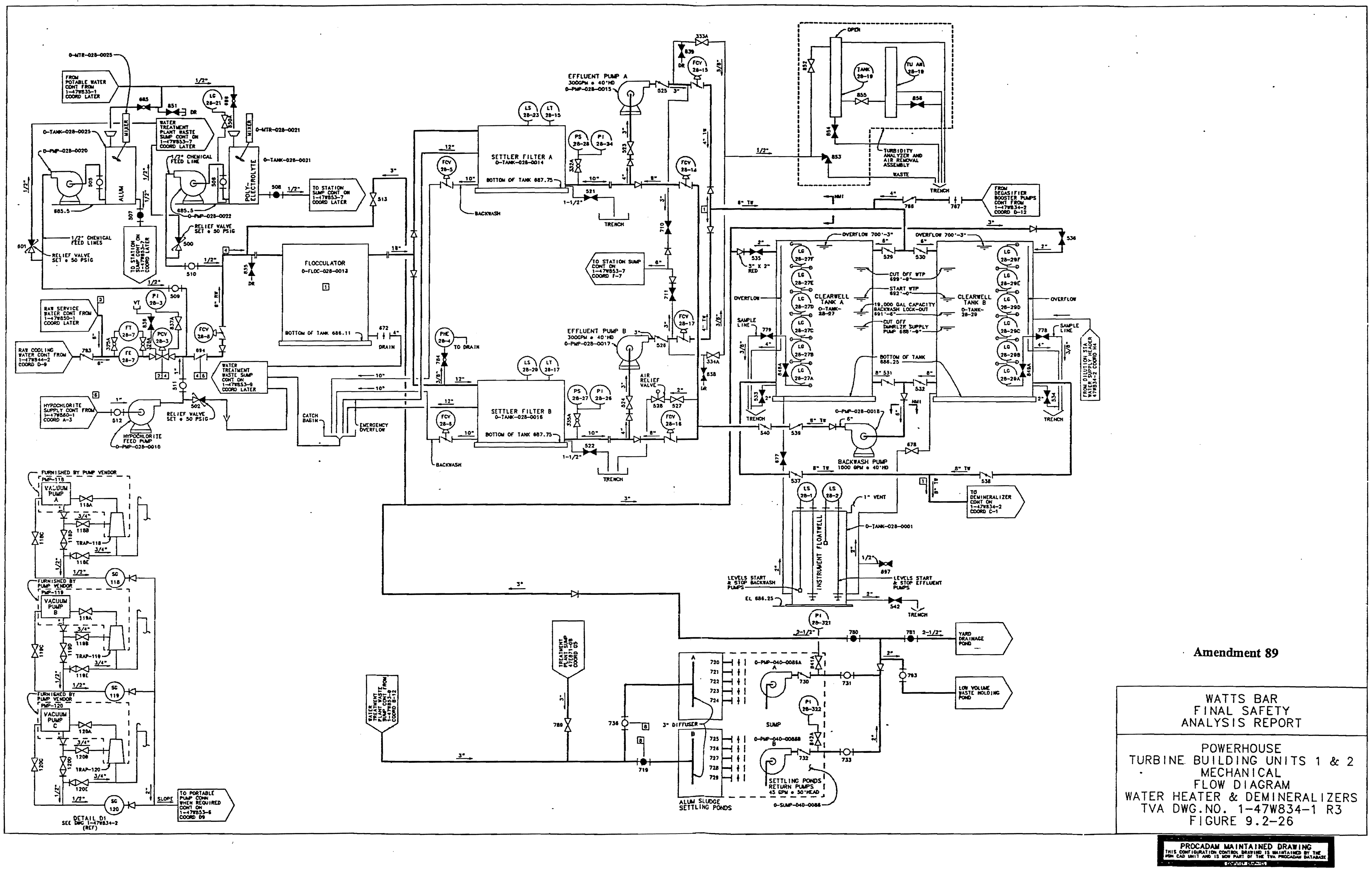

Figure 9.2-26 Powerhouse, Turbine Building Units 1 & 2 Flow Diagram for Water Heater and Demineralizers

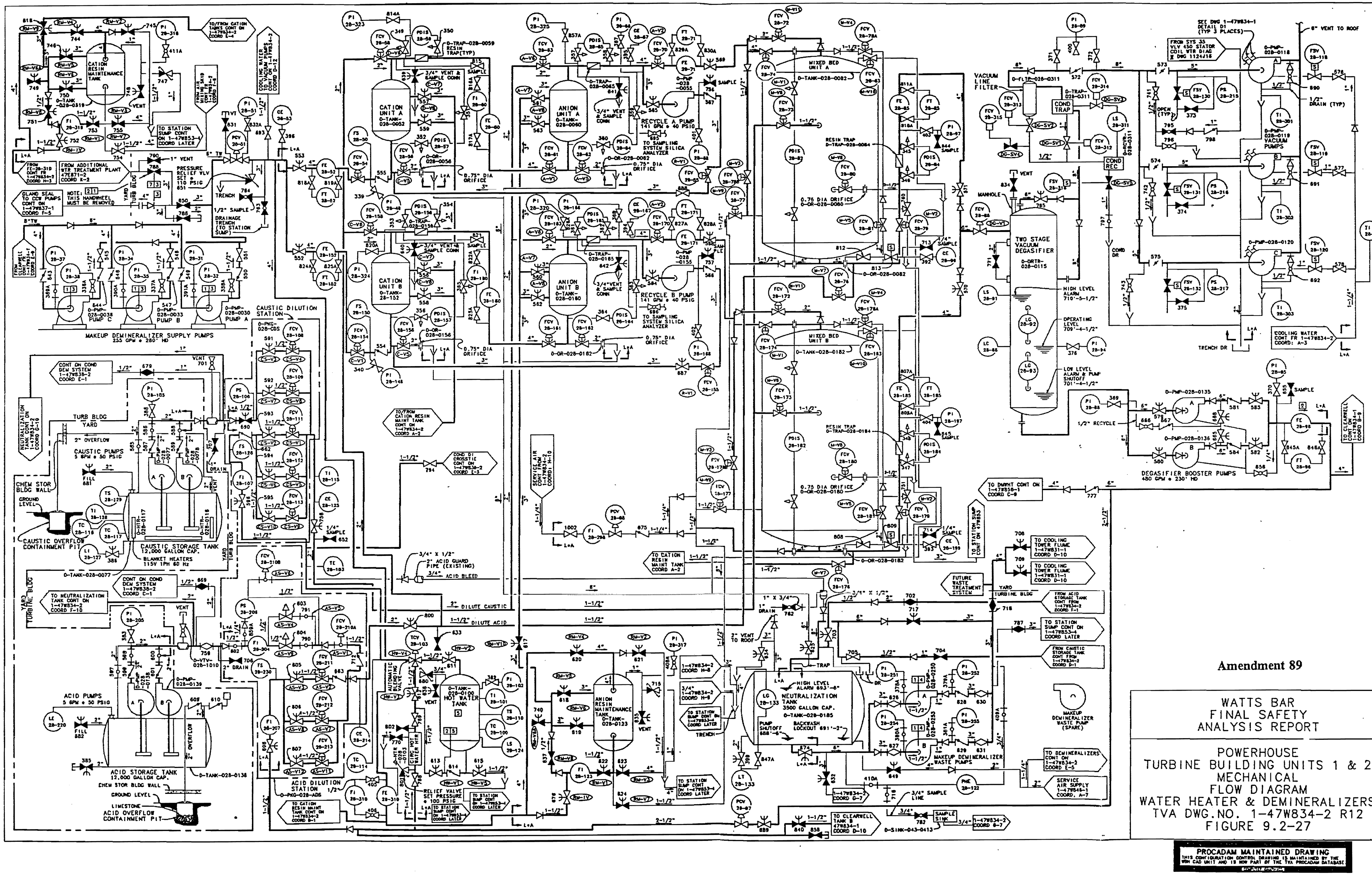

Figure 9.2-27 Powerhouse, Turbine Building Flow Diagram for Waterý Heater and Demineralizers

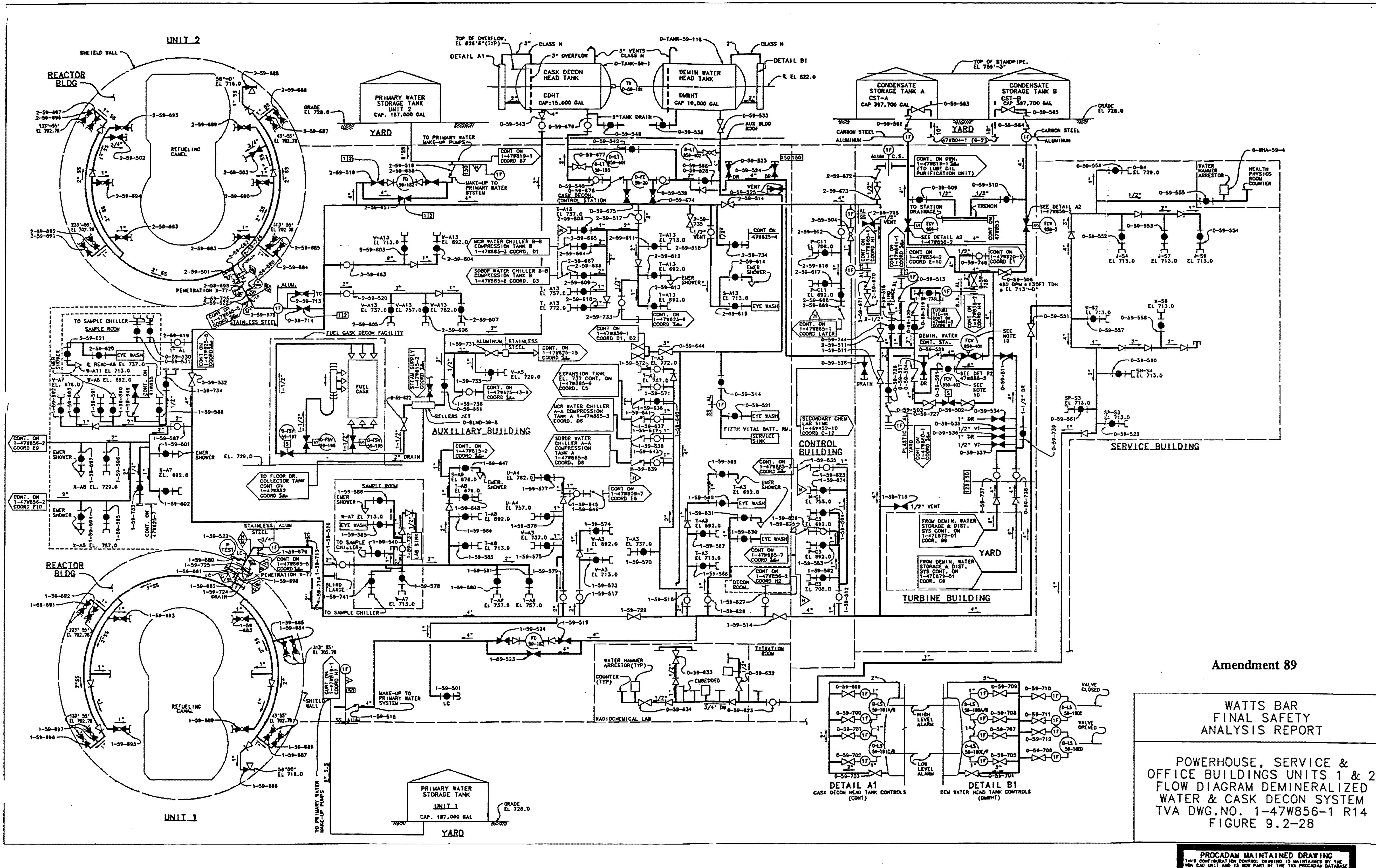

Figure 9.2-28 Powerhouse, Service & Office Buildings Units 1 & 2 Flow Diagram for Demineralized Water and Cask Decon System

Figure 9.2-29 Deleted by Amendment 62

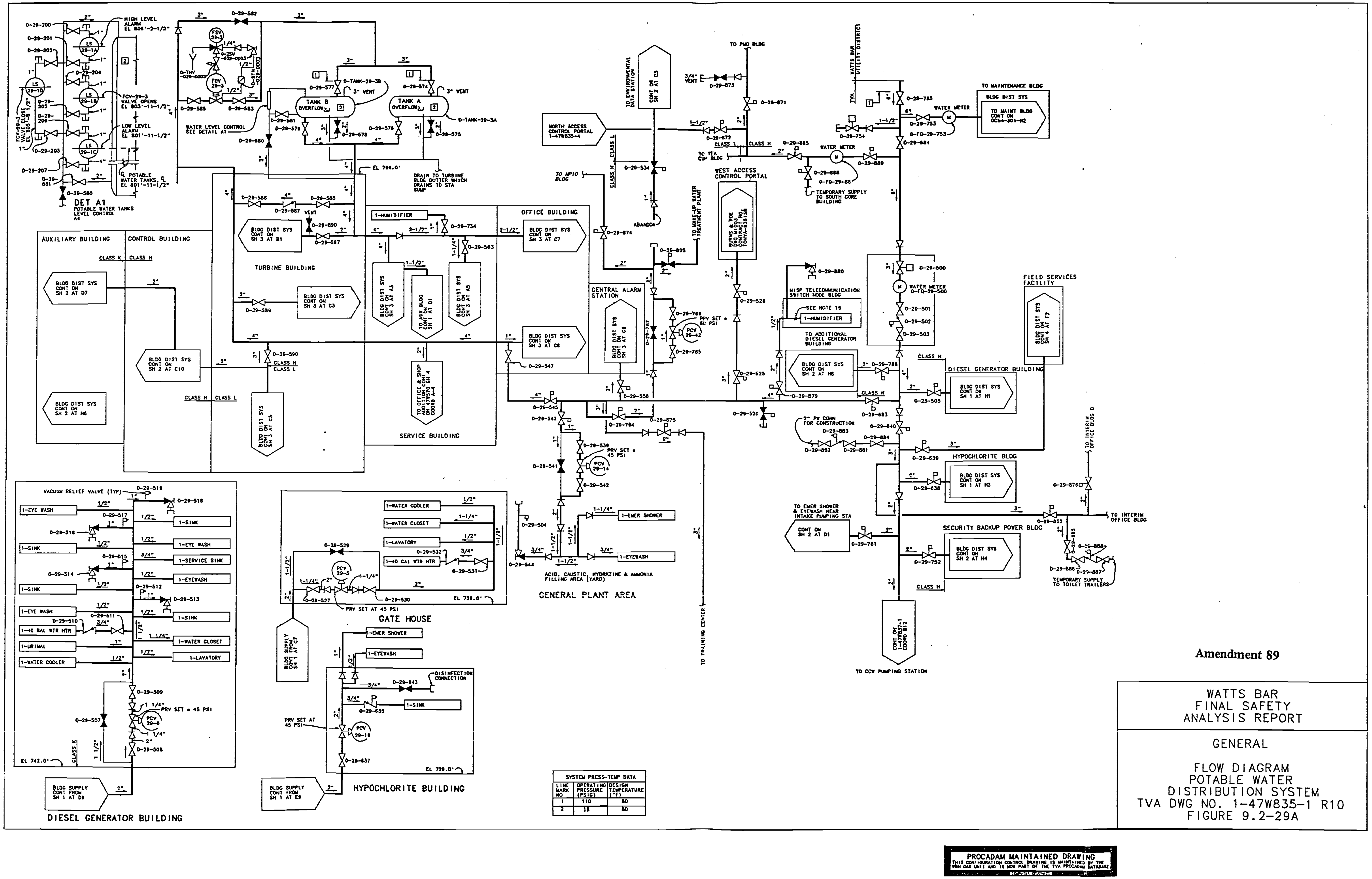

Figure 9.2-29a General Flow Diagram for Potable Water Distribution System

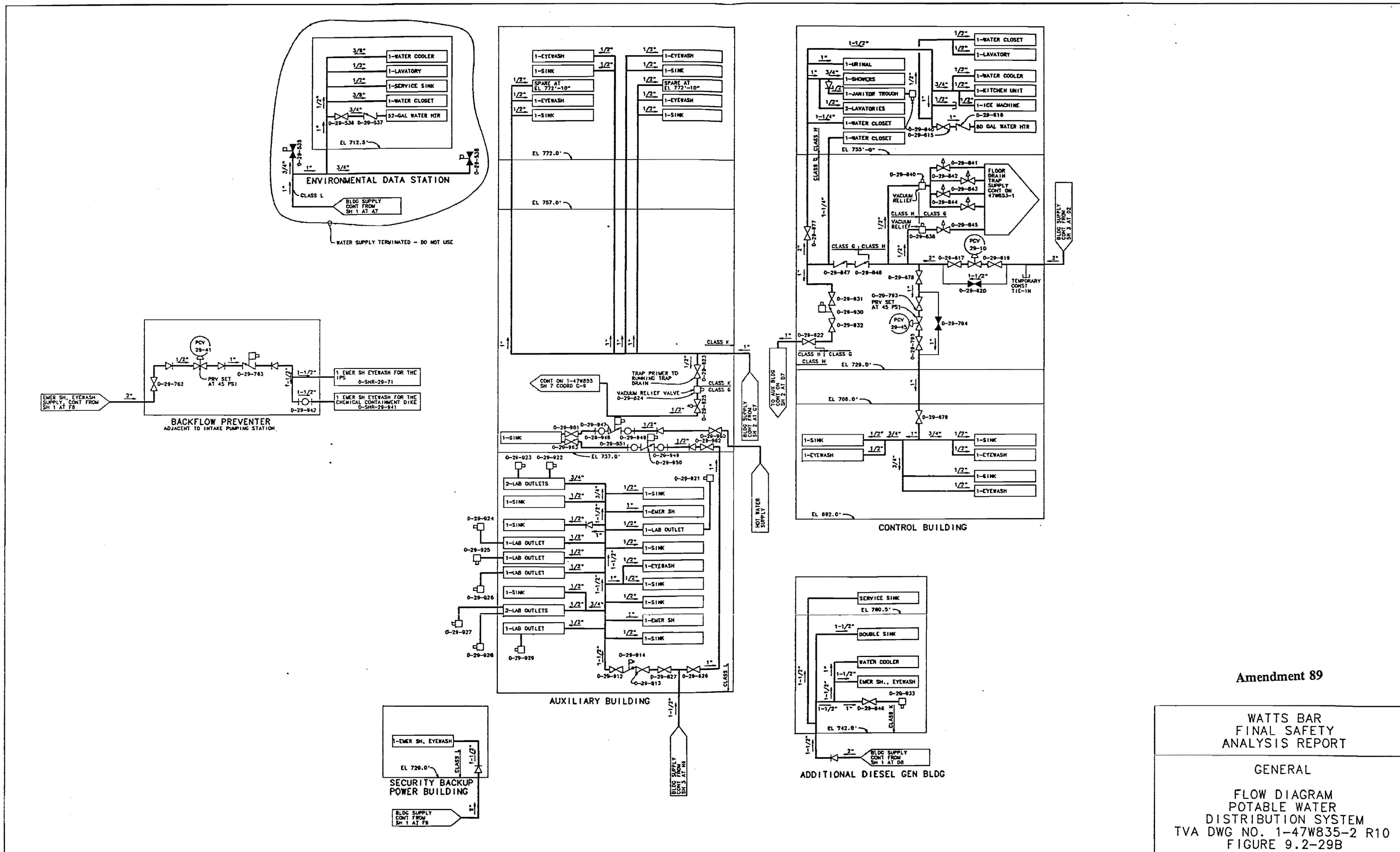

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Figure 9.2-29b General Flow Diagram for Potable Water Distribution System

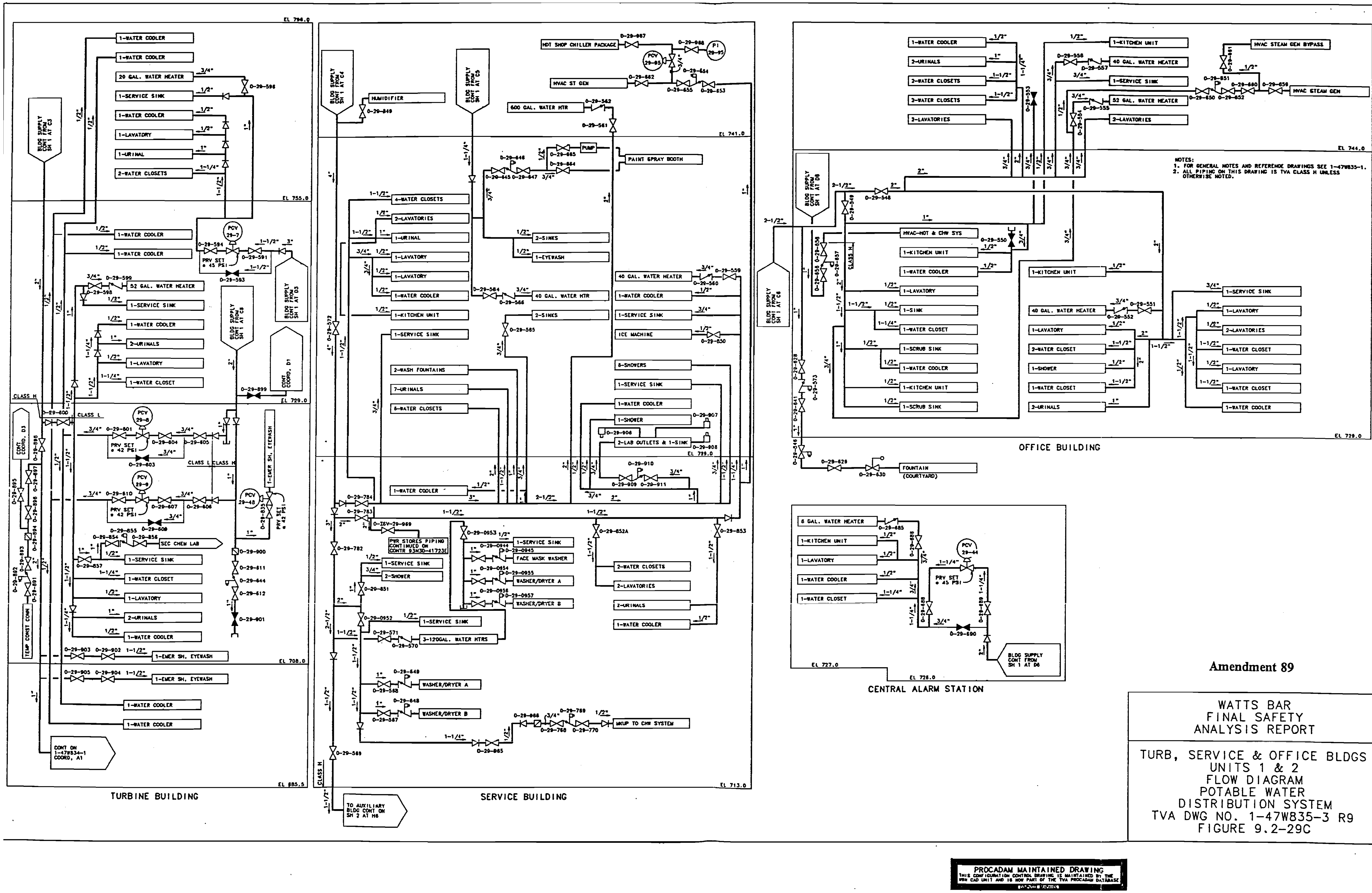

Figure 9.2-29c Turb, Service & Office Bldgs. Units 1 & 2 Flow Diagram for Potable Water Distribution System

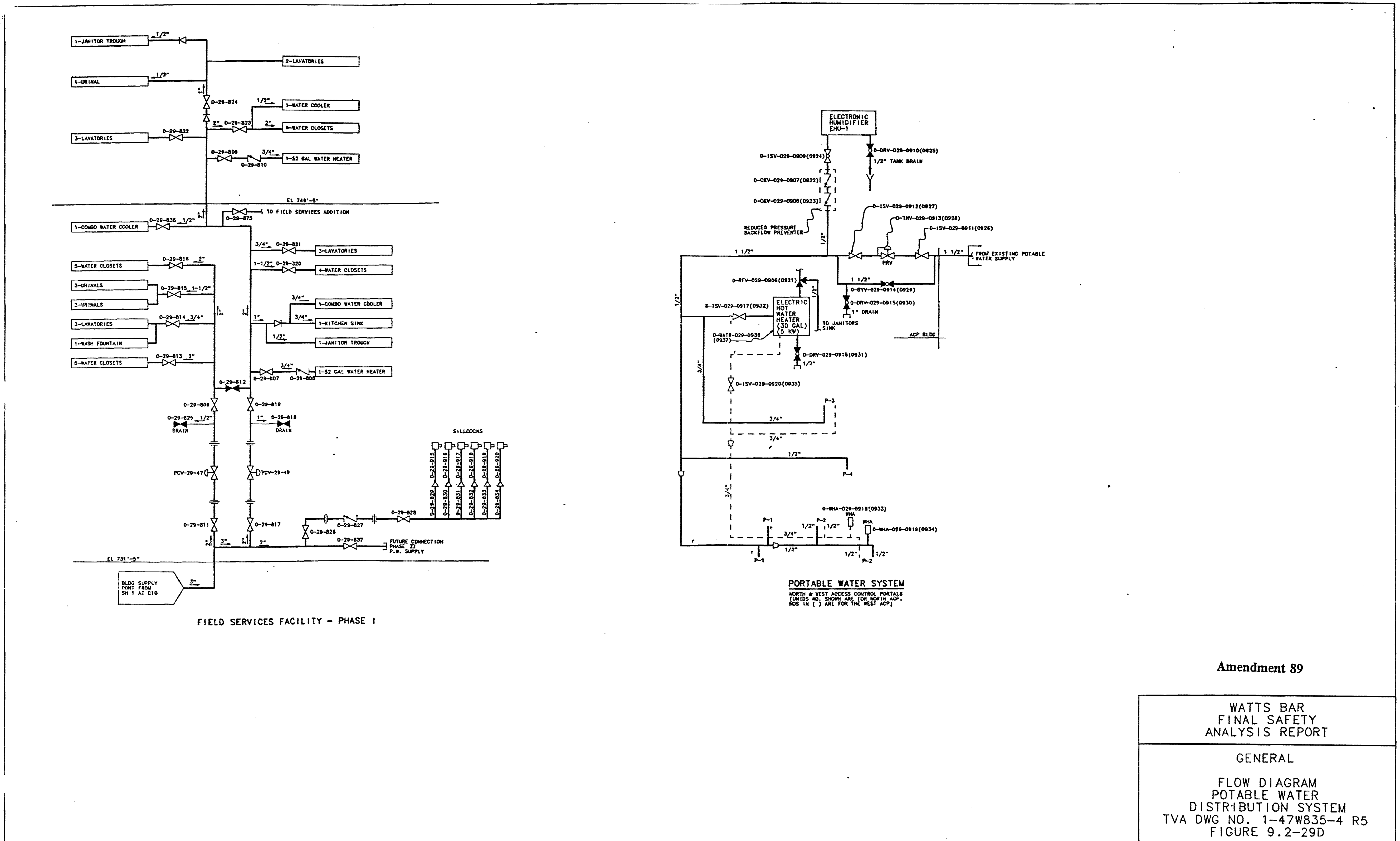

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Figure 9.2-29d General Flow Diagram for Potable Water Distribution System

Figure 9.2-30 Deleted by Amendment 94

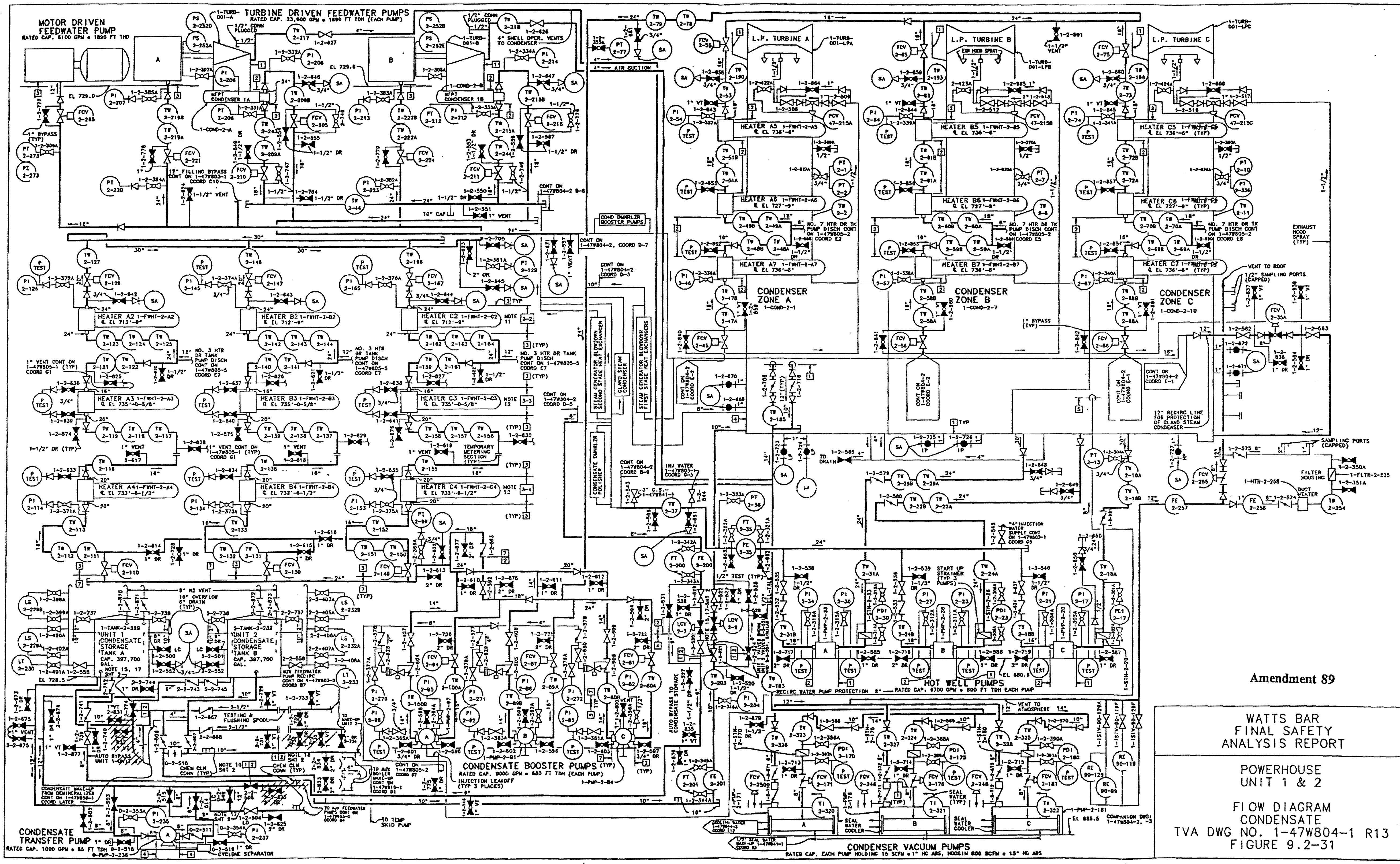

Figure 9.2-31 Powerhouse Units 1 & 2 Flow Diagram for Condensate

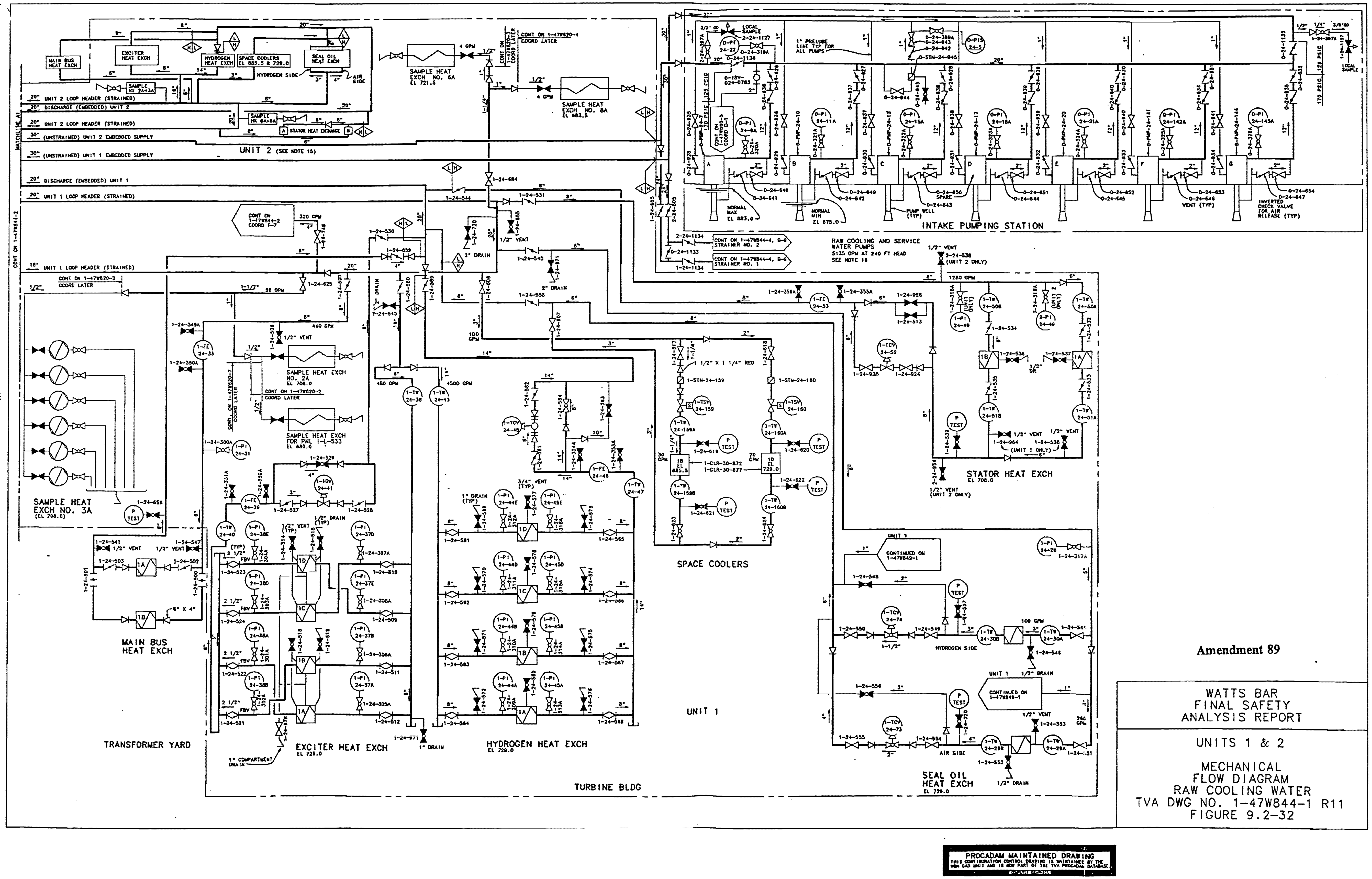

Figure 9.2-32 Powerhouse Flow Diagram for Raw Cooling Water

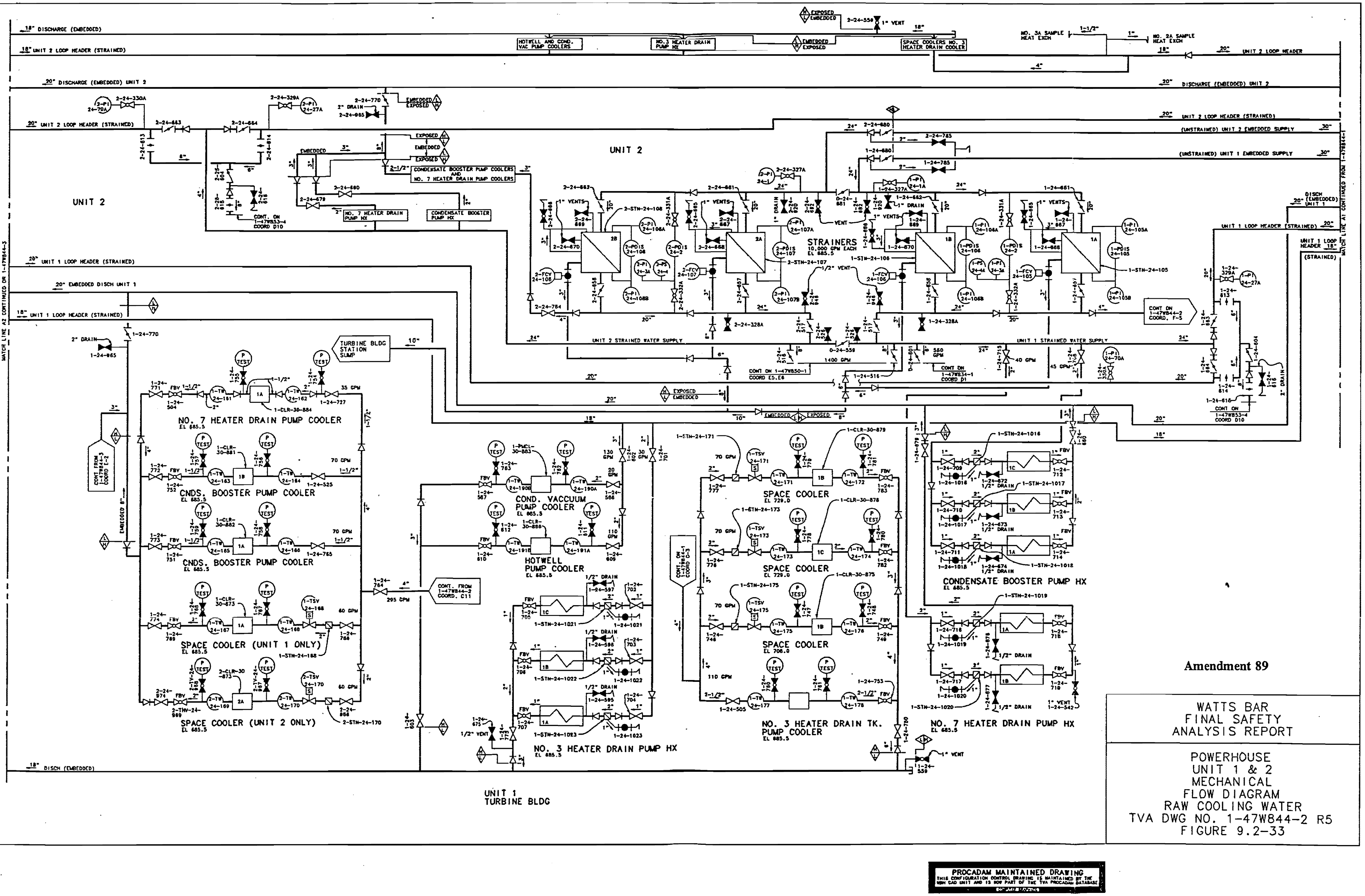

Figure 9.2-33 Powerhouse Flow Diagram for Raw Cooing Water

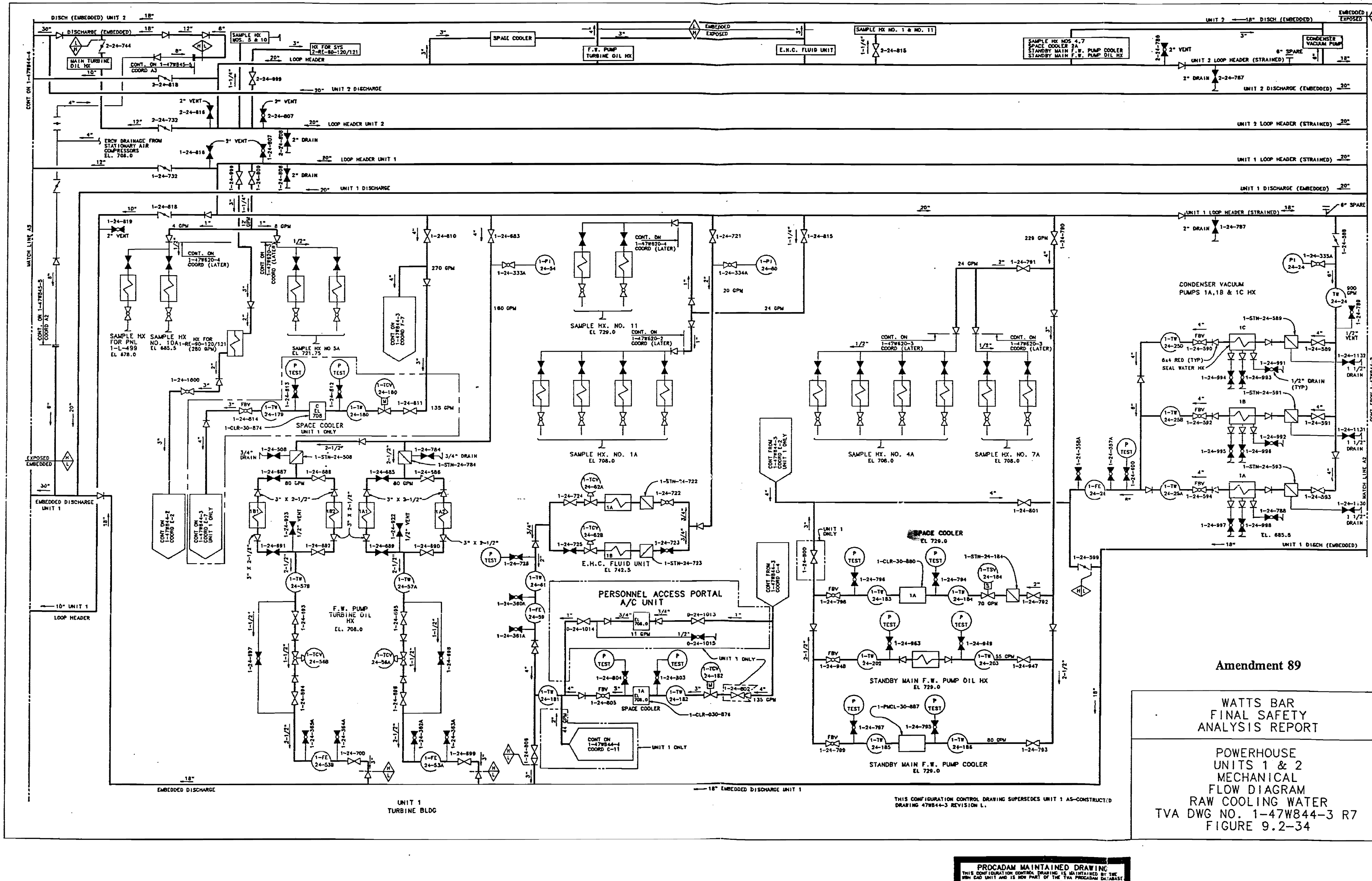

Figure 9.2-34 Powerhouse Flow Diagram for Raw Cooling Water

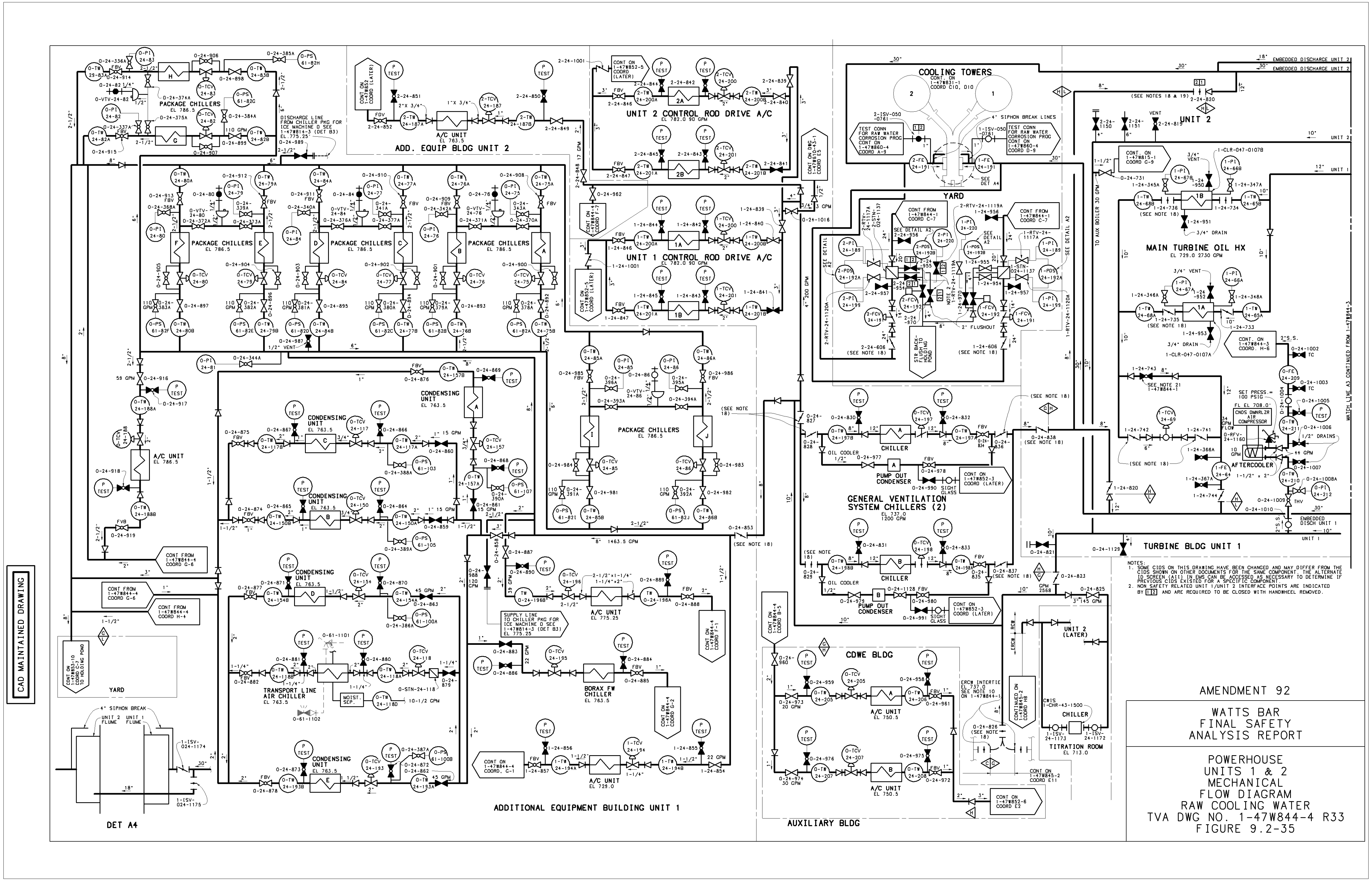

Figure 9.2-35 Powerhouse Units 1 & 2 Mechanical Flow Diagram for Raw Cooling Water

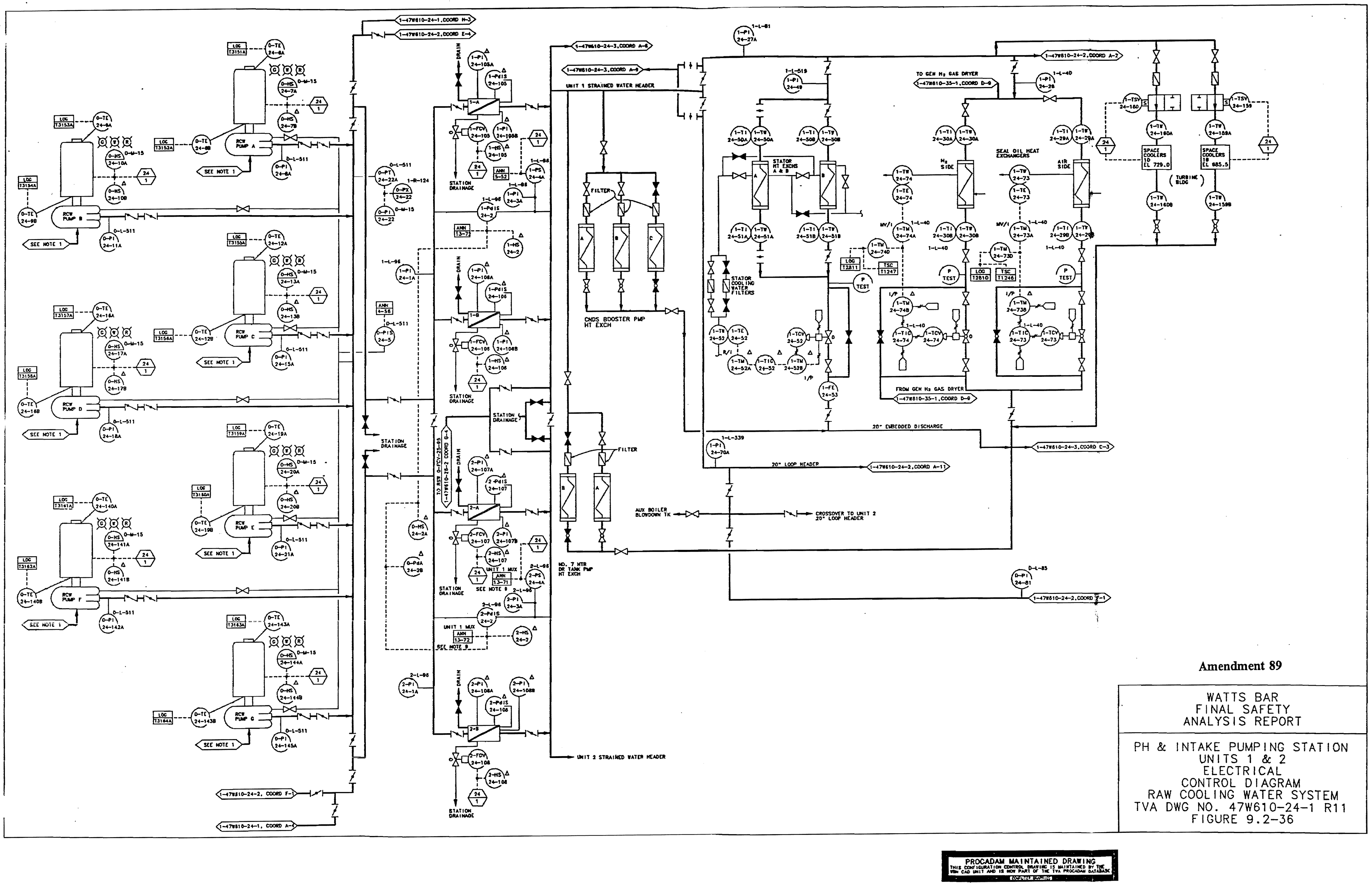

Figure 9.2-36 Powerhouse and Intake Pumping Station Electrical Control Diagram for Raw Cooling Water System

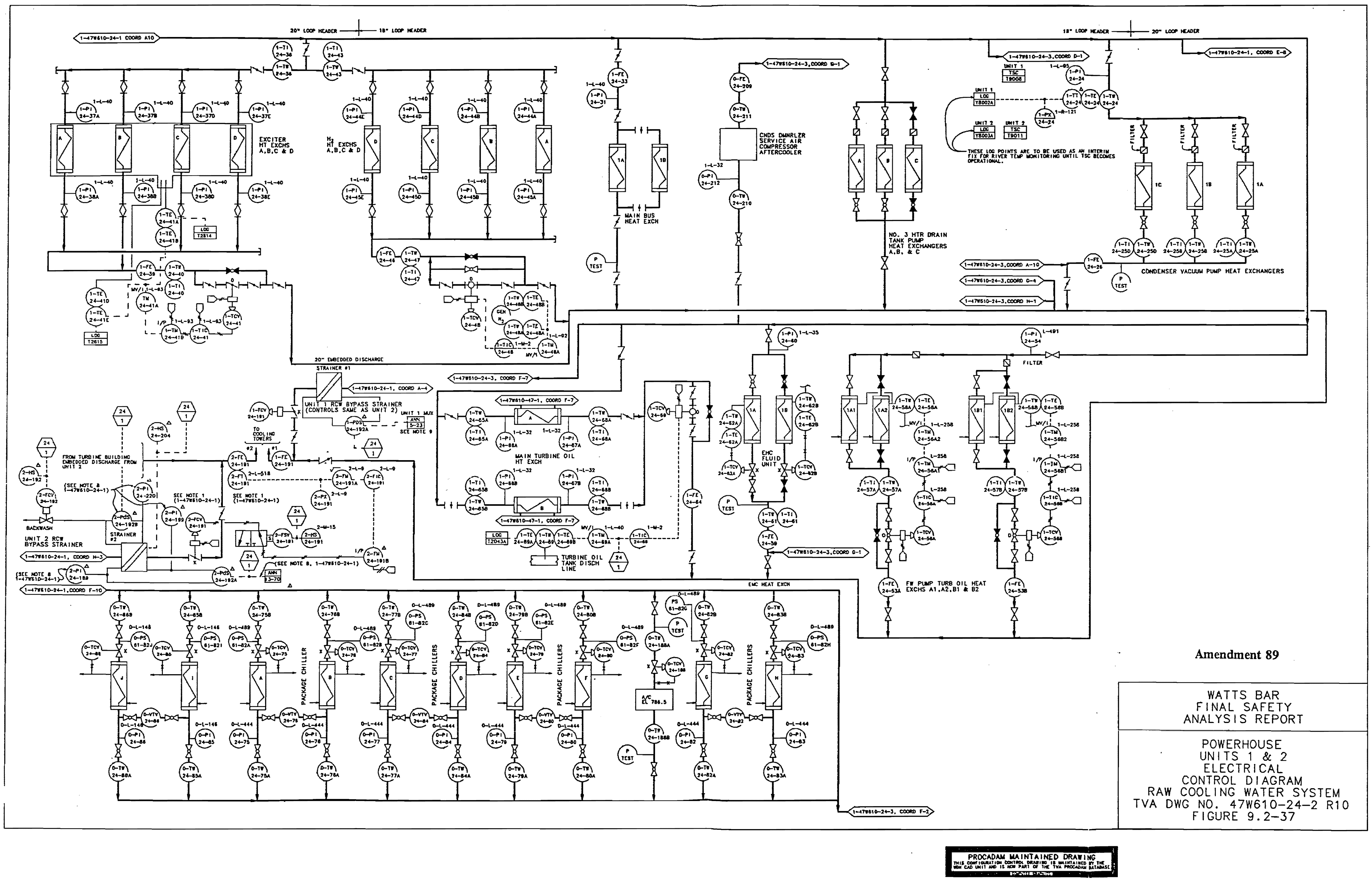

Figure 9.2-37 Powerhouse Units 1 & 2 Electrical Control Diagram for Raw Cooling Water System

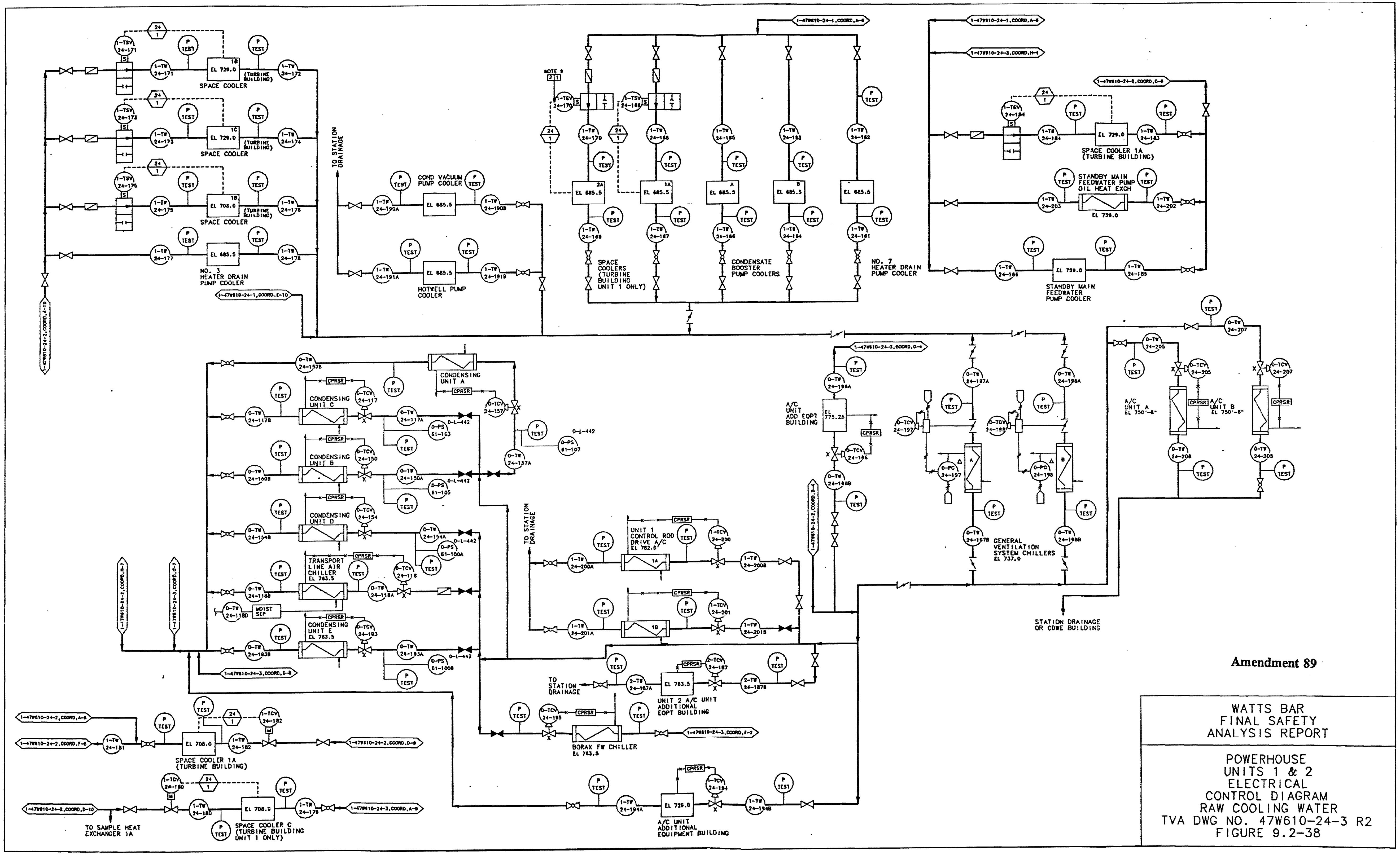

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Figure 9.2-38 Powerhouse Units 1 & 2 Electrical Control Diagram for Raw Cooling Water

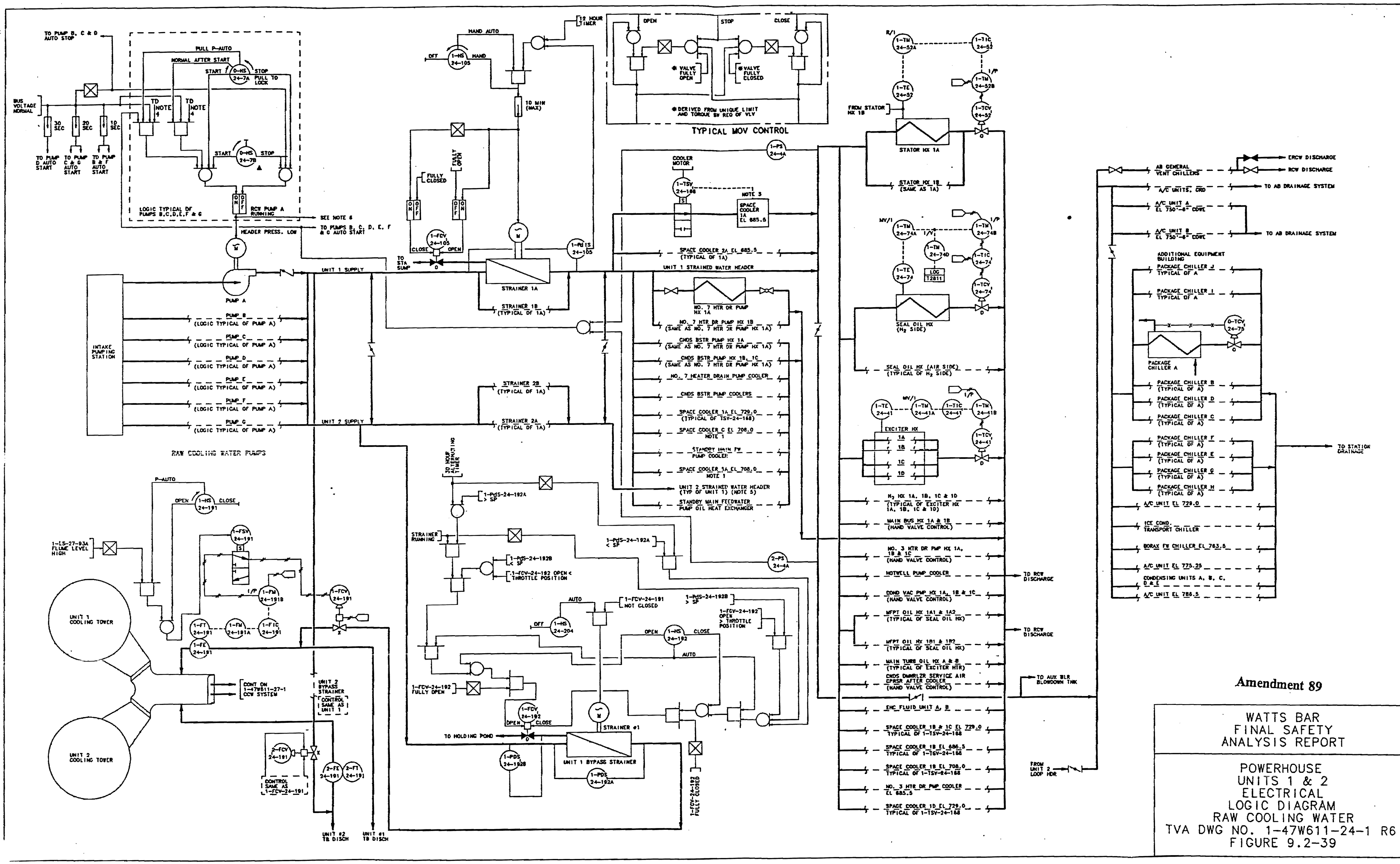

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Figure 9.2-39 Powerhouse Powerhouse Units 1 & 2 Logic Diagram for Raw Cooling Water

Security-Related Information - Withheld Under 10CFR2.390

Figure 9.2-40 Essential Raw Cooling Water Control Air and HPFP Piping (Unit 1)

9.3 PROCESS AUXILIARIES

9.3.1 Compressed Air System

9.3.1.1 Design Basis

The compressed air system is common to both units and is divided into two systems, the station control and service air system and the auxiliary control air systems for emergency use. The auxiliary control air system is comprised of two fully qualified and redundant trains or subsystems. The station control and service air system is designed to supply adequate compressed air capacity for general plant service, instrumentation, testing and control. Each subsystem of the auxiliary control air system supplies air to the auxiliary air distribution system of Unit 1 and Unit 2. The auxiliary air system ensures that all vital equipment will receive air from the appropriate assigned subsystem under all conditions, including safe shutdown earthquake and maximum possible flood.

9.3.1.2 System Description

Station control and service air is supplied by three motor-driven, non-lubricated, two stage, reciprocating compressors and one centrifugal air compressor. Two of the three reciprocating compressors or the centrifugal compressor will handle the total plant control air requirements under normal conditions with sufficient additional capacity to handle minimal service air requirements. With three reciprocating station air compressors operational and the centrifugal compressor shutdown for maintenance, the total plant control air and peak service air requirements will still be met. Peak service air requirements will occur during unit outages and other periods of heavy usage of pneumatic operated tools and equipment. The compressed air system includes normal accessory equipment such as intake air filters, cylinder cooling equipment, after coolers, and safety relief valves.

All four air compressors are provided with intake air silencers to reduce noise and vibration levels due to the resonance characteristics of the intake pipes.

The station compressors discharge into two redundant headers which are provided with manual isolation valves. These headers feed the two control air receivers which in turn supply air through redundant headers to the control air station. The control air station contains three complete trains of prefilters, dryers, and after filters. Each dryer train is sized to fully handle plant control air requirements for one unit. Manual bypasses are provided around each element for abnormal or emergency operation. The control air is then piped through two independent headers to valves, controllers, instruments, etc., throughout the plant.

Service air is supplied to the service air receiver by a single header from the control air receivers. Service air is supplied through a back pressure valve which closes if control air pressure drops below 80 psig, thus assuring that control air requirements take precedence over service air requirements. Service air is piped from the receiver to service outlets and miscellaneous equipment throughout the plant.

Auxiliary control air is supplied by two motor-driven, nonlubricated, single-stage, reciprocating compressors. Each compressor is sized to supply the total safety-related control air requirements in the event of an accident, flood, or loss of the station control air system. The auxiliary control air system (ACAS) is separated into two independent subsystems each containing its own compressor, receiver, dryer, and filter. The auxiliary control air piping is arranged so that the auxiliary receivers are charged from the non-qualified station control air system during normal operation. Electric power for the auxiliary systems is provided from both normal and emergency sources. The auxiliary control air system is located entirely within Category I structures and is designed to Category I seismic requirements. The auxiliary air system is automatically isolated from the station air system upon loss of air from the station system. Refer to the tabulation of descriptive information in Table 9.3-1.

The dryer and filter trains for both the station control and auxiliary control air systems are designed to give compressed air of high instrument quality. The auxiliary control air system inlet filters (from control air system) are designed to remove 100% liquid water entrainment and other foreign matter from the compressed airstream down to 0.9 micron size. The station control air prefilters are designed to remove 100% liquid water entrainment and other foreign matter from the compressed airstream down to 2 to 3 micron size. The air dryers dry the air to a dewpoint of 0°F or less at line pressure. The discharge of the auxiliary control air dryers is routed through an afterfilter which removes 100% of particles of desiccant and other foreign matter down to 0.9-micron size. The discharge of the station control air dryers is routed through three micron afterfilter elements which remove 100% of particles of desiccant and other foreign matter larger than 3 microns.

9.3.1.3 Safety Evaluation

The compressed air system meets General Design Criterion 5 and is designed to provide a highly reliable source of compressed air for all plant uses. The two independent auxiliary systems are powered from separate emergency electrical power sources to provide a single failure capability.

The station compressors are also powered from diverse electrical sources. One compressor is powered from the 480-volt Auxiliary Building common board, one from the 480-volt Turbine Building common board, and the other two from 480-volt shutdown boards. Two of the three reciprocating compressors or the centrifugal compressor will handle the total plant control air requirement. Thus two of the four station compressors can fail due to power loss, accident, or other cause, and system pressure will still be maintained. The compressed air system contains sufficient receiver capacity to supply air for several minutes. The loss of all four station compressors would result in the shutdown of both units after this reserve is expended. Loss of station control air pressure from an accident such as a pipe break would result in the shutdown of both units if the break was not manually isolated before system pressure fell below the point required to sustain plant operation. The auxiliary compressors will start automatically when the system pressure in its respective trained receiver falls below 80 psig.

The control air dryers are divided into three independent units each containing a prefilter, a dryer, and an afterfilter. The loss of a dryer unit would result in a high moisture content in the air. This would be alarmed by moisture sensors located in the discharge headers. The air supply would then be diverted to the spare dryer unit.

The station air compressor system is designed for 115 psig and arranged for parallel operation. The maximum system pressure is 105 psig. For reciprocating compressors A, B and C, further protection against system overpressure is provided by safety relief valves set at 115 psig placed between the reciprocating compressor and the aftercooler and on each receiver for the main air system. Safety relief valves are also placed on the auxiliary air compressors and auxiliary air receivers. These valves are also set at 115 psig. Station air compressor D has a relief valve located on its pulsation dampener.

The station air compressors and dryer units are located on Elevation 708.0 in the Turbine Building. The building at this elevation is not a Category I structure and is below plant grade. Therefore, the main air system must be considered inoperable during (or after) a seismic event and flooding above plant grade. The two independent auxiliary air systems are located on Elevation 757.0 of the Auxiliary Building. This is a Seismic Category I structure and above maximum possible flood elevation.

The auxiliary air systems are designed to Seismic Category I requirements; since they are completely separated, a single failure cannot render both systems inoperable. The auxiliary compressors start automatically upon loss of air from the main system for any reason. The auxiliary air system is automatically isolated from the main air system whenever the system pressure falls below 79.5 psig.

Each auxiliary air system is sized and equipped so that ample system capacity is provided for both units under all design basis accident conditions. Redundancy and train separation have been provided in the auxiliary compressed air system to the extent that no initial 'design basis event' followed by an arbitrarily selected 'single active failure' will prevent the system from performing its necessary safety functions. Total plant design is such that even total loss of all air will not prevent safe shutdown of both units, assuming no breaks in the primary or secondary piping.

The station control and service air system performs no safety related function. Containment penetration piping is installed to TVA Class B (Safety Class ANS-N-182) requirements and is an integral part of the containment isolation system. Also, station air system piping located inside Seismic I structures is installed to Seismic Category I(L) requirements (see Section 3.2.1). It normally supplies air to both trains of the auxiliary control air system, but is automatically isolated when the output pressure drops below an acceptable value.

A failure modes and effects analysis (FMEA) for the compressed air system has been performed and a summary of the result is presented in Table 9.3-7. Since the station control and service air is a non-essential system, the scope of the FMEA for the compressed air system will include only an analysis of the auxiliary control air system. The ERCW system, floor drainage, high pressure fire protection, and the normal and emergency power systems define system interfaces with the auxiliary control air system. The redundant ERCW and emergency power trains are assigned to the appropriate redundant auxiliary control air system. All equipment receiving auxiliary control air is listed in Table 9.3-8.

The auxiliary compressor suction is taken from a nonfiltered area. Calculations were performed to verify that the amount of radioactivity introduced into the main control room (MCR) habitability area during an accident condition is not significant. Also, as an additional safety precaution, the air lines leading into the MCR are filtered by charcoal and HEPA filters.

A safety precaution was also provided to protect the MCR from airborne contaminants in the event of a pipe leak that may originate from the fire protection system, which was routed inside the MCR. The air supply to the fire protection system was provided with an orifice and a seismically qualified check valve.

The auxiliary control air systems are used to ensure plant safety, even if the station control and service air system fails for any reason.

Safety-related components and equipment which require instrument air to perform an active safety function are supplied from the auxiliary control air compressors. These safety-related items and their related safety functions are identified below and discussed in the indicated FSAR sections.

(1) Auxiliary Feedwater (AFW) system steam generator level control and pressure control valves (Section 10.4.9) - These valves are required during all AFW operating conditions,

(2) Main steam atmospheric relief valves (Section 10.1) - control of these valves are necessary during flood mode operation,

(3) Auxiliary building gas treatment system (ABGTS) - flow control and isolation dampers (Section 6.2.3),

(4) Emergency gas treatment system (EGTS) isolation and flow control dampers and valves (Section 6.2.3),

(5) Control Building HVAC isolation and flow control valves, dampers, temperature controllers, transmitters, and other pneumatic instruments (Section 9.4.1),

(6) Radiation monitoring system containment isolation valves,

(7) RCS pressurizer spray line pressure control valves (Section 5.5.10)

(8) Sample isolation valves for radiation monitoring equipment which are required to remain functional during and after a safe shutdown earthquake, as discussed in Section 5.2.7.6, will be supplied with essential control air from the ACAS.

9.3.1.4 Tests and Inspections

Preoperational testing of the compressed air system and components is to be performed in compliance (see Section 14.2.7 for exceptions) with the requirements of Regulatory Guide 1.68.3, April 1982, 'Preoperational Testing of Instrument and Control Air Systems'. The compressed air system preoperational tests are discussed in more detail in Chapter 14.

Periodic tests will be performed after plant startup to ensure proper operation of the auxiliary system and isolation valves.

9.3.1.5 Instrumentation Applications

The control air system is designed to operate automatically. The auxiliary systems are started automatically upon loss of air pressure from the primary system. Control room instrumentation monitors control air pressure. Position lights indicate closure of any isolation valve. Audible alarms are produced in the MCR for high compressor oil temperature, low oil pressure, high discharge air temperature, high dewpoint of auxiliary control air, and low auxiliary control air pressure. Local indication of air pressure at various points and air temperature, is also provided in addition to local trouble lights. See Figure 9.3-1 and 9.3-2 for detailed control application, Figures 9.3-3 and 9.3-4 for logic, and Figures 9.3-5, 9.3-5A, and 9.3-6 for the detailed flow diagrams.

9.3.2 Process Sampling System

9.3.2.1 Design Basis

The process sampling system is composed of both the routine and post accident sampling subsystems. The routine sampling subsystem is designed to obtain samples from the various process systems in each of the two units. The samples are obtained in the titration room, hot sample room, or locally (grab samples) for laboratory analysis. This system has no primary safety-related function except for containment isolation valves. During a loss-of-coolant accident, this system is isolated at the containment boundary.

The postaccident sampling subsystem (PASS) is used to acquire samples of the reactor coolant and containment atmosphere during a loss of coolant accident (LOCA). This system has no primary safety-related function. However, the operation of this subsystem requires the operation of various closed containment isolation valves. The PASS is discussed in Section 9.3.2.6.

9.3.2.2 System Description

The routine sampling subsystem consists of the following collection areas and equipment:

(1) The titration room where secondary process system samples are routed for automatic analysis of several variables such as pH, conductivity, dissloved oxygen, and sodium. Typically these variables are indicated and recorded, and any variable exceeding established limits is annunciated.

In addition, nonradioactive grab samples are obtained in this room.

(2) The hot sample room where primary samples are routed for automatic analysis of several variables such as pH, sodium and conductivity. These variables are indicated in the hot sample room and typically recorded in the titration room, except the evaporator condensate demineralizer samples which are recorded in the hot sample room. Any variable exceeding established limits is annunciated. Most hot sample room samples are radioactive grab samples which are taken to the radiochemical laboratory for further analysis.

(3) Local grab samples are taken throughout the plant for detailed chemical and radiochemical analysis. These samples are analyzed either onsite or offsite, depending upon the analyses required.

(4) The boron analyzer, as described below, is not used for Unit 1 operations, and is not used in identifying boron concentration in RCS. During full power operations, primary system sampling is conducted once every week to determine boron concentration. Since periodic sampling can effectively measure boron concentration in RCS, the boron analyzer is not relied upon to provide indications of boron concentration. Periodic sampling is described below. Boron concentration monitors (one per unit) are also located in the hot sample room. The reactor coolant system (RCS) letdown system boron concentration is monitored using these monitors, recorded, and displayed in the main control room (Panels 1-M-6 and 2-M-6).

(5) A gas analyzer system sequentially monitors points in the waste disposal and chemical volume and control systems for hydrogen and oxygen concentrations in a nitrogen atmosphere. The concentrations are displayed, and recorded, and an alarm is given at the analyzer when appropriate.

The routine sampling subsystem is operated manually throughout the full range of operations. Sample lines originating within containment have isolation valves near the sample point and inside and outside containment for automatic containment isolation. Sample lines outside containment normally have manual isolation valves. Sample line isolation valve hand switches are normally located on a wall panel in the hot sample room. Each sample line to the titration or hot sample room cubicles normally has indicators for pressure, temperature, and flow rate. Samples, whether local or to a sample room, normally have pressure throttling valves and heat exchangers (if required).

To ensure that representative samples are obtained, the sample points are normally located in a free-flowing stream and the sample takeoff points are normally on the side of the horizontal pipes. Prior to the collection of a sample, each sample line is purged of stagnant process fluid. The volume of fluid purged and the volume of sample collected are dependent on the stream being sampled, length of sample line, and analysis to be performed.

Process sampling of the RCS is used to detect failed fuel. RCS sampling is used to determine gross specific activity and dose equivalent I-131 analyses. The gross specific activity is performed every seven days and the dose equivalent I-131 specific activity is performed every fourteen days, both during power operation. Operations is notified if a negative trend or significant change develops in the analysis.

Process sampling of the RCS is also used to measure boron concentration. Boron concentration measurement is performed once every week, during power operation. Operations is notified if a negative trend of significant change develops in the analysis.

Each sample is listed in Table 9.3-2 giving the sampled system, sample location, system design temperature and pressure, sample type (local, titration room, hot sample room, gas analyzer, or boron concentration monitor). Sampling lines from systems covered by TVA Classes A, B, C and D from root valve through first valve in sampling lines, or through second containment isolation valve if sample lines are extensions of containment, are the same class or higher as the sampled systems. Also, sample lines which form a primary pressure boundary for the boron concentration monitor are TVA Class B. Each of these sample lines which interface with TVA Class A piping has a 3/8 inch O.D. The sample line itself serves as a flow restrictor. Sample lines in Seismic Category I structures are a minimum of TVA Class G.

Remaining sample lines are TVA Class H, except the boric acid and waste evaporator sample cylinder stations, which are TVA Class C. The sample piping and equipment, where applicable, meets the following codes and standards:

(1) NEMA SG-5 and IC-1.

(2) ASME Boiler and Pressure Vessel Code, Section III (applicable sections) and Section IX (applicable sections).

(3) ANSI B31.1 and B16.5.

(4) IEEE.

(5) ASTM.

(6) SAMA PUB19 and PMC20-2-1970.

The hot sample room cubicles are able to withstand a 1.0 g horizontal acceleration to ensure their stability during a seismic event. Also, the hot sample room cubicle entry block valves meet ASME Section III, Paragraph NC-3676, Code Class 2 with applicable 'N' stamp.

The routine sampling subsystem provides the capability for sampling the reactor coolant hotleg and steam generator blowdown, in an emergency sample area during a maximum flood condition. Portable sample analyzer equipment is used to measure the boron concentration in the reactor coolant system (RCS).

9.3.2.3 Safety Evaluation

Sample lines have the required indicators, pressure throttling valves, heat exchangers, etc., to ensure plant operator safety when collecting samples.

The hot sample room has the following special safety features (due to handling primary loop samples):

(1) Samples lines from the RCS hot legs contain a delay coil to provide a 40-second sample transient time within containment, plus a 20-second transient time from containment to the hot sample cubicles to provide decay time for N-16.

(2) Cubicles 1A and 2A are expected to contain the most highly radioactive samples. Sample lines to these sinks are equipped with stainless steel sample cylinders. Cubicles 1A and 2A have a 2-inch lead shield behind the front plate of the cubicles. Four (total) 2-inch lead shielded sample cylinders designed to decrease body dosage to the plant operator are available for use during conditions approximating 1% failed fuel.

(3) Cubicles are designed to permit collection of a sample behind a shatterproof window.

(4) Cubicles have individual exhaust hoods and fans to ensure that leakage of any gas is exhausted from the cubicle. Airborne particulates are removed by HEPA filters, and liquids are drained through the cubicle sink.

(5) Entry block valves meet the ASME Section III, Class 2 (described in Section 9.3.2.2).

The presence of high pressure and temperature sample lines outside reactor containment is not considered hazardous because of the limited flow capacity.

9.3.2.4 Tests and Inspections

System equipment is tested prior to plant operation under normal conditions. Periodic tests are performed after plant operation begins, to ensure proper operation of the routine sampling subsystem equipment.

9.3.2.5 Instrumentation Applications

The routine sampling subsystem is designed to be operated manually except for the gas analyzer, boron concentration monitor, and the automatic analyzers (e.g., conductivity, pH, cation conductivity, silica, sodium, hydrazine, dissolved oxygen).

9.3.2.6 Postaccident Sampling Subsystem

The postaccident sampling subsystem (PASS) provides samples of the reactor coolant, containment atmosphere, and containment sump fluid during a LOCA. It is designed to meet the intent of and provide for sample acquisition, analysis, and disposal, as described in Section II.B.3 of NUREG-0737, and keep personnel exposures within GDC19 limits (see Section 3.1).

9.3.2.6.1 System Description

The PASS is composed of the following:

(a) The postaccident sampling facility (PASF) which contains Sentry Equipment Corporation (SEC) high radiation sampling system (HRSS) or equivalent and associated control panels.

(b) Sample connections to the reactor coolant, containment sump, and containment atmosphere.

(c) Tubing, valving, and fittings as required to convey samples to the PASS.

9.3.2.6.2 Postaccident Sampling Facility

The PASF is located in the Auxiliary Building on Elevation 729 between columns A5, W, and X (for Unit 1) and A11, W, and X (for Unit 2). Each unit has a separate PASF.

The PASF consists of piping, tubing, valves, components, and instrumentation necessary to obtain, do partial analysis, and dispose of the samples described in Section 9.3.2.6. The major equipment used for these activities is the SEC HRSS. It is described in Section 9.3.2.6.3. The ventilation exhaust is filtered with charcoal adsorbers and high-efficiency particulate air (HEPA) filters. Liquid waste from the SEC HRSS, with the exception of the sampling panel drip pans, is routed to the waste holdup tank. From this tank the liquid is routed back to containment or the radwaste system for disposal. The liquid waste from the panels drip pans is routed to the floor drain system.

Gaseous waste is routed back to containment. Boron and isotopic analysis is performed.

9.3.2.6.3 Sampling Equipment

The major component used in the PASF for sampling acquisition and portions of the chemical analysis is the SEC HRSS. This system is composed of the liquid sampling panel (LSP), chemical analysis panel (CAP), containment air sampling panel (CASP), and their associated control panels. These components are discussed in the ensuing sections.

9.3.2.6.3.1 Liquid Sampling Panel

The following types of samples can be obtained from the LSP during accident conditions:

(a) Undiluted and diluted (1,000:1) liquid grab samples of the reactor coolant.

(b) An in-line sample of pressurized coolant.

(c) A diluted (15,000:1) stripped gas sample from the reactor coolant pressurized liquid sample.

The LSP is able to purge sample lines before sampling to assure representative samples will be obtained and to flush the lines after sampling to reduce residual radioactivity.

The LSP uses shielded cart/casks for the removal of the reactor coolant samples. The cask is mounted on a cart, which allows the samples obtained to be mobile. A shielded syringe is typically used to handle the aliquot to be analyzed. Isotopic analysis of reactor coolant (undiluted concentration 1 μCi/g to 10 Ci/g) can be performed.

9.3.2.6.3.2 Chemical Analysis Panel

The CAP can receive reactor coolant liquid and gas samples from LSP. The CAP has the capability to analyze for the following parameters: pH, specific conductivity, dissolved oxygen, chloride, hydrogen, temperature, and total dissolved gas. The ranges of the on-line equipment are listed below for their specific analyses:

(a)	pH	1 -13
(b)	Conductivity	0.1-500 μmho/cm
(c)	Chlorides	0.1-20 ppm
(d)	Dissolved Hydrogen	10-2000 cc(STP)/kg
(e)	Dissolved Oxygen	0.1-20 ppm

Lines carrying liquid and gaseous samples have the capability to be flushed to limit personnel radiation exposure and prepare for the acquisition of the next sample.

9.3.2.6.3.3 Containment Air Sampling Panel (CASP)

The CASP is used to obtain samples of the containment atmosphere. A particulate, iodine, and gas partitioning system is used to obtain these components in the containment atmosphere sample. As an alternate method, samples are located in shielded cart/casks. The shielded mobile assemblies can be used for sample transport to onsite analysis facilities. All CASP sample lines are purged with nitrogen following the sampling operations to remove radioactive gases and prepare for the next sample.

Also, the sample lines are heat traced to minimize plateout of radioactive material. Each of these components is then analyzed for radioactivity.

9.3.2.6.3.4 HRSS Control Panels

Operation of the HRSS is performed at various control panels. These panels give readouts of all in-line analysis performed by the CAP. The control panels are separated from the sample panels within the PASF. This separation makes possible a reduction in the operators' exposure to radiation from the sampling panels in the PASF.

9.3.2.6.4 Sample Points

The sample points chosen for use during postaccident conditions were selected to be representative of the required samples. The reactor coolant samples are obtained from the reactor vessel hot leg loops. Containment sump samples are acquired from the discharge of the residual heat removal system (RHR) pumps. Containment atmosphere samples are acquired from upper and lower containment from an opening at Elevations 815 (upper) and 750 (lower).

9.3.2.6.5 Postaccident Counting Facilities

Radiological analysis of liquids and gaseous samples is performed in plant counting room facilities. Analyses are performed within applicable Regulatory Guide 1.97 criteria. Appropriate radiation shielding is provided to reduce counting equipment background levels as necessary.

9.3.2.6.6 Piping, Tubing, and Valves

Sample piping, tubing, and valves are normally 304, 316, or 304L stainless steel designed to assure turbulent flow (RE $\geq$ 4,000). Sample lines between the containment isolation valves, and containment isolation valves, are ASME Section III, Class 2.

Sample lines outside containment are ANSI B31.1. The minimum tube size is 1/4 or 3/8 inch and root valves are 1/2 inch.

Sample lines are routed to be as short as practical, avoiding traps, dips, and deadlegs to the PASF. Provisions have been incorporated to allow flushing of sample lines to reduce unnecessary radiation exposure to operating personnel. Also, consideration has been given to the routing of sample and waste return lines so that the radiation field of the pipe is consistent with the zone of the area it traverses. This is also accomplished by routing lines through shielded pipe tunnels, trenches, or chases.

All sample lines have been thermally evaluated to assure that pipe expansion caused by high operating temperatures does not impact the integrity of the sample piping or supports.

9.3.2.6.7 Safety Evaluation

The design life of all major components, equipment, and instrumentation is 40 years (100 days during accident conditions). The PASF does not serve a safety-related function.

9.3.2.6.8 Tests and Inspections

The postaccident sampling (PAS) equipment is preoperationally tested before startup. Instruments are calibrated and tested to verify equipment readiness. This equipment is used periodically to simulate actual sampling techniques for personnel training purposes.

9.3.3 Equipment and Floor Drainage System

9.3.3.1 Design Bases

Equipment drains and floor drains in the Auxiliary and Reactor Buildings are designed so that tritiated liquids (defined as liquids whose tritium concentration is 10% or more of the reactor water tritium concentration) are normally handled separately from nontritiated liquids, in so far as possible. Equipment drains and floor drains are routed to collector tanks in which the liquid can be held pending further treatment.

Except as specified below, Turbine Building drains are collected in the sump and periodically sampled as required by the NPDES permit for discharges.

Drainage in the condensate demineralizer area of the Turbine Building drains to the condensate polishing demineralizer sump. The sump contents are routed to the neutralization tank for processing and subsequent discharge. Drainage in the makeup water treatment plant area of the Turbine Building drains to the water treatment plant (WTP) waste sump. The WTP sump contents are routed to the alum sludge settling ponds. The supernatant from the alum sludge settling ponds is discharged to the yard Low Volume Waste Holding Pond.

9.3.3.2 System Design

The liquid drains are normally segregated into three basic systems. The first system collects all tritiated water. This system is further divided into aerated liquids, which are collected in the tritiated drain collector tank and deaerated liquids, which are collected in the reactor coolant drain tank or the CVCS holdup tank. This segregation promotes the recycling (if required) of radioactive tritiated liquids. The second system collects nontritiated water in the floor drain collector tank. The third system provides for returning all CCS water from equipment drains to the CCS surge tank.

Detailed data for the various equipment and floor drains are presented in Table 9.3-3. Information contained in this table was generated from Attachment 2 (MED 830502 239) of Westinghouse Letter, WAT-D-221. The flow and logic diagrams for the system are contained in Figures 9.3-7 to 9.3-14.

Critical exposed drain piping in the Control Building is supported per Seismic Category I(L) requirements.

Critical exposed drain piping in other areas where ESF equipment is located is supported per Seismic Category I(L) requirements.

Embedded drain piping in Category I structures is in seismically qualified concrete, and therefore meets seismic considerations in that the flow paths will remain inviolate during a safe shutdown earthquake.

9.3.3.2.1 Drains from Lowest Floor Level in the Auxiliary Building

In the Auxiliary Building, most equipment is located at an elevation which permits gravity feed into the desired drain collector tank. However, since the drain collector tanks are located on the lowest floor, the drains on this floor cannot be gravity fed to a drain collector tank. Therefore, there is an Auxiliary Building Floor and Equipment Drains (ABF & ED) sump and a tritiated sump. The drains on this floor are piped to the ABF & ED sump or to the tritiated sump. These sumps are then pumped to their respective drain tanks. Samples are taken and if the tritiated sump contains an acceptably small tritium content, it is pumped to the floor drain collector tank. There are sumps in the Additional Equipment Buildings that are normally pumped to the floor drain collector tank. If tritium is present, then the sumps are normally pumped to the tritiated drain collector tank.

Excess fluid due to flooding would be collected in the ABF & ED passive sump. This passive sump is large enough to contain any postulated major rupture Watts Bar could experience. Most equipment components sit on foundations high enough to keep them above most flood levels. Floor drains were provided in all areas where there is possibility of major rupture. Leak detectors are located where required in the Auxiliary Building and Reactor Building to alarm for a buildup of water on the floor.

9.3.3.2.2 Residual Heat Removal Pump (RHR) and Containment Spray Pump (CSP) Compartments

Each residual heat removal pump and containment spray pump is located in a separate curbed compartment designed to control any leakage. There is a small sump located in each compartment with a drain pipe extending above the bottom of the sump. There are 2 weep holes of 1/2 inch diameter in the drain pipe at the sump bottom to take care of small ordinary seepage. The drain pipe is designed to handle a leakage of 50 gpm and is piped to the Auxiliary Building floor and equipment drain sump. A water level detector is located in each RHR and CSP compartment sump to sound an alarm prior to overflowing in the drain pipe. An emergency drain is provided in each RHR and containment spray pump room, as shown in Figure 1.2-7, plan Elevation 676.0. These drains are provided to direct large breaks to the large, ABF & ED passive sump volume above Elevation 666.

The design basis for the emergency drains is to provide environmental isolation for each separately drained area unless needed for drainage purposes. These functions are assured by installing a breakaway plate in a 4-foot by 4-foot square hole in each room, which is held in place by breakaway bolts. If drainage into the room exceeds the capacity of the normal drain and flows over a small lip surrounding the breakaway emergency drain hole, the weight of approximately 2 feet 8 inches of water above the emergency drain causes failure of the bolts and a large drain is established to remove water from the pump room. Water then released to the ABF & ED passive sump can be processed by opening the passive sump to the ABF & ED sump by means of a 6 inch valve.

9.3.3.2.3 CVCS Holdup Tank Compartment and Tritiated Drain Collector Tank Room

The CVCS holdup tanks are located in separate watertight rooms designed to contain the tank contents should a tank rupture. The tritiated drain collector tank is in a curbed room designed to contain the tank volume should there be a rupture. A drain with a normally closed valve is provided from each room to the building sump. In case of a rupture, the valve keeps the water within the room until the level of the drain collector tank is lowered to handle the additional volume of water.

Since these tanks are not essential, the rooms are not designed to exclude flood water. In case of flooding, the tanks are filled with a sufficient volume of water to prevent flotation and are sealed.

Both open and closed drains are provided in the tritiated system. The open drains are defined as being open to the atmosphere, and they usually empty into a funnel connected to the embedded drain header. The closed drains are connected directly to the drain header and are not open to the atmosphere. The embedded drain headers are normally routed to an 8 inch horizontal collection header at the tritiated drain collector tank. This header has a blind flange at each end to aid in cleaning. The various drain headers normally extend through the top of the 8 inch collection header to within 1-1/2 inches of the bottom of the header. The outlet from the 8 inch collection header to the tritiated drain collector tank is normally a 4 inch pipe welded to the upper half of the 8 inch pipe. This provides a 2 inch water seal in the 8 inch pipe at all times.

The floor drain collector tank, in addition to receiving all of the floor drains, also collects nontritiated open and closed equipment drains. These drains are normally piped to an 8 inch header at the floor drain collector tank where water seal is maintained at all times. The 8 inch header normally has a 4 inch pipe welded to the top half which discharges to the floor drain collector tank. This ensures a 2 inch water seal. Some of the floor drains located in areas where a strong possibility exists for a tritium leak are provided with solid stainless steel cover plates to prevent tritium from entering the systems. The use of floor drains has been limited to areas where an emergency need for them exists. The floor drains are normally not used for regular maintenance washdown.

9.3.3.2.4 Volume Control Tanks

The volume control tanks are located in rooms with a curb to contain the liquid in case of a rupture. A floor drain is provided and piped separately to the floor drain collector tank to provide rapid room drainage.

9.3.3.2.5 Boric Acid Tanks

The boric acid tanks are enclosed by a curb designed to contain the acid should there be a major tank leak. A number of floor drains are located within this area with a valve on the drain header to the floor drain collector tank. This valve permits the containment of the boric acid until it is pumped by a portable pump to other storage tanks. In case there are no storage tanks available, the acid can be diluted before being released to the floor drain collector tank.

9.3.3.3 Drains - Reactor Building

Most equipment drains in the Reactor Building are for tritiated deaerated liquids which are piped to the reactor coolant drain tank. The reactor coolant drain pumps, pump this liquid to either the CVCS holdup tanks or to the tritiated drain collector tank in the Auxiliary Building.

The annulus floor drains are piped to the annulus sump which is emptied by gravity to the ABF & ED passive sump by opening a 10 inch butterfly valve in the Auxiliary Building.

The rest of the floor drains and equipment drains are piped to either the Reactor Building Floor and Equipment Drains (RBF&ED) sump or the RBF&ED pocket sump. The RBF & ED sump pumps automatically pump this liquid to the tritiated drain collector tank in the Auxiliary Building. If analysis shows the liquid is nontritiated it can be pumped to the floor drain collector tank.

9.3.3.4 Design Evaluation

The drains are segregated and leakage is contained to ensure that there is no leakage of fluid or fumes to the atmosphere. This has been accomplished with the use of water seals or traps in drain lines where there is a possibility of cross-ventilation. See Chapter 11 for a more in-depth evaluation.

There is no mechanism for an inadvertent transfer of contaminated fluids to the non-contaminated drainage system. In the Auxiliary and Reactor Buildings only contaminated drain systems are provided.

9.3.3.5 Tests and Inspections

Open equipment and floor drains are periodically monitored to ensure that there is no cross-ventilation. The water seals and traps are serviced by periodic addition of water through the drain and drains are inspected periodically for blockage.

9.3.3.6 Instrumentation Application

Instrumentation related to this system is described in Chapter 11.

9.3.3.7 Drain List

The following are the tanks used to collect drains from the NSSS:

(1) Chemical Drain Tank (CDT) - collects radioactive samples from laboratory. (Described in Chapter 11, Radioactive Waste Management)

(2) Component Cooling Surge Tank (CCST) - collects chromated water from component cooling equipment drains.

(3) Reactor Building Floor and Equipment Drain (RBF&ED) Sump and the RBF&ED Pocket Sump - collect water from floor drains and aerated equipment drains inside the containment, and the sump pumps can be directed to the FDT or the TDT.

(4) Floor Drains Collector Tank (FDT) - collects non-tritiated equipment and floor drains.

(5) Laundry and Hot Shower Drain Tank (LHSDT) - collects water from laundry and hot showers (described in Chapter 11).

(6) CVCS Holdup Tank (CVCSHT) - collects deaerated tritiated water (reactor grade) inside the containment.

(7) Tritiated Drain Collector Tank (TDT) - collects aerated tritiated water in the Auxiliary Building, via the drain header (DH), from the RCDT and RBF&ED sump and RBF&ED pocket sump in containment and from the tritiated sump.

(8) Component Cooling Pump Seal Drain Tank (CCSDT) - collects seal leakage from CCS pumps and returns source to CCS.

9.3.4 Chemical and Volume Control System

The chemical and volume control system (CVCS), shown in Figure 9.3-15, is designed to provide the following services to the RCS:

(1) Maintenance of programmed water level in the pressurizer, i.e., maintain required water inventory in the RCS.

(2) Maintenance of seal-water flow to the reactor coolant pumps.

(3) Control of reactor coolant water chemistry conditions, activity level, soluble chemical neutron adsorber concentration and makeup.

(4) Processing of excess reactor coolant to effect recovery and re-use of boric acid and primary makeup water.

(5) Emergency core cooling (part of the system is shared with the emergency core cooling system).

9.3.4.1 Design Bases

Quantitative design bases are given in Table 9.3-4 with qualitative descriptions given below. The design codes of the components in the system are given in Section 3.2.

9.3.4.1.1 Reactivity Control

The CVCS regulates the concentration of chemical neutron adsorber (boron) in the reactor coolant to control reactivity changes resulting from the change in reactor coolant temperature between cold shutdown and hot full-power operation, burnup of fuel and burnable poisons, buildup of fission products in the fuel, and xenon transients.

Reactor Makeup Control

(1) The CVCS is capable of borating the RCS through either one of two flow paths and from either one of two boric acid sources.

(2) The amount of boric acid stored in the CVCS always exceeds that amount required to borate the RCS to cold shutdown concentration assuming that the control assembly with the highest reactivity worth is stuck in its fully withdrawn position. This amount of boric acid also exceeds the amount required to bring the reactor to hot shutdown and to compensate for subsequent xenon decay.

9.3.4.1.2 Regulation of Reactor Coolant Inventory

The CVCS maintains the coolant inventory in the RCS within the allowable pressurizer level range for all normal modes of operation including startup from cold shutdown, full power operation and plant cooldown. This system also has sufficient makeup capacity to maintain the minimum required inventory in the event of minor RCS leaks (see the Technical Specifications for a discussion of maximum allowable RCS leakage).

9.3.4.1.3 Reactor Coolant Purification

The CVCS is capable of removing fission and activation products, in ionic form or as particulates, from the reactor coolant in order to provide access to those process lines carrying reactor coolant during operation and to reduce activity releases due to leaks.

9.3.4.1.4 Chemical Additions for Corrosion Control

The CVCS provides a means for adding chemicals to the RCS which control the pH of the coolant during initial startup and subsequent operation, scavenge oxygen from the coolant during startup, and counteract the production of oxygen in the reactor coolant due to radiolysis of water in the core region.

The CVCS is capable of maintaining the oxygen content and pH of the reactor coolant within limits specified in Table 5.2-10.

9.3.4.1.5 Seal Water Injection

The CVCS is able to continuously supply filtered water to each reactor coolant pump seal, as required by the reactor coolant pump design.

9.3.4.1.6 Hydrostatic Testing of the Reactor Coolant System

The CVCS is capable of supplying water at the maximum test pressure specified to verify the integrity of the RCS. The hydrostatic test is performed prior to initial operation and as part of the periodic RCS inspection program.

9.3.4.1.7 Emergency Core Cooling

The centrifugal charging pumps in the CVCS also serve as the high-head safety injection pumps in the emergency core cooling system. Other than the centrifugal charging pumps and associated piping and valves, the CVCS is not required to function during a loss-of-coolant accident (LOCA). During a LOCA, the CVCS is isolated except for the centrifugal charging pumps and the piping in the safety injection path.

9.3.4.2 System Description

The CVCS is shown in Figure 9.3-15 (piping and instrumentation diagram) with system design parameters listed in Table 9.3-4. The CVCS consists of several subsystems: the charging, letdown and seal water system; the reactor coolant purification and chemistry control system; the reactor makeup control system. The codes and standards to which the individual components of the CVCS are designed are listed in Chapter 3.2.

9.3.4.2.1 Charging, Letdown, and Seal Water System

The charging and letdown functions of the CVCS are employed to maintain a programmed water level in the RCS pressurizer, thus maintaining proper reactor coolant inventory during all phases of plant operation. This is achieved by means of continuous feed and bleed process during which the feed rate is automatically controlled based on pressurizer water level. The bleed rate can be chosen to suit various plant operational requirements by selecting the proper combination of letdown orifices in the letdown flow path.

Reactor coolant is discharged to the CVCS from a reactor coolant loop cold leg; it then flows through the shell side of the regenerative heat exchanger where its temperature is reduced by heat transfer to the charging flow passing through the tubes. The coolant then experiences a large pressure reduction as it passes through the letdown orifice(s) and flows through the tube side of the letdown heat exchanger where its temperature is further reduced. Downstream of the letdown heat exchanger a second pressure reduction occurs. This second pressure reduction is performed by the low pressure letdown valve, the function of which is to maintain upstream pressure thus preventing flashing downstream of the letdown orifices.

The coolant then flows through one of the mixed bed demineralizers. The flow may then pass through the cation bed demineralizer which is used intermittently when additional purification of the reactor coolant is required.

The coolant then flows through the reactor coolant filter and into the volume control tank through a spray nozzle in the top of the tank. Hydrogen is continuously available for maintaining the desired hydrogen pressure in the volume control tank. A remotely operated vent allows the removal of hydrogen and fission gases stripped from the reactor coolant when required. The contaminated hydrogen is vented back to the gaseous waste processing system. The partial pressure of hydrogen in the volume control tank determines the concentration of hydrogen dissolved in the reactor coolant for control of oxygen produced by radiolysis of water in the core.

Three pumps (one positive displacement pump, and two centrifugal charging pumps) are provided to take suction from the volume control tank and return the cooled, purified reactor coolant to the RCS. Normal charging flow is handled by one of the three charging pumps. This charging flow splits into two paths. The bulk of the charging flow is pumped back to the RCS through the tube side of the regenerative heat exchanger. The letdown flow in the shell side of the regenerative heat exchanger raises the charging flow to a temperature approaching the reactor coolant temperature. The flow is then injected into a cold leg of the RCS. Two charging paths are provided from a point downstream of the regenerative heat exchanger. A flow path is also provided from the regenerative heat exchanger outlet to the pressurizer spray line. An air-operated valve in the spray line is employed to provide auxiliary spray to the vapor space of the pressurizer during plant cooldown. This provides a means of cooling the pressurizer near the end of plant cooldown, when the reactor coolant pumps, which normally provide the driving head for the pressurizer spray, are not operating.

A portion of the charging flow is directed to the reactor coolant pumps (nominally 8 gpm per pump) through a seal water injection filter. It is directed down to a point between the pump shaft bearing and the thermal barrier cooling coil. Here the flow splits and a portion (nominally 5 gpm per pump) enters the RCS through the labyrinth seals and thermal barrier. The remainder of the flow is directed up the pump shaft, cooling the lower bearing, and to the number 1 seal leakoff. The number 1 seal leakoff flow discharges to a common manifold, exits from the containment, and then passes through the seal water return filter and the seal water heat exchanger to the suction side of the charging pumps,or by alternate path to the volume control tank. A very small portion of the seal flow leaks through to the number 2 seal. A number 3 seal provides a final barrier to leakage of reactor coolant to the containment atmosphere. The number 2 leakoff flow is discharged to the reactor coolant drain tank in the waste disposal system. The number 3 seal leakoff flow is also discharged to the reactor coolant drain tank in the waste disposal system.

The excess letdown path is provided as an alternate letdown path from the RCS in the event that the normal letdown path is inoperable. Reactor coolant can be discharged from a cold leg to flow through the tube side of the excess letdown heat exchanger where it is cooled by component cooling water. Downstream of the heat exchanger a remote-manual control valve controls the letdown flow. The flow normally joins the number 1 seal discharge manifold and passes through the seal water return filter and heat exchanger to the suction side of the charging pumps. The excess letdown flow can also be directed to the reactor coolant drain tank. When the normal letdown line is not available, the normal purification path is also not in operation. Therefore this alternate condition would allow continued power operation for a limited period of time, dependent on RCS chemistry and activity. The excess letdown flow path is also used to provide additional letdown capability during the final stages of plant heatup. This path removes some of the excess reactor coolant due to expansion of the system as a result of the RCS temperature increase.

Surges in RCS inventory due to load changes are accommodated for the most part in the pressurizer. The volume control tank provides surge capacity for reactor coolant expansion not accommodated by the pressurizer. If the water level in the volume control tank exceeds the normal operating range, a proportional controller modulates a three-way valve downstream of the reactor coolant filter to divert a portion of the letdown to the holdup tanks in the boron recycle system. If the high-level limit in the volume control tank is reached, an alarm is actuated in the control room and the letdown flow is completely diverted to the boron recycle system holdup tanks.

The boron recycle system (Section 9.3.7) receives and processes reactor coolant effluent for reuse of the boric acid and purified water. The system decontaminates the effluent by means of demineralization and gas stripping, and uses evaporation to separate and recover the boric acid and reactor makeup water.

Low level in the volume control tank initiates makeup from the reactor makeup control system. If the reactor makeup control system does not supply sufficient makeup to keep the volume control tank level from falling to a lower level, a low alarm is actuated. Manual action may correct the situation or, if the level continues to decrease, an emergency low level signal from both of the level channels causes the suction of the charging pumps to be transferred to the refueling water storage tank.

The reciprocating charging pump is also used to perform hydrostatic tests which verify the integrity and leak-tightness of the RCS. The pump can pressurize the RCS to the maximum designated test pressure. The hydrostatic test is performed prior to initial operation and is part of the periodic RCS in-service inspection program.

9.3.4.2.2 Chemical Control, Purification and Makeup System

Reactor coolant chemistry specifications are given in Table 5.2-10.

pH Control

The pH control chemical employed is lithium hydroxide. This chemical is chosen for its compatibility with the materials and water chemistry of borated water/stainless steel/zirconium/inconel systems. In addition, Lithium-7 is produced in the core region due to irradiation of the dissolved boron in the coolant.

The concentration of Lithium-7 in the RCS is maintained in the range specified for pH control (Table 5.2-10). If the concentration exceeds this range, as it may during the early stages of a core cycle, the cation bed demineralizer is employed in the letdown line in series operation with a mixed bed demineralizer. Since the amount of lithium to be removed is small and its buildup can be readily calculated, the flow through the cation bed demineralizer is not required to be full letdown flow. If the concentration of Lithium-7 is below the specified limits, lithium hydroxide can be introduced into the RCS via the charging flow. The solution is prepared in the laboratory and poured into the chemical mixing tank. Reactor makeup water is then used to flush the solution to the suction manifold of the charging pumps.

Oxygen Control

During reactor startup from the cold condition, hydrazine is employed as an oxygen scavenging agent. The hydrazine solution is introduced into the RCS in the same manner as described above for the pH control agent. Hydrazine is not employed at any time other than startup from the cold shutdown state. Dissolved hydrogen is employed to control and scavenge oxygen produced due to radiolysis of water in the core region. Sufficient partial pressure of hydrogen is maintained in the volume control tank such that the specified equilibrium concentration of hydrogen is maintained in the reactor coolant. A pressure control maintains a minimum pressure in the vapor space of the volume control tank. This valve can be adjusted to provide the correct equilibrium hydrogen concentration (25 to 35 cc hydrogen at STP per kilogram of water). Hydrogen is supplied from the hydrogen manifold in the waste disposal system.

Reactor Coolant Purification

Mixed bed demineralizers are provided in the letdown line to provide cleanup of the letdown flow. The demineralizers remove ionic corrosion products and certain fission products. One demineralizer is in continuous service and can be supplemented intermittently by the cation bed demineralizer, if necessary, for additional purification. The cation resin removes principally cesium and lithium isotopes from the purification flow. The second mixed bed demineralizer serves as a standby unit for use if the operating demineralizer becomes exhausted during operation.

A further cleanup feature is provided for use during cold shutdown and residual heat removal. A remotely operated valve admits a bypass flow from the residual heat removal system (RHRS) into the letdown line upstream of the letdown heat exchanger. The flow passes through the heat exchanger, through a mixed bed demineralizer and the reactor coolant filter to the volume control tank. The fluid is then returned to the RCS via the normal charging route.

Filters are provided at various locations to ensure filtration of particulate and resin fines and to protect the seals on the reactor coolant pumps.

Fission gases are removed from the reactor coolant when required by venting of the volume control tank via the waste disposal system to the hold up tank.

9.3.4.2.3 Chemical Shim and Reactor Coolant Makeup

The reactor makeup control system consists of a group of instruments arranged to provide a manually preselected makeup composition to the charging pump suction header or the volume control tank. The makeup control functions are those of maintaining desired operating fluid inventory in the volume control tank and adjusting reactor coolant boron concentration for reactivity control. In addition for emergency boration and makeup, the capability exists to provide refueling water at 2000 ppm boron directly to the suction of the charging pumps.

The boric acid is stored in three boric acid tanks. Two boric acid transfer pumps are provided for each unit with one pump normally aligned with one boric acid tank and continuously running at low speed to provide recirculation for the boric acid system and the boric acid tank. On a demand signal by the reactor makeup control system, the boric acid transfer pump is shifted to high speed and delivers boric acid to the suction header of the charging pumps.

The primary makeup water pumps, taking suction from the primary water storage tank, are employed for various makeup and flushing operations throughout the systems. One of these pumps also starts on demand from the reactor makeup controller and provides flow to the suction header of the charging pumps or the volume control tank through the letdown line and spray nozzle.

During reactor operation, changes are made in the reactor coolant boron concentration for the following conditions:

(1) Reactor startup - boron concentration must be decreased from shutdown concentration to achieve criticality.

(2) Load follow - boron concentration must be either increased or decreased to compensate for the xenon transient following a change in load.

(3) Fuel burnup - boron concentration must be decreased to compensate for fuel burnup and the buildup of fission products in the fuel.

(4) Cold shutdown - boron concentration must be increased to the cold shutdown concentration.

The reactor makeup control system can be set up for the following modes of operation:

(1) Automatic Makeup

The "automatic makeup" mode of operation of the reactor makeup control system provides blended boric acid solution, preset to match the boron concentration in the RCS. Automatic makeup compensates for minor leakage of reactor coolant without causing significant changes in the reactor coolant boron concentration.

Under normal plant operating conditions, the mode selector switch is set in the "automatic makeup" position. This switch position establishes a preset control signal to the total makeup flow controller and establishes positions for the makeup stop valves for automatic makeup. The boric acid flow controller is set to blend to the same concentration of borated water as contained in the RCS. A preset low level signal from the volume control tank level controller initiates automatic makeup by shifting the operating boric acid transfer pump to high speed, opening the makeup stop valve to the charging pump suction, and positioning the boric acid flow control valve and the primary makeup water flow control valve. Since a primary makeup water pump runs continuously, automatic starting of this pump is not required. The flow controllers then blend the makeup stream according to the preset concentration. Makeup addition to the charging pump suction header causes water level in the volume control tank to rise. At a preset high level point, the makeup is stopped. This operation may be terminated manually at any time.

If the automatic makeup fails or is not aligned for operation and the tank level continues to decrease, a low level alarm is actuated. Manual actions may correct the situation or, if the level continues to decrease, an emergency low level signal opens the stop valves in the refueling water supply line to the charging pumps, and closes the stop valves in the volume control tank outlet line.

(2) Dilution

The "dilute" mode of operation permits the addition of a preselected quantity of reactor makeup water at a preselected flow rate to the RCS. The operator sets the mode selector switch to "dilute," the total makeup flow controller set point to the desired flow rate, the total makeup batch integrator to the desired quantity and initiates system start. This opens the reactor makeup water flow control valve, and opens the makeup stop valve to the volume control tank inlet. Excessive rise of the volume control tank water level is prevented by automatic actuation (by the tank level controller) of a three-way diversion valve which routes the reactor coolant letdown flow to the boron recycle system. When the preset quantity of water has been added, the batch integrator causes makeup to stop. Also, the operation may be terminated manually at any time.

(3) Alternate Dilution

The "alternate dilute" mode of operation is similar to the dilute mode except a portion of the dilution water flows directly to the charging pump suction and a portion flows into the volume control tank via the spray nozzle and then flows to the charging pump suction. This decreases the delay in diluting the RCS caused by directing dilution water to the volume control tank.

(4) Boration

The "borate" mode of operation permits the addition of a preselected quantity of concentrated boric acid solution at a pre-selected flow rate to the RCS. The operator sets the mode selection switch to "borate", the concentrated boric acid flow controller setpoint to the desired flow rate, the concentrated boric acid batch integrator to the desired quantity, and initiates system start. This opens the makeup stop valve to the charging pumps suction, positions the boric acid flow control valve, and transfers the selected boric acid transfer pump to hi-speed, which delivers 3.5 to 4.0 wt/% boric acid solution to the charging pumps suction header. The total quantity added in most cases is so small that it has only a minor effect on the volume control tank level. When the preset quantity of concentrated boric acid solution is added, the batch integrator causes makeup to stop. Also, the operation may be terminated manually at any time.

(5) Manual

The "manual" mode of operation permits the addition of a pre-selected quantity and blend of boric acid solution to the refueling water storage tank, to the holdup tanks in the boron recycle system, or to some other location via a temporary connection. While in the manual mode of operation, automatic makeup to the RCS is precluded. The discharge flow path must be prepared by opening manual valves in the desired path.

The operator sets the mode selector switch to "manual", the boric acid and total makeup flow controllers to the desired flow rates, the boric acid and total makeup batch integrators to the desired quantities, and actuates the makeup start switch.

The start switch actuates the boric acid flow control valve and the reactor makeup water flow control valve and transfers the pre-selected reactor makeup water pump and boric acid transfer pump to high-speed.

When the preset quantities of boric acid and reactor makeup water have been added, the batch integrators cause makeup to stop. This operation may be stopped manually by actuating the makeup stop switch.

If either batch integrator is satisfied before the other has recorded its required total, the pump and valve associated with the integrator which has been satisfied will terminate flow. The flow controlled by the other integrator will continue until that integrator is satisfied. In the manual mode, the boric acid flow is terminated first to prevent piping systems from remaining filled with 3.5 - 4.0 wt/% boric acid solution.

The quantities of boric acid and reactor makeup water injected are totalized by the batch counters and the flow rates are recorded on strip recorders. Deviation alarms sound for both boric acid and reactor makeup water if flow rates deviate from setpoints.

9.3.4.2.4 Component Description

A summary of principal component design parameters is given in Table 9.3-5, and safety classifications and design codes are given in Section 3.2. All CVCS piping that handles radioactive liquid is austenitic stainless steel. All piping joints and connections are welded, except where flanged connections are required to facilitate equipment removal for maintenance and hydrostatic testing.

Charging Pumps

Three charging pumps are supplied to inject coolant into the RCS. Two of the pumps are of the single speed, horizontal, centrifugal type and the third is a positive displacement (reciprocating) pump equipped with variable speed drive. All parts in contact with the reactor coolant are fabricated of austenitic stainless steel or other material of adequate corrosion resistance. The centrifugal pump seals and the reciprocating pump stuffing box are provided with leakoffs to collect the leakage before it can leak to the atmosphere. The CCS system provides normal cooling water to the CCP lube and gear oil coolers for pumps 1A-A and 1B-b. ERCW, via the CCP 1A-A room cooler, provides backup cooling water to the CCP 1A-A lube and gear oil cooler. The reciprocating pump design prevents lubricating oil from contaminating the charging flow. There is a minimum flow recirculation line to protect the centrifugal charging pumps from a closed discharge valve condition. Charging flow rate is determined from a pressurizer level signal. The means of flow control for the reciprocating pump is by variation of pump speed. The reciprocating charging pump is also used to hydrotest the RCS. When operating a centrifugal charging pump, the flow paths remain the same but charging flow control is accomplished by a modulating valve on the discharge side of the centrifugal pumps. The centrifugal charging pumps also serve as high head safety injection pumps in the emergency core cooling system. A description of the charging pump function upon receipt of safety injection signal is given in Section 6.3.2.2.

Regenerative Heat Exchanger

The regenerative heat exchanger is designed to recover heat from the letdown flow by reheating the charging flow, which reduces thermal effects on the charging penetrations into the reactor coolant loop piping.

The letdown stream flows through the shell side of the regenerative heat exchanger and the charging stream flows through the tubes. The unit is constructed of austenitic stainless steel, and is of all welded construction.

The temperatures of both outlet streams from the heat exchanger are monitored with indication given in the control room. A high temperature alarm is actuated on the main control board if the temperature of the letdown stream exceeds desired limits.

Letdown Heat Exchanger

The letdown heat exchanger cools the letdown stream to the operating temperature of the mixed bed demineralizers. Reactor coolant flows through the tube side of the exchanger while component cooling water flows through the shell side. All surfaces in contact with the reactor coolant are austenitic stainless steel, and the shell is carbon steel.

The low pressure letdown valve, located downstream of the heat exchanger, maintains the pressure of the letdown flow upstream of the heat exchanger in a range sufficiently high to prevent two phase flow. Pressure indication and high pressure alarm are provided on the main control board.

The letdown temperature control indicates and controls the temperature of the letdown flow exiting from the letdown heat exchanger. A temperature sensor, which is part of the CVCS, provides input to the controller in the component cooling system. The exit temperature of the letdown stream is thus controlled by regulating the component cooling water flow through the letdown heat exchanger. Temperature indication is provided on the main control board. If the outlet temperature from the heat exchanger is excessive, a high temperature alarm is actuated and a temperature controlled valve diverts the letdown directly to the volume control tank.

The outlet temperature from the shell side of the heat exchanger is allowed to vary over an acceptable range compatible with the equipment design parameters and required performance of the heat exchanger in reducing letdown stream temperature.

Excess Letdown Heat Exchanger

The excess letdown heat exchanger cools reactor coolant letdown flow at a rate which is equivalent to the portion of the nominal seal injection flow which flows into the RCS through the reactor coolant pump labyrinth seals.

The excess letdown heat exchanger can be employed either when normal letdown is temporarily out of service to maintain the reactor in operation or it can be used to supplement maximum letdown during the final stages of heatup. The letdown flows through the tube side of the unit and component cooling water is circulated through the shell. All surfaces in contact with reactor coolant are austenitic stainless steel and the shell is carbon steel. All tube joints are welded.

A temperature detector measures the temperature of the excess letdown flow downstream of the excess letdown heat exchanger. Temperature indication and high temperature alarm are provided on the main control board.

A pressure sensor indicates the pressure of the excess letdown flow downstream of the excess letdown heat exchanger and excess letdown control valve. Pressure indication is provided on the main control board.

Seal Water Heat Exchanger

The seal water heat exchanger is designed to cool fluid from three sources: reactor coolant pump number 1 seal leakage, reactor coolant discharged from the excess letdown heat exchanger, and miniflow from a centrifugal charging pump. Reactor coolant flows through the tube side of the heat exchanger and component cooling water is circulated through the shell. The design flow rate through the tube side is equal to the sum of the nominal excess letdown flow, maximum design reactor coolant pump seal leakage, and miniflow from one centrifugal charging pump. The unit is designed to cool the above flow to the temperature normally maintained in the volume control tank. All surfaces in contact with reactor coolant are austenitic stainless steel and the shell is carbon steel.

Volume Control Tank

The volume control tank provides surge capacity for part of the reactor coolant expansion volume not accommodated by the pressurizer. When the level in the tank reaches the high level setpoint, the remainder of the expansion volume is accommodated by diversion of the letdown stream to the holdup tanks in the boron recycle system. The volume control tank also provides a means for introducing hydrogen into the coolant to maintain the required equilibrium concentration and is used for degassing the reactor coolant. It also serves as a head tank for the charging pumps.

Venting of hydrogen gas which may come out of solution and collect in the charging pump suction lines is provided through three vent lines which are connected to piping high points between the volume control tank and the charging pumps. These vent lines are connected to a header which then connects to the volume control tank vent line upstream of the vent valve.

A spray nozzle located inside the tank on the letdown line provides liquid to gas contact between the incoming fluid and the hydrogen atmosphere in the tank.

Hydrogen (from the hydrogen manifold in the waste disposal system) is continuously available to the volume control tank while a remotely operated vent valve, discharging to the waste disposal system, permits removal of gaseous fission products which are stripped from the reactor coolant and collected in this tank. Relief protection, gas space sampling, and nitrogen purge connections are also provided. The tank can also accept the seal water return flow from the reactor coolant pumps although this flow normally goes directly to the suction of the charging pumps.

Volume control tank pressure and temperature are monitored with indication given in the control room. Alarm is actuated in the control room for high and low pressure conditions and for high temperature. The volume control tank pressure control valve is automatically closed by the low pressure signal.

Two level channels govern the water inventory in the volume control tank. These channels provide local and remote level indication, level alarms, level control, makeup control, and emergency makeup control.

If the volume control tank level rises above the normal operating range, one channel provides an analog signal to a proportional controller which modulates the three-way valve downstream of the reactor coolant filter to maintain the volume control tank level within the normal operating bank. The three-way valve can split letdown flow so that a portion goes to the holdup tanks and a portion to the volume control tank. The controller would operate in this fashion during a dilution operation when reactor makeup water is being fed to the volume control tank from the reactor makeup control system.

If the modulating function of the channel fails and the volume control tank level continues to rise, the high level alarm will alert the operator to the malfunction and the full letdown flow will be automatically diverted by the backup level channel.

During normal power operation, a low level in the volume control tank initiates auto makeup which injects a pre-selected blend of boric acid solution and reactor makeup water into the charging pump suction header. When the volume control tank level is restored to normal, auto makeup stops.

If the automatic makeup fails or is not aligned for operation and the tank level continues to decrease, a low level alarm is actuated. If the level continues to decrease, a low-low signal from both of the level channels opens the isolation valves in the refueling water supply line. This signal also closes the isolation valves in the volume control tank outlet line which in turn closes the isolation valves of the hydrogen vent header for the charging pump suction side piping. Failure of volume control tank controller may require operator action to prevent damage to the charging pump. Following a low-low level alarm, the operator would have sufficient time to transfer the charging pump suction to the RWST, stop the pump or restore letdown to the volume control tank to prevent pump damage.

Chemical Mixing Tank

The primary use of the chemical mixing tank is in the preparation of caustic solutions for pH control and hydrazine solution for oxygen scavenging.

Mixed Bed Demineralizers

Two flushable mixed bed demineralizers assist in maintaining reactor coolant purity. A lithium-form cation resin and hydroxyl-form anion resin are charged into the demineralizers. The anion resin is converted to the borate form in operation.

Both types of resin remove fission and corrosion products. The resin bed is designed to reduce the concentration of ionic isotopes in the purification stream, except for cesium, yttrium and molybdenum, by a minimum factor of 10.

Each demineralizer has more than sufficient capacity for one core cycle with 1% of the rated core thermal power being generated by defective fuel rods. One demineralizer is normally in service with the other in standby.

A temperature sensor monitors the temperature of the letdown flow downstream of the letdown heat exchanger and if the letdown temperature exceeds the maximum allowable resin operating temperature (approximately 140°F), a three-way valve is automatically actuated to bypass the flow around the demineralizers. Temperature indication and high alarm are provided on the main control board. The air-operated three-way valve failure mode directs flow to the volume control tank.

Cation Bed Demineralizers

A flushable demineralizer with cation resin in the hydrogen form is located downstream of the mixed bed demineralizers and is used intermittently to control the concentration of Lithium-7 which builds up in the coolant from the B^{10} (n, a) Lithium-7 reaction. The demineralizer also has sufficient capacity to maintain the Cesium-137 concentration in the coolant below 1.0 µCi/cc with 1% defective fuel. The resin bed is designed to reduce the concentration of ionic isotopes, particularly cesium and lithium.

The demineralizer has more than sufficient capacity for one core cycle with 1% of the rated core thermal power being generated by defective fuel rods.

Reactor Coolant Filter

The reactor coolant filter is located in the letdown line upstream of the volume control tank. The filter collects resin fines and particulates from the letdown stream. The nominal flow capacity of the filter is equal to the maximum purification flow rate.

Two local pressure indicators are provided to show the upstream and downstream of the reactor coolant filter and thus provide filter differential pressure.

Seal Water Injection Filters

Two seal water injection filters are located in parallel in a common line to the reactor coolant pump seals; they collect particulate matter that could be harmful to seal faces. Each filter is sized to accept flow in excess of the normal seal water flow requirements.

A differential pressure indicator monitors the pressure drop across each seal water injection filter and gives local indication with high differential pressure alarm on the main control board.

Seal Water Return Filter

This filter collects particulates from the reactor coolant pump seal water return and from the excess letdown flow. The filter is designed to pass the sum of the excess letdown flow and the maximum design leakage from all reactor coolant pumps.

Two local pressure indicators are provided to show the pressures upstream and downstream of the filter and thus provide indication of differential pressure across the filter.

Boric Acid Blender

The boric acid blender promotes thorough mixing of boric acid solution and primary makeup water for the reactor coolant makeup circuit. The blender consists of a conventional pipe-tee. The blender decreases the pipe length required to homogenize the mixture for taking a representative local sample. A sample point is provided in the piping just downstream of the blender.

Letdown Orifices

Three letdown orifices are provided to reduce the letdown pressure from reactor conditions and to control the flow of reactor coolant leaving the RCS. The orifices are placed into or out of service by remote operation of their respective isolation valves. One orifice is designed for normal letdown flow with the other two serving as standby. One or both of the standby orifices may be used in parallel with the normally operating orifice for either flow control when the RCS pressure is less than normal or greater letdown flow during maximum purification or heatup. Each orifice consists of an assembly which provides for permanent pressure loss without recovery. In addition to the three letdown orifices noted above, another orifice has been provided to limit the rate of thermal change on the welds upstream of the Regenerative Heat Exchanger. All letdown orifices assemblies are made of austenitic stainless steel or other adequate corrosion resistant material.

A flow monitor provides indication in the control room of the letdown flow rate, and a high alarm to indicate unusually high flow.

A low pressure letdown controller located downstream of the letdown heat exchanger controls the pressure upstream of the letdown heat exchanger to prevent flashing of the letdown liquid. Pressure indication and high pressure alarm are provided on the main control board.

Seal Water Return Bypass Orifice

An orifice in each reactor coolant pump number 1 seal bypass line is only in service during startup or shutdown when the RCS pressure is low. The bypass flow is necessary to ensure adequate flow for cooling of the pump's lower radial bearing and to limit the temperature rise of the water cooling the number 1 seal. The orifice is constructed of austenitic stainless steel and designed to pass adequate flow for the differential pressure existing at the lowest allowable RCS pressure for reactor coolant pump operation.

Chemical Mixing Tank Orifice

An orifice is provided in the piping upstream of the mixing tank. This orifice limits the flow rate through the tank to 2 gpm to avoid slugging the pump seals with concentrated chemicals.

Reactor Coolant Pump Standpipe Orifice

A seal stand pipe which contains water applies a constant head to the reactor coolant pump No. 3 seal to minimize leakage along the reactor coolant pump shaft. An orifice is provided in the standpipe drain line to the reactor coolant drain tank to limit the rate of drainage from the standpipe to the design leakage rate for the No. 2 seal. An increase in the No. 2 seal leak rate would then result in an increase in standpipe level and an eventual high level alarm which would alert the operator of a possible reactor coolant pump seal failure.

Charging Pump Bypass Orifices

A bypass orifice is provided for each centrifugal charging pump. The purpose of these orifices is to provide a minimum flow for pump protection.

Valves

Where pressure and temperature conditions permit, diaphragm type valves are used to essentially eliminate leakage to the atmosphere. All packed valves which are larger than 2 inches and which are designated for radioactive services are provided with stuffing box and lantern leakoff connections. All control (modulating) and three-way valves are either provided with stuffing box and leakoff connections or are totally enclosed. Leakage to the atmosphere is essentially zero for these valves. Basic material of construction is stainless steel for all valves which handle radioactive liquid or boric acid solutions.

Relief valves are provided for lines and components that might be pressurized above design pressure by improper operation or component malfunction.

(1) Charging Line Downstream of Regenerative Heat Exchanger

If the charging side of the regenerative heat exchanger is isolated while the hot letdown flow continues at its maximum rate, the volumetric expansion of coolant on the charging side of the heat exchanger is relieved to the RCS through a spring-loaded check valve.

(2) Letdown Line Downstream of Letdown Orifices

The pressure relief valve downstream of the letdown orifices protects the low pressure piping and the letdown heat exchanger from overpressure when the low pressure piping is isolated. The capacity of the relief valve is equal to the maximum flow rate through all letdown orifices. The valve set pressure is equal to the design pressure of the letdown heat exchanger tube side.

(3) Letdown Line Downstream of Low Pressure Letdown Valve

The pressure relief valve downstream of the low pressure letdown valve protects the low pressure piping and equipment from overpressure when this section of the system is isolated. The overpressure may result from leakage through the low pressure letdown valve. The capacity of the relief valve equals the maximum flow rate through all letdown orifices. The valve set pressure is equal to the design pressure of the demineralizers.

(4) Volume Control Tank

Hydrogen (from the hydrogen manifold in the waste disposal system) is continuously available to the volume control tank while a remotely operated vent valve, discharging to the waste disposal system, permits removal of gaseous fission products when required which are stripped from the reactor coolant and collected in this tank. Relief protection, gas space sampling and nitrogen purge connections are also provided. The tank can also accept the seal water return flow from the reactor coolant pumps although this flow normally goes directly to the suction of the charging pumps.

(5) Charging Pump Suction

A relief valve on the common charging pump suction header relieves pressure that may build up if the suction line isolation valves are closed or if the system is overpressurized. Also, each charging pump has a relief valve to provide overpressure protection of the suction piping in the event of check valve backleakage. Valve set pressure is equal to the design pressure of the associated piping and equipment.

(6) Seal Water Return Line (Inside Containment)

This relief valve is designed to relieve over-pressurization in the seal water return piping inside the containment if the motor-operated isolation valve is closed. The valve is designed to relieve the total leakoff flow from the No. 1 seals of the reactor coolant pumps plus the design excess letdown flow. The valve is set to relieve at the design pressure of the piping.

(7) Seal Water Return Line (Charging Pumps Bypass Flow)

This relief valve protects the seal water heat exchanger and its associated piping from over-pressurization. If either of the isolation valves for the heat exchanger are closed and if the bypass line is closed, the piping would be over-pressurized by the miniflow from the centrifugal charging pumps. The valve is sized to handle the miniflow from the centrifugal charging pumps. The valve is set to relieve at the design pressure of the heat exchanger.

(8) Positive Displacement Pump Discharge

The pressure relief valve on the positive displacement pump discharge line relieves the rated pumping capacity if the pump is started with the discharge isolation valve closed. The set pressure of the valve is equal to or less than the design pressure of the pump discharge piping.

Piping

All CVCS piping that handles radioactive liquid is austenitic stainless steel. All piping joints and connections are welded, except where flanged connections are required to facilitate equipment removal for maintenance and hydrostatic testing.

9.3.4.2.5 System Operation

Reactor Startup

Reactor startup is defined as the operations which bring the reactor from cold shutdown to normal operating temperature and pressure.

It is assumed that:

(1) Normal residual heat removal is in progress.

(2) RCS boron concentration is at the cold shutdown concentration.

(3) Reactor makeup control system is set to provide makeup at the cold shutdown concentration.

(4) RCS is either water solid or drained to minimum level for the purpose of refueling or maintenance. If the RCS is water solid, system pressure is maintained by operation of a charging pump and controlled by the low pressure letdown valve in the letdown line (letdown is achieved via the residual heat removal system).

(5) The charging and letdown lines of the CVCS are filled with coolant at the cold shutdown boron concentration. The letdown orifice isolation valves are closed.

If the RCS requires filling and venting, the procedure is as follows:

(1) One charging pump is started, which provides blended flow from the reactor makeup control system at the cold shutdown boron concentration.

(2) The vents on the head of the reactor vessel and pressurizer are opened.

(3) The RCS is filled and the vents closed.

The system pressure is raised by using the charging pump and controlled by the low pressure letdown valve. When the system pressure is adequate for operation of the reactor coolant pumps, seal water flow to the pumps is established and the pumps are operated and vented sequentially until all gases are cleared from the system. Final venting takes place at the pressurizer.

After the filling and venting operations are completed, charging and letdown flows are established. All pressurizer heaters are energized and the reactor coolant pumps are employed to heat up the system. After the reactor coolant pumps are started, the residual heat removal pumps are stopped but pressure control via the residual heat removal system (RHRS) and the low pressure letdown line is continued as the pressurizer steam bubble is formed. At this point, steam formation in the pressurizer is accomplished by manual control of the charging flow and automatic pressure control of the letdown flow. When the pressurizer water level reaches the no-load programmed setpoint, the pressurizer level control is shifted to control the charging flow to maintain programmed level. The RHRS is then isolated from the RCS and the normal letdown path is established. The pressurizer heaters are now used to increase RCS pressure.

The reactor coolant boron concentration is now reduced by operating the reactor makeup control system in the "dilute" mode. The reactor coolant boron concentration is corrected to the point where the control rods may be withdrawn and criticality achieved. Nuclear heatup may then proceed with corresponding manual adjustment of the reactor coolant boron concentration to balance the temperature coefficient effects and maintain the control rods within their operating range. During heatup, the appropriate combination of letdown orifices is used to provide necessary letdown flow.

Prior to or during the heating process, the CVCS is employed to obtain the correct chemical properties in the RCS. The reactor makeup control system is operated on a continuing basis to ensure correct control rod position. Chemicals are added through the chemical mixing tank as required to control reactor coolant chemistry such as pH and dissolved oxygen content. Hydrogen overpressure is established in the volume control tank to assure the appropriate hydrogen concentration in the reactor coolant.

Power Generation and Hot Standby Operation

Base Load

At a constant power level, the rates of charging and letdown are dictated by the requirements for seal water to the reactor coolant pumps and the normal purification of the RCS. One charging pump is employed and charging flow is controlled automatically from pressurizer level. The only adjustments in boron concentration necessary are those to compensate for core burnup. These adjustments are made at infrequent intervals to maintain the control groups within their allowable limits. Rapid variations in power demand are accommodated automatically by control rod movement. If variations in power level occur, and the new power level is sustained for long periods, some adjustment in boron concentration may be necessary to maintain the control groups within their maneuvering band.

During normal operation, normal letdown flow is maintained and one mixed bed demineralizer is in service. Reactor coolant samples are taken periodically to check boron concentration, water quality, pH and activity level. The charging flow to the RCS is controlled automatically by the pressurizer level control signal through the discharge header flow control valve or the positive displace pump speed controller.

Load Follow

A power reduction will initially cause a xenon buildup followed by xenon decay to a new, lower equilibrium value. The reverse occurs if the power level increases; initially, the xenon level decreases and then it increases to a new and higher equilibrium value associated with the amount of the power level change.

The reactor makeup control system is used to vary the boron concentration in the reactor coolant to compensate for xenon transients occurring when reactor power level is changed.

The most important intelligence available to the plant operator, enabling him to determine whether dilution or boration of the RCS is necessary, is the position of the control rods. For example, if the control rods are below their desired position, the operator must borate the reactor coolant to bring the rods outward. If, on the other hand, the control rods are above their desired position, the operator must dilute the reactor coolant to bring the rods inward.

During periods of plant loading, the reactor coolant expands as its temperature rises. The pressurizer absorbs this expansion as the level controller raises the level setpoint to the increased level associated with the new power level. The excess coolant due to RCS expansion is let down and stored in the volume control tank. During this period, the flow through the letdown orifice remains constant and the charging flow is reduced by the pressurizer level control signal, resulting in an increased temperature at the regenerative heat exchanger outlet. The temperature controller downstream from the letdown heat exchanger increases the component cooling water flow to maintain the desired letdown temperature.

During periods of plant unloading, the charging flow is increased to make up for the coolant contraction not accommodated by the programmed reduction in pressurizer level.

Hot Shutdown

If required, for periods of maintenance, or following spurious reactor trips, the reactor can be held subcritical, but with the capability to return to full power within the period of time it takes to withdraw control rods. During this hot shutdown period, temperature is maintained at no-load T_{avg} by initially dumping steam to remove core residual heat, or at later stages, by running reactor coolant pumps to maintain system temperature.

Following shutdown xenon buildup occurs and increases the degree of shutdown; i.e., initially, with initial xenon concentration and all control rods inserted, the core is maintained at a minimum of 1% Δk/k subcritical. The effect of xenon build-up is to increase this value to a maximum of about 3% Δk/k at about eight hours following shutdown from equilibrium full power conditions. If hot shutdown is maintained past this point, xenon decay results in a decrease in degree of shutdown. Since the value of the initial xenon concentration is about 1% Δk/k (assuming that an equilibrium concentration had been reached during operation), boration of the reactor coolant is necessary to counteract the xenon decay and maintain shutdown.

If a rapid recovery is required, dilution of the system may be performed to counteract this xenon buildup. However, after the xenon concentration reaches a peak, boration must be performed to maintain the reactor subcritical as the xenon decays out.

Cold Shutdown

Cold shutdown is the operation which takes the reactor from hot shutdown conditions to cold shutdown conditions (reactor is subcritical by at least 1% Δk/k and $T_{avg} \leq$ 200°F).

Before initiating a cold shutdown, the RCS hydrogen concentration is lowered by reducing the volume control tank overpressure, by replacing the volume control tank hydrogen atmosphere with nitrogen, and by continuous purging to the waste disposal system.

During the plant cooldown, charging is provided to make up for coolant contraction. During the initial phase of the cooldown, the makeup is provided from the boric acid tanks. The boric acid tanks should be used until at least the technical specification minimum volume has been charged. At that point, operators can continue using the boric acid tanks if additional volume is available, or shift suction of the charging pumps to the refueling water storage tank. If the boric acid tanks are used, 3.5 to 4.0% boric acid solution should be charged until the reactor coolant system reaches the desired cold shutdown concentration. The cooldown is completed by using blended makeup at the cold shutdown concentration.

Contraction of the coolant during cooldown of the RCS results in actuation of the pressurizer level control to maintain normal pressurizer water level. The charging flow is increased, relative to letdown flow, and results in a decreasing volume control tank level. The volume control tank level controller automatically initiates makeup to maintain the inventory.

After the RHRS is placed in service and the reactor coolant pumps are shutdown, further cooling of the pressurizer liquid is accomplished by charging through the auxiliary spray line. Coincident with plant cooldown, a portion of the reactor coolant flow is diverted from the RHRS to the CVCS for cleanup. Demineralization of ionic radioactive impurities and stripping of fission gases reduce the reactor coolant activity level sufficiently to permit personnel access for refueling or maintenance operations.

9.3.4.3 Safety Evaluation

9.3.4.3.1 Reactivity Control

Any time that the plant is at power, the quantity of boric acid retained and ready for injection always exceeds that quantity required for the normal cold shutdown assuming that the control assembly of greatest worth is in its fully withdrawn position. This quantity always exceeds the quantity of boric acid required to bring the reactor to hot shutdown and to compensate for subsequent xenon decay. An adequate quantity of boric acid is also available in the refueling water storage tank to achieve cold shutdown.

When the reactor is subcritical, i.e., during cold or hot shutdown, refueling and approach to criticality, the neutron source multiplication is continuously monitored and indicated. Any appreciable increase in the neutron source multiplication, including that caused by the maximum physical boron dilution rate, is slow enough to give ample time to start a corrective action to prevent the core from becoming critical. The rate of boration, with a single boric acid transfer pump operating, is sufficient to take the reactor from full power operation to 1% shutdown in the hot condition, with no rods inserted, in less than 90 minutes. In less than 100 additional minutes, enough boric acid can be injected via the normal boron charging path to compensate for xenon decay, although xenon decay below the equilibrium operating level will not begin until approximately 25 hours after shutdown. Additional boric acid is employed if it is desired to bring the reactor to cold shutdown conditions.

Two separate and independent flow paths are available for reactor coolant boration, i.e., the charging line and the reactor coolant pump seal injection line. A single failure does not result in the inability to borate the RCS.

If the normal charging line is not available, charging to the RCS is continued via reactor coolant pump seal injection at the rate of approximately 5 gpm per pump. At the charging rate of 20 gpm (5 gpm per reactor coolant pump), approximately 6.5 hours are required to add enough boric acid solution to counteract xenon decay, although xenon decay below the full power equilibrium operating level will not begin until approximately 25 hours after the reactor is shutdown.

As backup to the normal boric acid supply, the operator can align the refueling water storage tank outlet to the suction of the charging pumps.

Since inoperability of a single component does not impair ability to meet boron injection requirements, plant operating procedures allow components to be temporarily out of service for repairs. However, with an inoperable component, the ability to tolerate additional component failure is limited. Therefore, operating procedures require immediate action to affect repairs of an inoperable component, restrict permissible repair time, and require demonstration of the operability of the redundant component.

9.3.4.3.2 Reactor Coolant Purification

The CVCS is capable of reducing the concentration of ionic isotopes in the purification stream as required in the design basis. This is accomplished by passing the letdown flow through one of the mixed bed demineralizers which removes ionic isotopes, except those of cesium, molybdenum and yttrium, with a minimum decontamination factor of 10. Through occasional use of the cation bed demineralizer the concentration of cesium can be maintained below 1.0 µCi/cc, assuming 1% of the rated core thermal power is being produced by fuel with defective cladding. The cation bed demineralizer is capable of passing the maximum purification letdown flow, though only a portion of this capacity is normally utilized. Each mixed bed demineralizer is capable of processing the maximum purification letdown flow rate. If the normally operating mixed bed demineralizer resin has become exhausted, the second demineralizer can be placed in service. Each demineralizer is designed, however, to operate for one core cycle with 1% defective fuel.

A further cleanup feature is provided for use during residual heat removal operations. A remote-operated valve admits a bypass flow from the RHRS into the letdown line at a point upstream of the letdown heat exchanger. The flow passes through the heat exchanger and then passes through one of the mixed bed demineralizers and the reactor coolant filter to the volume control tank. The fluid is then returned to the RCS via the normal charging route.

The maximum temperature that will be allowed for the mixed bed and cation bed demineralizers is approximately 140°F. If the temperature of the letdown stream approaches this level, the flow will be automatically diverted so as to bypass the demineralizers. If the letdown is not diverted, the only consequence would be a decrease in ion removal capability. Ion removal capability starts to decrease when the temperature of the resin goes above approximately 160°F for anion resin or above approximately 250°F for cation resin. The resins do not lose their exchange capability immediately. Ion exchange still takes place (at a faster rate) when temperature is increased. However, with increasing temperature, the resin loses some of its ion exchange sites along with the ions that are held at the lost sites. The ions lost from the sites may be reexchanged farther down the bed. The number of sites lost is a function of the temperature reached in the bed and of the time the bed remains at the high temperature. Capability for ion exchange will not be lost until a significant portion of the exchange sites are lost from the resin.

There would be no safety problem associated with over-heating of the demineralizer resins. The only effect on reactor operating conditions would be the possibility of an increase in the reactor coolant activity level. If the activity level in the reactor coolant were to exceed the limit given in the Technical Specifications, reactor operation would be restricted as required by the Technical Specifications.

9.3.4.3.3 Seal Water Injection

Flow to the reactor coolant pumps' seals is assured by the fact that there are three charging pumps, any one of which is capable of supplying the normal charging line flow plus the nominal seal water flow.

9.3.4.3.4 Hydrostatic Testing of the Reactor Coolant System

The positive displacement pump can pressurize the RCS to its maximum specified hydrostatic test pressure. The pump is capable of producing a hydrostatic test pressure greater than that required.

9.3.4.3.5 Leakage Provisions

CVCS components, valves, and piping which see radioactive service are designed to limit leakage to the atmosphere. Leakage to the atmosphere is limited through:

(1) Welding of all piping joints and connections except where flanged connections are provided to facilitate maintenance and hydrostatic testing,

(2) Extensive use of leakoffs to collect leakage, and

(3) Use of diaphragm valves where conditions permit.

The volume control tank in the CVCS provides an inferential measurement of leakage from the CVCS as well as the RCS. Low level in the volume control tank actuates makeup at the prevailing reactor coolant boron concentration. The amount of leakage can be inferred from the amount of makeup added by the reactor makeup control system.

9.3.4.3.6 Ability to Meet the Safeguards Function

A failure analysis of the portion of the CVCS which is safety-related (used as part of the emergency core cooling system) is included as part of the emergency core cooling system failure analysis presented in Section 6.3.

9.3.4.4 Tests and Inspections

As part of plant operation, periodic tests, surveillance inspections and instrument calibrations are made to monitor equipment condition and performance. Most components are in use regularly; therefore, assurance of the availability and performance of the systems and equipment is provided by control room and/or local indication.

Technical Specifications have been established concerning calibration, checking, and sampling of the CVCS.

9.3.4.5 Instrumentation Application

Process control instrumentation is provided to acquire data concerning key parameters about the CVCS. The location of the instrumentation is shown on Figure 9.3-15.

The instrumentation furnishes input signals for monitoring and/or alarming purposes. Indications and/or alarms are provided for the following parameters:

(1) Temperature

(2) Pressure

(3) Flow

(4) Water level

The instrumentation also supplies input signals for control purposes. Some specific control functions are:

(1) Letdown flow is diverted to the volume control tank upon high temperature indication upstream of the mixed bed demineralizers.

(2) Pressure upstream of the letdown heat exchanger is controlled to prevent flashing of the letdown liquid.

(3) Charging flow rate is controlled during charging pump operation.

(4) Water level is controlled in the volume control tank.

(5) Reactor makeup is controlled.

9.3.5 Failed Fuel Detection System

9.3.5.1 Design Bases

The gross failed fuel detection system (GFFDS) consists of equipment designed to indicate gross fuel failure by monitoring the delayed neutron activity in the reactor coolant.

The GFFDS is not used for Unit 1 operations, and is not used in identifying conditions of fuel failure. During full power operations, primary system sampling is conducted every 7 and 14 days for gross specific activity and dose equivalent I-131, respectively. If power changes 15% or more in any one hour, a special sample is required between 2 and 6 hours after the power change. Since periodic sampling can effectively detect any changes in coolant activity, the GFFDS is not relied upon to provide indications of fuel failure. Periodic sampling is described in section 9.3.2.2

9.3.5.2 System Description

The gross failed fuel detector is connected to the hot leg of a primary coolant loop (Figure 9.3-16). The coolant sample passes through a cooler and then into a coil encompassing a neutron detector and moderator, then to a connection upstream of the mixed bed demineralizers after which it flows back into the volume control tank. The sample delay time to the neutron detector is adjusted by means of a flow controller. The delay time also depends on the length of tubing used. Once set, the flow is kept relatively constant by the automatic flow control valve. A transmitting flowmeter is installed for periodic checks of the flow rate. A sensor monitors the sample cooler outlet temperature.

Figure 9.3-17 shows the block diagram of the gross failed fuel detector channel. The detector, pre-amplifier, sample cooler, and associated flow controls are located outside the containment. The signal processing equipment and readout are mounted in a rack located in the control room. The delayed neutron signal of the detector is displayed on a recorder located in the rack. The response time for the gross failed fuel detector is on the order of 60 seconds.

9.3.5.3 Safety Evaluation

The GFFDS does not perform a safety-related function, and is not designed to satisfy any specific safety criteria. As shown on Figure 9.3-16, the gross failed fuel detector is outside of containment and is installed in the primary coolant hot leg sample line. It is isolated from the containment by means of the sample system isolation valves. The safety evaluation of the sampling system, including the isolation valves, is discussed in Section 9.3.2.

9.3.5.4 Tests and Inspections

The GFFDS is equipped with a test oscillator in the preamplifier and a test oscillator in the electronics drawer, each of which can be used to test the proper operation of the signal processing circuitry.

9.3.5.5 Instrument Applications

Instrumentation associated with GFFDS is described in Section 9.3.5.2.

9.3.6 Auxiliary Charging System

9.3.6.1 Design Bases

The auxiliary charging system is designed to provide makeup to the reactor coolant system (RCS) when the plant is operating in the "flood mode." For definition of "flood mode" see Section 2.4.14. This system is an essential part of the equipment used in flood protection provisions. This system is also designated as the flood mode boration makeup system.

The auxiliary charging system includes the following equipment:

(1) 4 full-capacity auxiliary charging pumps (2 per unit).

(2) 1 auxiliary makeup tank.

(3) 2 filters

(4) 1 demineralizer.

(5) 2 auxiliary charging booster pumps.

(6) Associated instrumentation and control equipment.

Each auxiliary charging pump capacity is 100 gph and each auxiliary charging booster pump capacity is 300 gph. Both capacities are several times greater than the maximum leakage loss from the primary system. Leakage loss is based on No. 2 and No. 3 seal leakage (580 gpd) with No. 1 seal injection and return lines isolated for each reactor coolant pump of both units plus the total recoverable leakage of 225 gpd at an RCS pressure of 350 psig (maximum during 'flood mode'). Nonrecoverable leakage need not be considered during flood mode operation since any two of the four steam generators will provide adequate cooling and a steam generator with primary to secondary leakage can be isolated. Also, any other system leakage will be considerably less than during normal operation.

The auxiliary makeup tank has a usable capacity of 868 gallons to provide a minimum of 12 hours makeup (801 gallons) based on the above leakage loss from each unit.

The filters and demineralizer are provided for cleanup of makeup water. The filters are designed for a flow rate of 10 gpm each, and the demineralizer is designed for a flow rate of 27 gpm. All auxiliary charging system equipment is located above flood level on the 757.0 elevation of the Auxiliary Building.

9.3.6.2 System Design Description

The auxiliary charging system is shown on Figure 9.3-18. The initial fill of makeup water for the auxiliary makeup will come from the demineralized water tanks. The majority of leakage, from RCS pump seals, etc., is collected in the reactor coolant drain tank (RCDT) and is pumped by the reactor coolant drain tank pumps to the auxiliary makeup tank. This recoverable leakage is the main preferred source of makeup water. Additional makeup water is supplied from other preferred sources: (1) accumulator tanks via the RCDT pumps, (2) pressurizer relief tank via the RCDT pumps, and (3) demineralized water tanks.

The above preferred sources of makeup water are backed up by the pumps of the high pressure fire protection system which can pump river water to the auxiliary makeup tank. To prevent inadvertent injection of raw water into the primary system, this source is connected, via fire hose, only if it is needed.

The makeup water is borated to the extent necessary to maintain refueling shutdown concentration in the RCS. Hydrazine and lithium hydroxide are added to makeup water as required. The boric acid, lithium hydroxide, and hydrazine are added and mixed with the makeup water in the auxiliary makeup tank in a batch process.

The primary system is sampled periodically and analyzed for boron concentration. Sample outlets are provided that are accessible in the flood mode.

The makeup water is pumped from the auxiliary makeup tank to the primary system as demanded by pressurizer level. One booster pump per plant and one charging pump per unit are sufficient to provide the required makeup; two booster pumps and four charging pumps are provided.

Spool pieces are used to connect the auxiliary charging system to the normal charging liners. These spool pieces are installed only in the event of a flood warning and after the reactor coolant system pressure has been reduced to less than 350 psig.

9.3.6.3 Design Evaluation

The auxiliary charging system components are commercial grade components.

Sufficient separation and redundancy of components and circuits are provided so that no single failure can jeopardize the operation. All components are capable of being supplied with emergency power.

Refer to Sections 2.4.14.1.2 and 2.4.14.9 for the limitation on the coincidence of seismic events and a flood exceeding plant grade. All essential features of the auxiliary charging system are designed to meet or exceed the resulting acceleration of the limited seismic requirement.

9.3.6.4 Tests and Inspection

All components of the auxiliary charging system are accessible for inspection. The system will be tested during preoperational testing to assure its adequacy.

9.3.6.5 Instrument Application

Manual control is employed to the maximum extent practicable.

The RCDT has both "Hi" and "Hi-Hi" level alarms to indicate an out of tolerance condition. The "Hi" level alarm also starts the RCDT pumps. Completely manual operation will be used to transfer water to the auxiliary makeup tank (AMT). Levels in the AMT can be visually checked (a level indicator is provided) since the tank has a 1/2-day supply under worst case conditions. The redundant pressure loops in the reactor coolant system serve as indications of the low pressure necessary for the activation of the auxiliary charging pumps.

9.3.7 Boron Recycle System

The boron recycle system (BRS) receives and recycles reactor coolant effluent for reuse of the boric acid and makeup water. The system decontaminates the effluent by means of demineralization and gas stripping, and uses evaporation to separate and recover the boric acid and makeup water. The boric acid evaporator package is not required for the operation of Unit 1. Liquid waste will be processed through the waste disposal mobile demineralizer (Reference Section 11.2.3).

9.3.7.1 Design Bases

9.3.7.1.1 Collection Requirements

The BRS collects and processes effluent which can be readily reused as makeup to the reactor coolant system (RCS). For the most part, this effluent is the deaerated, tritiated, borated, and radioactive water from the letdown and drains.

The BRS is designed to collect, via the letdown line in the chemical and volume control system (CVCS), the excess reactor coolant that results from the following plant operations during one core cycle:

(1) Dilution for core burnup from approximately 1100 ppm boron at the beginning of an annual core cycle to approximately 10 ppm near the end of the core cycle.

(2) Hot shutdowns and startups. Four hot shutdowns are assumed to take place during an annual core cycle.

(3) Cold shutdowns and startups. Three cold shutdowns are assumed to take place during an annual core cycle.

(4) Refueling shutdown and startup.

The BRS also collects and processes water from the following sources:

(1) Reactor coolant drain tank (waste disposal system) This tank collects leakoff type drains from equipment inside the containment. The contents of this tank are sent to the holdup tanks.

(2) Pressure relief valves - The holdup tanks collect the discharge from the volume control tank.

(3) Accumulators (safety injection system) - The holdup tanks collect effluent resulting from leak testing of accumulator check valves.

(4) Waste disposal system - The monitor tank provides storage for the WDS effluent and this effluent can be processed by the BRS, if necessary.

(5) Refueling water purification pumps in the spent fuel pool cooling and cleaning system. The holdup tanks provide a means of storing the fuel transfer canal water in case maintenance is required on the transfer equipment. The holdup tanks are an alternate storage method for use when the transfer canal water is outside the chemistry limit for use in the refueling water storage tank.

(6) Valve leakoffs and equipment drains.

The BRS also collects and processes water if required from the boric acid tank. A holdup tank provides storage of boric acid if a boric acid tank must be emptied for maintenance. The boric acid solution is transferred to and stored in a recycle holdup tank after first being diluted with reactor makeup water by the blender to ensure against precipitation of the boric acid in the unheated recycle holdup tank. This diluted boric acid solution will be reprocessed by the boric acid evaporator, and the concentrated boric acid will be stored in the boric acid tanks after maintenance is complete.

The holdup tanks can also collect water which passes through the condensate filters, concentrates filters, and ion exchange filters if that water does not meet the chemistry requirements of the system and must be reprocessed.

9.3.7.1.2 Capacity Requirement

The BRS is designed to process the total volume of water collected during a core cycle as well as short term surges. The design surge is that produced by a cold shutdown and subsequent startup during the latter part of a core cycle or by a refueling shutdown and startup.

9.3.7.1.3 Purification Requirement

The water collected by the BRS contains dissolved gases, boric acid, and suspended solids. The BRS is designed to provide sufficient cleanup of the water to satisfy the chemistry requirements of the recycled reactor makeup water and 3.5 to 4.0 wt/% boric acid solution.

The maximum radioactivity concentration buildup in the BRS components is based on operation of the reactor at its engineered safeguards design rating with defective fuel rods generating 1% of the rated core thermal power. For each component, the shielding design considers the maximum buildup on an isotopic basis including only those isotopes which are present in significant amounts. Filtration, demineralization, and evaporation are the means by which the activity concentrations are controlled.

9.3.7.2 System Description

The BRS is shown in Figures 9.3-15 (Piping and Instrumentation Diagram) and 9.3-20. Excess liquid effluents containing boric acid flow from the reactor coolant system through the letdown line and are collected in the holdup tanks. As liquid enters the holdup tanks, the nitrogen cover gas is displaced to the gas decay tanks in the waste disposal system through the waste vent header.

The concentration of boric acid in the holdup tanks varies throughout core life from the refueling concentration to essentially zero at the end of the core cycle. A holdup tank recirculation pump is provided to transfer liquid from one holdup tank to another.

Liquid effluent in the holdup tanks is processed as a batch operation through two recycle processing trains which are shared by the two units. This liquid is pumped by a gas stripper feed pump through a pair of evaporator feed ion exchangers. The liquid then flows through an ion exchanger filter, and into the gas stripper section of the combined boric acid evaporator-gas stripper package where dissolved gases are removed from the liquid. These gases are vented to the waste disposal system. The liquid effluent from the gas stripper section enters the boric acid evaporator.

The vapor produced in the boric acid evaporator is condensed in the evaporator condenser and the condensate is pumped through a condensate cooler where it is cooled to the operating temperature of the evaporator condensate demineralizers. If necessary, nonvolatile evaporator carry over is removed by one of the two evaporator condensate demineralizers. The distillate then flows through the condensate filter and then to the primary water storage tank. A high radiation signal from a detector on the line to the primary water storage tank causes the flow to be diverted back to the holdup tanks for reprocessing.

The condensate can be accumulated in the monitor tank if analysis is desired. Discharge from the monitor tank may be pumped by either of the monitor tank drain pumps to the primary water storage tank, to the evaporator condensate demineralizers, to the holdup tanks for reprocessing, or to the environment via the waste disposal system. The monitor tank is also used to store liquid wastes from the waste disposal system for sampling before being discharged to the environment.

The dilute boric acid solution originally in the boric acid evaporator remains as the bottoms of the distillation process and is concentrated to approximately 3.5 to 4.0% boric acid. Boric acid evaporator bottoms are sampled and, if analysis indicates that the solution meets specifications for use as boric acid makeup, the solution is then sent to the boric acid tanks via the concentrates filters. Otherwise, concentrates are returned to the holdup tanks for reprocessing by the evaporator train or to the waste disposal system.

9.3.7.2.1 Component Descriptions

A summary of principal component data is given in Table 9.3-6 and the code requirements are given in Section 3.2.

Boric Acid Transfer Pumps

Two horizontal, centrifugal, two speed pumps with mechanical seals are supplied for each unit. One pump of each pair is aligned with one boric acid tank and runs continuously at low speed to provide recirculation of the boric acid system and boric acid tank. The second pump of each pair is aligned with the third boric acid tank and is considered as a standby pump, with service being transferred as operation requires. These standby pumps also intermittently circulate fluid through the third tank. Manual or automatic initiation of the reactor makeup control system will activate the running pump for that unit to the higher speed to provide normal makeup of boric acid solution as required. For emergency boration, supplying of boric acid solution to the suction of the charging pump can be accomplished by manually actuating one or two pumps. The transfer pumps also function to transfer boric acid solution from the batching tank to the boric acid tanks. In addition to the automatic actuation by the makeup control system and manual actuation from the main control board, these pumps may also be controlled locally.

Holdup Tank Recirculation Pump

The recirculation pump is used to mix the contents of a holdup tank for sampling or to transfer the contents of a holdup tank to another holdup tank. When one of the holdup tanks is used to store water from the fuel transfer canal, the recirculation pump is used to return the water to the transfer canal. The pump is the centrifugal type, manually actuated, with all wetted surfaces constructed of austenitic stainless steel.

Gas Stripper Feed Pumps

One gas stripper feed pump supplies feed to each gas stripper boric acid evaporator train from the holdup tanks via the evaporator feed ion exchangers. The third pump is a standby and is available for operation in the event either operating pump malfunctions. These centrifugal pumps are constructed of austenitic stainless steel.

Monitor Tank Pumps

The two monitor tank pumps discharge water from the monitor tank. The centrifugal pumps are constructed of austenitic stainless steel.

Boric Acid Tanks

Approximately two and one-half full tanks of 4 wt/% boric acid solution (based on 9,890/tank gallons usable volume) are required for shutdown and refueling of one unit. This is normally the most limiting evolution that an operator must perform involving system boration, i.e., the addition of maximum amount of boron to the RCS. Two tanks, one for each unit, supply boric acid for each reactor coolant makeup system during normal operation, while the third tank serves as a spare.

The concentration of boric acid solution in storage is maintained between 3.5 and 4.0% by weight. Periodic manual sampling and corrective action, if necessary, ensure that these limits are maintained. As a consequence, measured boric acid solution can be delivered to the reactor coolant to control the chemical poison concentration. The combination overflow and breather vent connection has a water loop seal to minimize vapor discharge during storage of the solution.

Manually-operated electric immersion heaters in each boric acid tank can raise the temperature of boric acid solution to 100°F, if required. The heaters are sheathed in austenitic stainless steel.

One temperature detector provides temperature measurement of each tank's contents. Local temperature indication is provided and high and low temperature alarms are indicated on the main control board.

A level detector indicates the level in each boric acid tank. Level indication with high and low level alarms is provided on the main control board. The low alarm is set to indicate the minimum level of boric acid in the tank to ensure sufficient boric acid to provide suction head to the boric acid transfer pumps.

Batching Tank

The batching tank is used for mixing a makeup supply of boric acid solution for transfer to the boric acid tanks.

A local sampling point is provided for verifying the solution concentration prior to transferring it out of the tank. The tank is provided with an agitator to improve mixing during batching operations and electric strip heaters to heat the tank contents to expedite dissolution of boric acid.

Holdup Tanks

Two holdup tanks are shared between Units 1 and 2. The holdup tanks hold radioactive liquid which enters from the letdown line. The liquid is released from the reactor coolant system during startup, shutdowns, load changes and from boron dilution to compensate for burnup. The contents of one tank are normally being processed by the ion exchangers and the gas stripper-boric acid evaporator train while the other tank is being filled. When it is necessary to empty the fuel transfer canal, one of the tanks is emptied and is used to store the canal water.

Monitor Tank

The monitor tank accumulates liquid from the waste disposal system for sampling. After sampling, the contents can be pumped either to the primary water storage tank or back to the demineralizers. The liquid can be discharged to the environment, but this route will not normally be used. The tank can also be used to accumulate condensate from the boric acid evaporator trains if sampling is desired. After sampling the condensate can be pumped to the evaporator condensate demineralizers, to the holdup tanks, to the primary water storage tank, or to the environment.

Evaporator Feed Ion Exchangers

Two flushable evaporator feed ion exchangers are provided for the removal of lithium, iodine, and fission products from the holdup tank effluent. Two ion exchangers are employed in series for each gas stripper boric acid evaporator train. The first ion exchanger in each pair contains mixed-bed resin and the second ion exchanger contains cation resin. Cation resins are in hydrogen form and anion resins, originally in hydroxyl form, become converted to the borate form in operation. The total resin capacity in each pair is sufficient for one equilibrium core cycle assuming load-follow and 1% of the rated core thermal power being generated by defective fuel.

Evaporator Condensate Demineralizer

Two flushable, anion demineralizers are provided as polishing demineralizers for distillate from the evaporator. Although the bed may become saturated with boron at the normally low concentration (<10 ppm) leaving the evaporator, they will still remove boron if the concentration increases because of an evaporator upset.

Boric Acid Filter

The boric acid filter collects particulates from the boric acid solution being pumped from the boric acid tanks by the boric acid transfer pumps. The filter is designed to pass the design flow of two boric acid transfer pumps operating simultaneously.

Local pressure indicators indicate the pressure upstream and downstream of the boric acid filter and thus, can be used to provide filter differential pressure.

Condensate Filter

One condensate filter is provided for each evaporator downstream of the demineralizers. The filters collect resin fines and particulates from the distillate streams. The design flow rate is equal to the evaporator throughput rate. The vessels are constructed from austenitic stainless steel and the filter elements are disposable fiber cartridges.

Concentrates Filter

Two concentrates filters are provided to filter the completed batch of 3.5 to 4.0 wt/% boric acid from the evaporator in transit to the boric acid tanks. The design flow rate is compatible with the design flow of the boric acid evaporator concentrates pumps and is chosen to enable transfer of a completed batch within about one-half hour. The vessels are constructed from austenitic stainless steel and connections are provided for venting and draining. The filter element is a disposable fiber cartridge.

Ion-Exchange Filter

An ion-exchange filter is provided to collect resin fines and particulate from the feed to each gas stripper and boric acid evaporator package. The design flow rate is equal to the rated flow to the gas stripper and boric acid evaporator package. The vessels are provided with connections for venting and draining and are constructed of austenitic stainless steel. The filter elements are made of a disposable fiber.

Orifices

Boric Acid Tank Orifice

Each boric acid tank orifice is designed to pass the minimum flow required to provide sufficient recirculation through the piping and tanks with the transfer pumps. The orifice is constructed of austenitic stainless steel.

Gas Stripper and Boric Acid Evaporator Packages

The gas stripper and boric acid evaporator package (one per unit) removes nitrogen, hydrogen, and fission gases from the evaporator feed and then concentrates the weak boric acid solution to 3.5 to 4.0 wt/% boric acid for reuse. The package consists of a feed preheater, stripping column, vent condenser, evaporator, absorption tower, evaporator condenser, distillate cooler, distillate pumps, boric acid concentrates pumps, vent compressor, and associated piping, valves and instrumentation.

The borated feed water from the holdup tanks flows into the package to the feed preheater which heats the feed stream with process steam. The steam flow is controlled by temperature control of the feed exiting from the feed preheater.

The preheated feed flows into the stripping column where nitrogen, hydrogen, and fission gases are stripped from the borated water. The feed flow is controlled by the evaporator liquid level. The stripped gases are vented via the vent header to the waste disposal system. This venting is aided by the vent compressor during periods of high vent header pressure.

The evaporator concentrates the borated liquid to 3.5 to 4.0 wt/% boric acid. The evaporator bottoms are continuously recirculated by one of the boric acid concentrates pumps, and are monitored by a density meter. When a batch is completed it is transferred to the boric acid tanks if sample analysis indicates that it is suitable for reuse. If it cannot be reused, the concentrated boric acid solution can be returned to the holdup tanks for further processing or transferred to the waste disposal system.

Except for vapors used as stripping steam, all vapors leaving the evaporator flow through the absorption tower and then are condensed in the evaporator condenser. The distillate is pumped through a distillate cooler and out of the unit. A portion of the distillate is recycled to the absorption tower to serve as the absorption medium. After the distillate leaves the gas stripper boric acid evaporator package, it goes to the primary makeup water storage tank for reuse. If analysis of the distillate is required, it is sent to the monitor tank.

9.3.7.2.2 System Operation

The boron recycle system is employed, when required to process the contents of the holdup tanks. Sufficient instrumentation readouts and alarms are provided to properly operate the system.

Evaporation

Water is accumulated in the holdup tank until sufficient quantity exists to warrant an evaporator startup. Prior to startup of the evaporator, the contents of the recycle holdup tank are analyzed and, if necessary, are recirculated through the evaporator feed demineralizers and filter. The flow can be discharged back to the holdup tank or to the evaporator. The evaporator is then operated to produce a batch of 3.5 to 4.0 wt/% boric acid.

During the operation of the evaporator, condensate is continuously sent to the primary water storage tank via the evaporator condensate demineralizer. The condensate is monitored for high activity and, on a high radiation alarm, the flow is automatically diverted to the recycle holdup tank for reprocessing.

After a batch of boric acid is concentrated to 3.5 to 4.0 wt/%, it is analyzed to ensure that it is within specifications for reuse. If it meets the specifications it is transferred through the concentrates filter to the boric acid tanks. If it does not, it can be returned to the holdup tank via the concentration filter for reevaporation or, if desired, the concentrated boric acid can be sent to the waste disposal system for disposal.

Maintenance Drains

When large amounts of water must be drained from the RCS or the fuel storage area (or fuel transfer canal) to the BRS, a recycle holdup tank is drained of water. The water can then be stored in this tank until maintenance is completed and, after checking the chemistry, returned. After returning the water, the recycle holdup tank is again vented to the gaseous waste processing system where it is directed to a waste gas decay tank to prevent accumulation of air (i.e., nitrogen) in the high activity gas decay tanks during the venting.

Reactor Makeup Water Cleanup

If the reactor makeup water requires purification, it can be recirculated through the evaporator condensate demineralizer until its chemistry is within specifications. If further processing is necessary, water from the reactor water storage tank can be directed through the recycle evaporator condensate demineralizer and into the recycle holdup tanks for reevaporation.

9.3.7.3 Safety Evaluation

Malfunctions in the BRS do not affect the safety of station operations. The BRS is designed to tolerate equipment faults with critical functions being met by the use of two pieces of equipment so that the failure of one will, at most, reduce the capacity of the BRS but not completely shut it down.

9.3.7.4 Tests and Inspections

The BRS is in intermittent use throughout normal reactor operation. Periodic visual inspection and preventive maintenance are conducted using normal industry practice.

9.3.7.5 Instrumentation Application

Process control instrumentation is provided to acquire data concerning key parameters about the BRS. The location of the instrumentation is shown in Figures 9.3-15 and 9.3-20.

The instrumentation furnishes input signals for monitoring and/or alarming purposes. Indications and/or alarms are provided for the following parameters:

(1) Temperature

(2) Pressure

(3) Flow

(4) Water level

(5) Radiation level

9.3.8 Heat Tracing

Electric heat tracing is used to supply heat to some of the insulated mechanical piping systems to prevent freezing of the fluid in the pipe or to provide process temperature control to maintain the media within its specified temperature range; and it is used on some instrument sense lines.

The following systems use heat tracing:

(a) Condensate - System 002

(b) Main and auxiliary feedwater - System 003(Note 1)

(c) Raw cooling water - System 024

(d) High pressure fire protection - System 026

(e) Sampling and water quality - System 043

(f) Safety injection - System 063

(g) Essential raw cooling water - System 067

(h) Radiation monitoring - System 090

(i) Makeup water treatment plant - System 928

(j) Main Steam - System 001(Note 1)

(k) Ice Condenser - System 061

Note 1 - No main control room alarm for instrument sense lines in North and South valve vault rooms.

Table 9.3-1 Compressed Air System Descriptive Information Station Control and Service Air Systems (Page 1 of 2)

Station Air Compressors	
Number	4
Type	3 Reciprocating, 1 centrifugal
Discharge pressure, psig	100
Discharge Temperature,°F	110 (A, B, C)
Capacity, scfm, total	610 (A, B, C)
Station Air Compressors A, B, C (reciprocating) Aftercoolers	
Number	1 per compressor
Type	Shell and tube
Tube side flow, scfm (air)	610 (A, B, C)
Shell side flow, gpm (water)	12.4 (A, B, C)
Shell side design pressure, psig	150
Tube side design pressure, psig	150
Shell material	Carbon steel
Tube material	Admiralty
Design code	ASME VIII
Discharge Temperature, °F	110
Design Temperature, °F	340
Station Air Compressor D Coolers	
Intercooler/Aftercooler	Integral
Type	Shell & Tube
Tube Side Flow, SCFM (Air)	1166
Total Shell Side Water Flow, gpm	96.3 (Includes flow to external oil cooler)
Discharge Temperature, °F	105
Shell side design pressure, psig	75
Tube Side Design pressure, psig	150
Shell Material	Cast Iron
Tube Material	Copper (ASTM B111)
Tube FIN Material	Copper (ASTM B152)
Header	Muntz Metal (ASTM B111)
Design Code	Manufacturer's standard

Table 9.3-1 Compressed Air System Descriptive Information Station Control and Service Air Systems (Page 2 of 2)

Station Air Receivers	
Number	3 (two control and one service air)
Capacity, ft^3	266
Design pressure, psig	150
Design temperature, °F	300
Operating pressure, psig	100
Operating temperature,°F	105
Material	Carbon steel
Design code	ASME VIII
Auxiliary Air Compressors	
Number	2
Type	Reciprocating
Discharge pressure, psig	100
Discharge temperature, °F	430 (to aftercooler)
Capacity, scfm	75 each (this value is the procurement capacity; actual tested capacity could be lower)
Auxiliary Air Compressor Aftercooler	
Number	1 per compressor
Type	Tube and shell
Tube side flow, scfm (air)	75
Shell side flow, gpm (water)	4.5
Discharge temperature, °F	100 (15°F above ERCW inlet temperature of 85°F)
Auxiliary Air Receivers	
Number	2
Capacity, ft^3	34
Design pressure, psig	125
Operating pressure, psig	115
Design Code	ASME Section VIII

Table 9.3-2 Process Sampling System Sample Locations and Data
(Page 1 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
CVCS	Downstream Letdown Heat Exchanger	P = 600 T = 400	Boron Analyzer
CVCS	Downstream Excess Letdown Heat Exchanger	P = 2485 T = 630	Boron Analyzer
CVCS	Boric Acid Evaporator Package Concentrate Sample	P = 150 T = 250	Local
CVCS	Boric Acid Evaporator Package Distillate Sample	P = 150 T = 250	Local
CVCS	Outlet Boric Acid Blender	P = 150 T = 250	Hot Sample Room
CVCS	*Outlet Batching tank	P = ATM T = 300	Local
CVCS	*Downstream Monitor Tank A and B (One Sample)	P = 150 T = 180	Local
CVCS	Downstream Concentrate Filter A & B (one Sample)	P = 200 T = 250	Local
CVCS	Downstream Evaporator Feed, Ion Exchanger No. 1 B	P = ATM T = 150	Hot Sample Room
CVCS	Downstream Evaporator Feed, Ion Exchanger No. 2 B	P = ATM T = 150	Hot Sample Room
CVCS	Volume Control Tank Vent	P = 75 T = 250	Hot Sample Room
CVCS	Inlet Mixed Bed Demineralizer	P = 200 T = 250	Hot Sample Room

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 2 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
CVCS	Outlet Mixed Bed Demineralizer	P = 200 T = 250	Hot Sample Room
CVCS	Before Evaporator Feed Ion Exchanger (A & B)	P = 150 T = 200	Hot Sample Room
CVCS	*CVCS Holdup Tank Recirc	P = 150 T = 200	Hot Sample Room
CVCS	Before Evaporator Cnds Demin (Unit 1)	P = 300 T = 250	Hot Sample Room
CVCS	After Evaporator Code Demin (Unit 1)	P = 300 T = 250	Hot Sample Room
CVCS	Before Evaporator Cnds Demin (Unit 2)	P = 300 T = 250	Hot Sample Room
CVCS	After Evaporator Cnds Demin (Unit 2)	P = 300 T = 250	Hot Sample Room
WDS	*Downstream Laundry Pump	P = 150 T = 180	Local
WDS	*Downstream Waste Condensate Pumps	P = 150 T = 180	Local
WDS	CVCS Boric Acid Evaporator	P = Ambient T = 120	Gas Analyzer
WDS	Waste Gas Decay Tanks	P = 150 T = 180	Gas Analyzer
WDS	Spent Resin Storage Tank	P = 150 T = 180	Gas Analyzer

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 3 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
WDS	CVCS Holdup Tanks A & B	P = 150 T = 200	Gas Analyzer
WDS	RCS Pressurizer Relief Tank	P = 2485 T = 650	Gas Analyzer
WDS	CVCS Vol. Control Tank	P = 75 T = 250	Gas Analyzer
WDS	Reactor Coolant Drain Tank	P = 150 T = 180	Gas Analyzer
WDS	*Chemical Drain Tank Recirculate	P = 150 T = 180	Local
WDS	*Cask Decontamination Collector Tank	P = 150 T = 180	Local
WDS	*Tritiated Drain Tank Recirculation	P = 150 T = 180	Hot Sample Room
WDS	*Floor Drain Collector Tank Recirculation	P = 150 T = 180	Hot Sample Room
RCS	Hot Leg Loop 1	P = 2485 T = 650	Hot Sample Room
RCS	Hot Leg Loop 3	P = 2485 T = 650	Hot Sample Room
RCS	Pressurizer Liquid	P = 2485 T = 650	Hot Sample Room
RCS	Pressurizer Gas	P = 2485 T = 650	Hot Sample Room

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 4 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
Main Stream	Steam Gen No. 1 to H.P. Turbine	P = 1185 T = 600	Titration Room
Main Steam	Steam Gen No. 1 to H.P. Turbine	P = 1185 T = 600	Local
Main Steam	Steam Gen No. 2 to H.P. Turbine	P = 1185 T = 600	Titration Room
Main Steam	Steam Gen No. 2 to H.P. Turbine	P = 1185 T = 600	Local
Main Steam	Steam Gen No. 3 to H.P. Turbine	P = 1185 T = 600	Titration Room
Main Steam	Steam Gen No. 3 to H.P. Turbine	P = 1185 T = 600	Local
Main Steam	Steam Gen No. 4 to H.P. Turbine	P = 1185 T = 600	Titration Room
Main Steam	Steam Gen No. 4 to H.P. Turbine	P = 1185 T = 600	Local
Main Steam	Steam Gen No. 1, 2, 3, & 4 Downcomers	P = 1185 T = 600	Hot Sample Room
Main Steam	Steam Gen Blowdown No. 1, 2, 3, & 4	P = 1185 T = 600	Hot Sample Room
Blowdown	Steam Gen Blowdown Flash Tank	P = 450 T = 250	Local
Blowdown	Downstream of Steam Gen Blowdown Heat Exchanger	P = 1185 T = 150	Local

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 5 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
S.F.P.C.	*Upstream Spent Fuel Pool Demin	P = 150 T = 200	Local
S.F.P.C.	*Downstream Spent Fuel Pool Demin	P = 150 T = 200	Local
S.F.P.C.	*Refueling Water Purification Filter (Upstream)	P = 150 T = 200	Local
S.F.P.C.	*Refueling Water Purification Filter (Downstream)	P = 150 T = 200	Local
Htr Dr & V	No. 3 Htr Drain Tank	P = 250 T = 370	Local
Htr Dr & V	No. 7 Htr Drain Tank	P = 50 T = 180	Titration Room
FW	Downstream Htr 1A-1	P = 1185 T = 465	Local
FW	Downstream Htr 1B-1	P = 1185 T = 465	Local
FW	Downstream Htr 1C-1	P = 1185 T = 465	Local
FW	Htrs 1 A-1, 1B-1, and 1C-1 Hdr	P = 1185 T = 465	Titration Room
FW	Auxiliary FW Pump Hdr 1A-A	P = 1975 T = 120	Local
FW	Auxiliary FW Pump Hdr 1B-B	P = 1975 T = 120	Local

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 6 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
FW	Turbine Driven Auxiliary FW Pump 1A	P = 1975 T = 120	Local
Cnds	Hotwell Pumps Discharge Header	P = 350 T = 270	Titration Room
Cnds	Inlet Cond Booster Pump	P = 350 T = 270	Titration Room
Cnds	Outlet Heaters A-5, A-6, and A-7s	P = 350 T = 270	Local
Cnds	Outlet Heaters B-5, B-6, and B-7	P = 350 T = 270	Local
Cnds	Outlet C-5, C-6, and C-7	P = 350 T = 270	Local
Cnds	Inlet to Heaters A-4, B-4, and C-4	P = 650 T = 300	Local
Cnds	Downstream Heater A-2	P = 650 T = 410	Local
Cnds	Downstream Heater B-2	P = 650 T = 410	Local
Cnds	Downstream Heater C-2	P = 650 T = 410	Local
Cnds	Heaters A-2, B-2, and C-2 Downstream Hdr	P = 650 T = 410	Local
Cnds	Upstream MFP A and B	P = 650 T = 410	

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 7 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
Cnds	Hotwell Pump Discharge Header	P = 350 T = 270	Local
Cnds	Downstream MFPT Cond A	P = 350 T = 270	Local
Cnds	Downstream MFPT Cond B	P = 250 T = 270	Local
Cnds	Condenser Inlet Tube Sheet	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condense Inlet Tube Sheet	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condenser Low Pressure	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condenser Low Pressure	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condenser Outlet Tube Sheet	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condenser Outlet Tube Sheet	P = 150/30" Hg & Total Vacuum T = 120	Local

Table 9.3-2 Process Sampling System Sample Locations and Data
(Page 8 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
Cnds	Condenser Intermediate Pressure Crossover	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condenser Intermediate Pressure Crossover	P = 150/30" Hg & Total Vacuum T = 120	Local
Cnds	Condensate Demineralizer Influent Header	P = 350 T = 270	
Cnds	Condensate Demineralizer Effluent Header	P = 350 T = 270	
Cnds	Outlet of Each Polisher Vessel	P = 300 T = 120	
Cnds	Dilute Caustic	P = 60 T = 75	
Cnds	Dilute Acid	P = 60 T = 120	
Cnds	Downstream Anion Tank	P = 75 T = 120	
Cnds	Condenser Bottom (High Pressure)	P = 150/30" Hg & Total Vacuum T = 120	Local
Ext Steam	Inlet Htrs A-1, B-1, and C-1	P = 475 T = 460	Local
Ext Steam	Inlet Htrs A-2, B-2, and C-2	P = 325 T = 420	Local

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 9 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
Ext Steam	Inlet Htrs A-3, B-3, and C-3	P = 250 T = 375	Local
Ext Steam	Inlet MST SEP Reheaters A-1, B-1, and C-1	P = 475 T = 460	Local
Ext Steam	Inlet MST SEP Reheaters A-2, B-2, and C-2	P = 475 T = 460	Local
RCW	RCW Header	P = 125 T = 130	Local
Aux Blr	*Auxiliary Deareator Tank	P = 50 T = 75	Titration Room
Aux Blr	*Continuous Blowdown (Aux Blr A)	P = 200 T = 300	Titration Room
Aux Blr	*Continuous Blowdown (Aux Blr B)	P = 200 T = 300	Titration Room
Aux Blr	*Upper Drum Stm Sample (Aux Blr A)	P = 200 T = 300	Titration Room
Aux Blr	*Upper Drum Stm Sample (Aux Blr B)	P = 200 T = 300	Titration Room
WTS	*WTS Mix Bed Demin No. 1	P = 150 T = 65	Local
WTS	*WTS Mix Bed Demin No. 2	P = 100 T = 150	Local
WTS	*Outlet Cation Bed	P = 100 T = 100	Local

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 10 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
WTS	*Outlet Cation Bed	P = 100 T = 100	Local
WTS	*Degasifier Outlet	P = 100	Local
WTS	*Filter Plant Effluent	P = 15 T = 95	Local
WTS	*Caustic Sample Inlet Mixed Bed Demin	P = 50 T = 95	Local
WTS	*Caustic Sample Inlet Anion Demin	P = 50 T = 100	Local
WTS	*Acid Sample Inlet Mixed Bed Demin	P = 50 T = 95	Local
WTS	*Acid Sample Inlet Cation Demin	P = 50 T = 95	Local
Station Drainage	*Demin Waste Sump Turbine Bldg	P = ATM T = 100	Local
CCS	Downstream Component Cooling System Heat Exchanger A	P = 150 T = 200	Local
CCS	Downstream Component Cooling System Heat Exchanger B	P = 150 T = 200	Local
CCS	Downstream Component Cooling System Heat Exchanger C	P = 150 T = 200	Local
ERCW	*Downstream CCS Heat Exchanger A	P = 160 T = 130	Local
ERCW	*Downstream CCS Heat Exchanger B	P = 160 T = 130	Local

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 11 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
ERCW	*Downstream CCS Heat Exchanger C	P = 160 T = 130	Local
PMW	Primary Water Storage Tank	P = 100 T = 130	Local
RHR	RHR Pump 1A Minimum Flow Line	P = 600 T = 400	Hot Sample Room
RHR	RHR Pump 1B Minimum Flow Line	P = 600 T = 400	Hot Sample Room
RHR	RHR Pump 2A Minimum Flow Line	P = 600 T = 400	Hot Sample Room
RHR	RHR Pump 2B Minimum Flow Line	P = 600 T = 400	Hot Sample Room
RHR	Upstream RHR Exchanger 1A	P = 600 T = 400	Hot Sample Room
RHR	Upstream RHR Exchanger 1B	P = 600 T = 400	Hot Sample Room
RHR	Upstream RHR Exchanger 2A	P = 600 T = 400	Hot Sample Room
RHR	Upstream RHR Exchanger 2B	P = 600 T = 400	Hot Sample Room
SIS	Accumulator Tanks No. 1, 2, 3, and 4	P = 875 T = 200	Hot Sample Room
SIS	Accumulator tank Header Outlet	P = 2485 T = 650	Hot Sample Room

Table 9.3-2 Process Sampling System Sample Locations and Data (Page 12 of 12)

Sampled System	Sample Location	Design Pressure: psig Temperature, °F	Sample Type (See Note 1)
SIS	SI Pump (Unit 1) Refueling Water	P = 1750 T = 200	Hot Sample Room
SIS	SI Pump (Unit 2) Refueling Water	P = 1750 T = 200	Hot Sample Room
SIS	Refueling Water Storage Tank	P = ATM T = 200	Local
SIS	Downstream Boron Injection Tank (Unit 1)	P = 2735 T = 200	Hot Sample Room
SIS	Upstream Boron Injection Tank (Unit 1)	P = 2735 T = 200	Hot Sample Room
SIS	Downstream Boron Injection Tank (Unit 2)	P = 2800 T = 200	Hot Sample Room
SIS	Upstream Boron Injection Tank (Unit 2)	P = 2800 T = 200	Hot Sample Room
Flood Mode Boration Makeup System	Downstream Auxiliary Boration Makeup System	P = 70 T = 180	Local
WLRS	Wet Layup Recirculation	P = 150 T = 200	Local
Gland Seal	Gland Seal water at Demineralized Water Connection	P = 100 T = 150	Local

*These are common plant samples.

Note 1: The sample type indicates sample collection area or sample equipment.
Note 2: All samples listed for unit 1 unless noted as unit 2 or common.

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 1 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
			Fluid (water and)				
Reactor Vessel	Flange Leak-off	X			A	RCDT	
Pressurizer Relief Tank	Drain	X			A	RCDT Pump Suction	
Reactor Coolant Pump	No. 2 Seal Leakoff	X[1]			A	RCDT	
(Seals	No. 3 Seal Leakoff*	X	X		A	RCDT	
Reactor Coolant Pump	Thermal Barrier Relief	X[2]	X	X	B or A	FDT or TDT via CS	
(Cooling)	Bearing oil cooler Pres. Relief	X	X	X	B or A	FDT or TDT via CS	
Loop Drain	Drain	X	X[3]		A	RCDT	
RTD Manifold Loop Drain		X	X		A	TDT via CS	
Volume Control Tank	Drain	X			A	TDT	
Boric Acid Tank	Pres. Relief	X			A	CVCS HT	
	Overflow	X			A	TDT	
	Drain	X			A	TDT[4]	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 2 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain [9] Channel	Drain Tank [10]	Comments
Batching Tank	Drain Overflow				A	TDT TDT	
Regenerative HX	Shell & Tube Drain	X	X[5]		A	TDT[4] via CS	
Letdown HX	Shell Drain		X	X	C	CCST	
	Tube Drain	X	X[5]		A	TDT	
Excess Letdown HX	Shell Drain		X	X	C	CCST	
	Tube Drain	X	X[5]		A	TDT	
Seal Water Hx	Shell Drain Tube Drain	 X	X X[5]	X	C A	CCST TDT	
Charging Pump	Drain	X	X[5]		A	TDT	
Boric Acid Transfer Pump	Drain	X	X[5]		A	TDT[4]	
All CVCS Filters	Drain	X	X[5]		A	TDT[6]	
All CVCS Resin Columns	Drain	X	X[5]		A	TDT	
Chemical Mixing Tank	Drain	X	X		A	TDT	
CVCS Holdup Tank	Safety Valve Relief	X			A	TDT	
	Drain	X			A	TDT via Sump	
Gas Stripper Feed Pump	Drain	X	X[5]		A	TDT via Sump	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 3 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
All CVCS Recycle Filters	Drain	X	X[5]		A	TDT	
All CVCS Recycle Resin Columns	Drain	X	X[5]		A	TDT	
Monitor Tank	Overflow	X			A	TDT	
	Drain	X			A	TDT	
Monitor Tank Pumps	Drain	X	X[5]		A	TDT	
CVCS Holdup Tank Recirculation Pump	Drain	X			A	TDT via Sump	
Reactor Coolant Pump Seal Injection Line	Drain	X	X[5]		A	TDT via CS	
Excess Letdown to Waste Disposal System	Drain	X			A	RCDT	
Evaporator Condensate Demineralizers Resin Flush Line	Drain	X			A	TDT	
Tritiated Drain Collector Tank	Overflow	X	X		A	Sump	
	Drain	X	X		A	Sump	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 4 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
Waste Condensate Tanks	Overflow	X			B	FDT	
Waste Condensate Pump	Drain				B	FDT	
Reactor Coolant Drain Tanks	Overflow (or Safety Valve)	X			A	TDT or FDT via CS	
	Drain	X			A	TDT or FDT via CS	
Floor Drain Collector Tank	Overflow		X		B	Sump	
	Drain		X		B	Sump	
Laundry and Hot Shower Tanks	Overflow		X		B	FDT	
Chemical Drain Tank	Drain & Overflow	X	X		A	TDT	
Component Coolant Drain Tank	Overflow		X	X	C	FDT	This is a small tank to be used for return of pump seal leakage to system
	Drain		X	X	C	FDT	
Spent Resin Storage Tank	Drain	X				TDT	
Reagent Tanks	Drain				A	TDT	
Waste Evaporator Feed Pumps	Drain	X	X		A	Sump	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 5 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel[9]	Drain Tank[10]	Comments
Waste Condensate Tank Pump	Drain		X[5]		B	FDT	
Chemical Drain Pump	Drain	X	X		A	TDT	
Auxiliary Waste Evaporator Feed Pumps	Drain		X		A	Sump	
Laundry Pump	Drain		X		B	FDT	
Reactor Coolant Drain Tank Pumps	Drain	X	X[5]		A	TDT via CS	
Auxiliary Waste Evaporator Feed Pumps	Drain		X		A	FDT	
Waste Evaporator Package	Drain	X			A	TDT	
Auxiliary Waste Evaporator Package					B	FDT	
Waste Package Area	Drains	X			A	TDT	
Waste Evaporator Feed Filter	Drain	X	X[5]		A	TDT via Sump	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 6 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
Aux. Waste Evap. Feed Filter	Drain	X	X[5]		A	TDT via Sump	Aux. waste evap. feed filter becomes tritiated when waste evap. feed is directed to that path.
Floor Drain Tank Filter	Drain	X	X[5]		A	TDT via Sump	
Waste Condensate Tank Feed Filter	Drain				B	FDT	
Waste Evap. Condensate Demineralizer	Drain	X	X		A	TDT	
Waste Gas Compressor	Condensate	X			A	TDT	Expected to be insignificant
	HX Drain			X		CSST	
Gas Decay Tank (Power)	Drain	X			A	TDT	
Gas Decay Tank (Shut-downs)	Drain	X			A	TDT via Sump Tank	
Accumulator	Drain	X			A	Flanged	Drain to RCDT
	Pressure Relief Drain	X			A	TDT	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 7 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
Boron Injection Tank	Drain	X	X[5]		A	TDT	
High Head Safety Injection Pump	Drain	X	X[5]		A	TDT	
Containment Spray Pump	Drain	X	X[5]		A	TDT via Sump	
Residual HX	Shell Drain		X	X	C	CCST	
	Tube Drain	X	X		A	TDT	
Residual Heat Removal Pumps	Drain	X	X		A	TDT via Sump	
Component Cooling Surge Tank	Pres. Relief		X	X	C	FDT	Pipe separately to FDT
	Overflow		X	X	C	FDT	
	Drain		X	X	C	FDT	
Component Cooling HX	Shell Drain		X	X	C	CSST	
	Tube Drain (ERCW)					Send overboard	Do not send to drain tanks in either channel.
Component Cooling Pumps	Drain		X	X	C	CCST via CCSDT	
Component Cooling Booster Pumps	Drain		X	X	C	Portable Container	
Component Cooling Pump	Drain		X	X	C	Portable Container	
Seal Drain Tank & Pump	Overflow		X	X	B	FDT	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 8 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel[9]	Drain Tank[10]	Comments
Spent Fuel Pit HX	Shell Drain		X	X	C	CCST[7]	
	Tube Drain	X	X		A	TDT[7]	
Spent Fuel Pit Pump	Drain	X	X		A	TDT[7]	
Spent Fuel Pit Skimmer Pump	Drain	X	X		A	TDT[7]	
Refueling Water Purification Pumps	Drain	X			A	TDT	
Refueling Water Purification Filter	Drain	X			A	TDT	
Spent Fuel Pit Leakage	Drain	X			A	TDT	
Spent Fuel Pit Skimmer Filter	Drain	X	X		A	TDT	
Spent Fuel Pit Demineralizer	Drain	X	X		A	TDT	
Radiochem. Laboratory	Spent or Treated Sample & Chem'ls	X				CDT	
	Radioactive Excess Tritiated Sample Sink Drain	X	X		A	TDT	
	Non-Tritium Sample & Rinse Sink Drains	X	X		B	FDT	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 9 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
Sample Heat Exchanger	Shell Drain		X	X	C	CCST	May be drained to portable container and recycled.
	Tube Drain	X	X		A	TDT	Empty into clean sample sink.
	Non-Tritium Tube Drain		X			FDT	Empty into non-tritiated sample sink.
Sample Vessel	Drain	X	X		A	CDT	
Sample Room	Sample Sink Drain	X	X		A	TDT	Liquid from secondary side must be re-turned to secondary side or discharged to FDT.
	Non-Tritium		X		B	FDT	
Floor Drain Inside Containment	Floor Drain		X		B	FDT via CS	
Floor Drains Aux. Building	Floor Drain		X		B	FDT	See 2.3.1 and 2.3.3.
Valve Leakoff Inside Containment	Leakoff	X			A	RCDT	

Table 9.3-3 Equipment and Floor Drainage Data Reactor Coolant System (Page 10 of 10)

Component	Drain Type	Tritium	Air	(Chromates or Nitrates)	Drain Channel [9]	Drain Tank [10]	Comments
Valve Leakoff Outside Containment	Leakoff	X			A	TDT	
	Leakoff	X	X		A	TDT	
Hot Shower	Drain		X		B	LHSDT	
Laundry	Drain		X		B	LHSDT	
Containment Fan Coolers	Condensate Drain	X[8]	X		A	FDT or TDT via CS	Service Water should not be put in CS. Use portable container or use procedure to force liquid into discharge header.
	Cooling Water Drain		X		Special		
Gas Analyzer Drain	Drain	X			A	TDT	
Fuel Transfer Canal Leakage	Drain	X			A	TDT	
Primary Water Makeup Pumps	Drain	X			A	TDT	
Liner Leakage (Reactor Bldg)	Drain	X			A	TDT	
Cask Landing Area	Drain	X			A	TDT	
Auxiliary Feedwater Pumps	Drain	X			A	TDT	

NOTES:

1. This liquid is aerated; however, because of the small amount it is directed to the RCDT.
2. Only in abnormal case or thermal barrier leak.
3. Becomes aerated during drain. Will be pumped from RHT back to loop for refilling.
4. Flush after drain.
5. Becomes aerated during drain.
6. Flush boric acid filter after drain.
7. Or drain to portable container and recycle to respective system.
8. If high concentration, flow can be directed to TDT.
9. Channel A is for tritiated liquid. Channel B is for non-tritiated liquid. Channel C is for Chromated liquid. See Section 9.3.3.2.
10. See Section 9.3.3.7 for explanation of acronyms.

Table 9.3-4 Chemical and Volume Control System Design Parameters

General	
Seal water supply flow rate, for four reactor ccolant pumps, nominal, gpm	32
Seal water return flow rate, for four reactor coolant pumps, nominal, gpm	12
Letdown flow:	
Normal, gpm (reciprocating/centrifugal pump operation)	45/75
Maximum, gpm	120
Charging flow (excludes seal water):	
Normal, gpm (reciprocating/centrifugal pump operation)	25/55
Maximum, gpm	100
Temperature of letdown reactor coolant entering system at full power, °F	557.5
Normal temperature of charging flow directed to Reactor Coolant System, °F	514
Temperature of effluent directed to Boron Recycle System, °F	127
Centrifugal charging pump bypass flow (each), gpm	60

Table 9.3-4 Chemical and Volume Control System Design Parameters

General	
Amount of 3.5 to 4.0% boric acid solution required to meet cold shutdown requirements at the end of a core cycle with the most reactive control rod stuck out of the core, gallons	See Figure 9.3-21 for Requirements
Maximum pressurization required for hydrostatic testing of Reactor Coolant System, psig	3107

Table 9.3-5 Principal Component Data Summary (Page 1 of 6)

Reciprocating Charging Pump	
Number	1 (per unit)
Design pressure, psig	3200
Design temperature, °F	300
Design flow, gpm	98
Design head, ft.	5800
Material	Austenitic stainless steel
Maximum operating pressure, psig (for hydrotest purposes)	3125
Centrifugal Charging Pumps	
Number	2 (per unit)
Design pressure, psig	2800
Design temperature, °F	300
Design flow, gpm	150
Design head, ft.	5800
Material	Austenitic stainless steel
Regenerative Heat Exchanger	
Number	1 (per unit)
Heat transfer rate at design conditions, Btu/hr	10.84×10^6
Shell Side	
Design pressure, psig	2485
Design temperature,°F	650
Fluid	Borated reactor coolant
Material	Austenitic stainless steel
Tube Side	
Design pressure, psig	2735
Design temperature, °F	650
Fluid	Borated reactor coolant
Material	Austenitic stainless steel
Shell Side (Letdown)	
Normal Flow, lb/hr	37,020
Inlet temperature, °F	557.5
Outlet temperature, °F	290
Tube Side (Charging)	
Normal Flow, lb/hr	27,148
Inlet temperature, °F	130
Outlet temperature, °F	514

Table 9.3-5 Principal Component Data Summary
(Page 2 of 6)

Letdown Heat Exchanger		
Number		1 (per unit)
Heat transfer rate at design conditions, Btu/hr		15.27×10^6
Shell Side		
Design pressure, psig		150
Design temperature, °F		250
Fluid		Component cooling water
Material		Carbon steel
Tube Side		
Design pressure, psig		600
Design temperature, °F		400
Fluid		Borated reactor coolant
Material		Austenitic stainless steel
Shell Side	(Heat up)	(Normal)
Flow, lb/hr	498,000	203,000
Inlet temperature, °F	95	95
Outlet temperature, °F	126	126

Table 9.3-5 Principal Component Data Summary (Page 3 of 6)

Tube Side (Letdown)	(Heatup)	(Normal)
Flow, lb/hr	59,232	37,050
Inlet temperature, °F	380	290
Outlet temperature, °F	126	127
Number		1 (per unit)
Heat transfer rate at design conditions, Btu/hr		4.79×10^6
Design pressure, psig	150	2485
Design temperature, °F	250	650
Design flow, lb/hr	115,000	12,340
Inlet temperature, °F	95	557.3
Outlet temperature, °F	137	195
Fluid	Component cooling water	Borated reactor coolant
Material	Carbon steel	Austenitic stainless steel
Seal Water Heat Exchanger		
Number	1 (per unit)	
Heat transfer rate at design conditions, Btu/hr	1.46×10^6	
	Shell Side	Tube Side
Design pressure, psig	150	200
Design temperature, °F	250	250
Design flow, lb/hr	99,500	47,879
Inlet temperature, °F	95	157.4
Outlet temperature, °F	109.7	127
Fluid	Component cooling water	Borated reactor coolant
Material	Carbon steel	Austenitic stainless steel
Volume Control Tank		
Number	1 (per unit)	
Volume, ft^3	400	
Design pressure, psig	75	
Design temperature, °F	250	
Material	Austenitic stainless steel	

Table 9.3-5 Principal Component Data Summary (Page 4 of 6)

Chemical Mixing Tank	
Number	1 (per unit)
Capacity, gal	5
Design pressure, psig	150
Design temperature, °F	200
Material	Austenitic stainless steel
Mixed Bed Demineralizers	
Number	2 (per unit)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	120
Resin volume, each, $ft.^3$	30
Material	Austenitic stainless steel
Cation Bed Demineralizer	
Number	1 (per unit)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	75
Resin volume, $ft.^3$	20
Material	Austenitic stainless steel
Reactor Coolant Filter	
Number	1 (per unit)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	150 (max.)
Particle retention	98% of 5 micron size
Material, (vessel)	Austenitic stainless steel
Seal Water Injection Filters	
Number	2 (per unit)
Design pressure, psig	3100
Design temperature, °F	250
Design flow, gpm	80
Particle retention	98% of 5 micron size
Material, (vessel)	Austenitic stainless steel
Seal Water Return Filter	
Number	1 (per unit)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	150 (max.)
Particle retention	98% of 25 micron size
Material, (vessel)	Austenitic stainless steel

Table 9.3-5 Principal Component Data Summary (Page 5 of 6)

Letdown Orifice	Approx. 3 gpm	45 gpm(note 1)	75 gpm(note 2)
Number	1 (per unit)	1 (per unit)	2 (per unit)
Design flow, lb/hr	Approx. 1482	22,230	37,050
Differential pressure at design flow, psid	1900	1900	1900
Design pressure, psig	2485	2485	2485
Design temperature, °F	650	650	650
Material	Austenitic Stainless Steel	Austenitic Stainless Steel	Austenitic Stainless Steel
Seal Water Return Bypass Orifice			
Number			4 (per unit)
Design flow, gpm			1
Differential pressure at design flow, psid			300
Design pressure, psig			2485
Design temperature, °F			250
Material			Austenitic Stainless Steel
Chemical Mixing Tank Orifice			
Number			1 (per unit)
Design flow, gpm			2
Differential pressure at design flow, psid			50
Design pressure, psig			150
Design temperature, °F			200
Material			Austenitic Stainless Steel
Reactor Coolant Pump Standpipe Orifice			
Number			4 (per unit)
Design, flow, gpm			0.5
Differential pressure			9 inches of H2O
Design pressure, psig			150
Design temperature, °F			200
Material			Stainless Steel
Charging Pump Bypass Orifice			
Number		2 (per unit)	
Design flow, gpm		60	
Differential pressure at design flow, psid		(1)	
Design pressure, psig		(1)	
Design temperature, °F		(1)	
Material		Stainless Steel	

Table 9.3-5 Principal Component Data Summary (Page 6 of 6)

Boric Acid Blender	
Number	1 (per unit)
Design pressure, psig	150
Design temperature, °F	250
Material	Austenitic Stainless Steel

(1) Supplied by Pump Manufacturer

NOTES:

1) During preoperational testing, only 44.7 gpm was achieved.

2) During preoperational testing, one (1) orifice only achieved 69.3 gpm.

Table 9.3-6 Boron Recycle System Principal Component Data Summary (Page 1 of 3)

Boric Acid Transfer Pumps	
Number	4 (shared)
Design pressure, psig	150
Design temperature, °F	250
Design flow, gpm	75
Design head, ft.	235
Material	Austenitic stainless steel
Gas Stripper Feed Pumps	
Number	3 (shared)
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	30
Design head, ft.	320
Material	Austenitic stainless steel
Holdup Tank Recirculation Pump	
Number	1 (shared)
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	500
Design head, ft.	100
Material	Austenitic stainless steel
Monitor Tank Pumps	
Number	2 (shared)
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	150
Design head, ft.	200
Material	Austenitic stainless steel
Boric Acid Tanks	
Number	3 (shared)
Capacity, gal.	11,000
Design pressure	Atmospheric
Design temperature, °F	200
Material	Austenitic stainless steel
Boric Acid Batching Tank	
Number	1 (shared)
Capacity, gal.	800
Design pressure	Atmospheric
Design temperature, °F	300
Material	Austenitic stainless steel

Table 9.3-6 Boron Recycle System Principal Component Data Summary (Page 2 of 3)

Holdup Tanks	
Number	2 (shared)
Capacity, ga.	126,000 (per tank)
Design pressure, psig	15
Design temperature, °F	200
Material	Stainless Steel
Monitor Tank	
Number	1 (shared)
Capacity, gal.	21,600
Design pressure	Atmospheric
Design temperature, °F	200
Material	Austenitic stainless steel
Evaporator Feed Ion Exchangers	
Number	4 (shared)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	72
Resin volume, $ft.^3$	20
Material	Austenitic stainless steel
Evaporator Condensate Demineralizers	
Number	2 (shared)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	75
Resin volume, each, $ft.^3$	20
Material	Austenitic stainless steel
Boric Acid Filters	
Number	1 (per unit)
Design pressure, psig	300
Design temperature, °F	250
Design flow, gpm	150
Participle retention	98% of 25 micron size
Material (vessel)	Austenitic stainless steel
Ion Exchanger Filters	
Number	2 (shared)
Design pressure, psig	200
Design temperature, °F	250
Design flow, gpm	35
Participle retention	98% of 25 micron size
Material	Austenitic stainless steel

Table 9.3-6 Boron Recycle System Principal Component Data Summary (Page 3 of 3)

Evaporator Condensate Filters	
Number	2 (shared)
Design pressure, psig	200
Design temperature, °F	250
Design flow, gpm	35
Particle retention	98% of 25 micron size
Material,(vessel)	Austenitic stainless steel
Concentrate Filters	
Number	2 (shared)
Design pressure, psig	200
Design temperature, °F	250
Design flow, gpm	35
Particle retention	98% of 25 micron size
Material,(vessel)	Austenitic stainless steel
Boric Acid Tank Orifice	
Number	3 (shared)
Design flow, gpm	3
Differential pressure at design flow, psid	100
Design pressure, psig	150
Design temperature, °F	200
Material	Austenitic stainless steel
Gas Stripper-Boric Acid Evaporator Package	
Number	2 (shared)
Design flow, gpm	30
Concentration of concentrate (boric acid), wt percent	4
Concentration of condensate	<10 ppm boron
Material	Stainless steel

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air System

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
1. Manual isolation vlv (all)	Maintenance isolation only.							NA	NA	NA		
2. Afterfilter (from control air (CA) system)	Assures that foreign particles do not enter aux. air from control air.	X	X	X	X			Filter plugged	Isolation valve closure	None- Loss of CA to affected subsystem, aux. air compr. will start and supply air. No loss of function.	None	
								Filter ruptured	None	Loss of affected subsystem if filter particles plug air lines or instruments in affected subsystem.	None	Filter rupture only due to very highΔ P.
3. Aux. air isol. valve 32-82	Isolates aux. air from CA on low CA header press.					X	X	Fails open	Local indication of valve position	None- Check valve will prevent backflow from affected subsystem. Aux. air compr. will start and supply air to affected subsystem.	None	
		X	X	X	X	X	X	Fails closed	Local indication of valve position	None-Loss of CA supply to affected subsystem. Aux. air compr. will start and supply air to affected subsystem.	None	Valve is designed to be fail closed.
4. Check valve	Prevents backflow					X	X	Fails open	None-	None Isolation valve will prevent depressurization thru CA system. No loss of function.	None	

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air System

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
5. Containment isol. valve 32-80	Closes on low air press. in aux. air line, remote operation signal, or phase B containment isolation.						X	Fails open	Low header air press. Control room valve position indication	Loss of subsystem if air lines are ruptured inside containment. Depressurization of affected subsystem for a downstream line break. Downstream check valve will prevent release of radiation containment. The effect of air in-leakage from the aux. air system on the containment pressure is negligible considering long term operator action.	None	Valve is designed to be fail closed. Containment isolation valve and downstream check valve act as redundant containment isolation barriers against radiation release during a downstream line break.
		X	X	X	X	X	X	Fails closed	Control room valve position indication.	Loss of affected subsystem instruments within the reactor bldg.	None	

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air System

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
6. Check valve	Prevents backflow from reactor bldg to aux. bldg thru aux. air line.					X		Fails open	None	Loss of affected subsystem if air lines are ruptured inside containment in which case containment isolation vlv. will isolate on low press. Air in-leakage from aux. air line will prevent back-flow of radiation prior to containment isolation vlv closure.		
General		X	X	X	X				The failure of any of the above components during any of these modes will have no effect on the system unless otherwise indicated above.			

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
1. Intake filter	Filters air prior to compressor					x	x	Filter plugged	Control room low header pressure	Loss of affected subsystem due to loss of air supply.	None	
								Filter cartridge rupture	None	Loss of affected subsystem due to compressor damage and resultant loss of air supply	None	
2. Compressor	Provides required pressure and flow.					x	x	Compr. or motor fails	Control room (compr. trip)	Loss of affected subsystem due to loss of air supply.	None	
								Unloader fails	Safety valve opens	Loss of affected subsystem due to loss of air supply. Safety valve on receiver or compr. discharge opens.	None	
3. Cooling water solenoid valve 32-61	N.O. shuts off water when compr. is not running.					X	X	Fails open	Visual loss of affected	Long term loss of affected subsystem due to damage to and loss of compr. and subsequent loss of air supply. No immediate effect on subsystem.	Damage due to rusting of cylinders	None

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
								Fails closed	High compr. air temp. alarm (local)	Long term loss of affected subsystem due due to higher than normal air temp. to dryer with degradation of air quality in affected subsystem. This will result in damage to compr. and eventual loss of air supply to affected subsystem.	None	
4. Manual isolation vlve	Isolate for maint. purposes only.							NA	NA	None	None	
5. Safety valve	Prevents excess press. in compr. discharge.					X	X	Fails open	Control room low header pressure	Loss of affected subsystem due to loss of air supply.	None	
						X	X	Fails closed	None	None Safety vlv on recvr will open.	None	

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
6. Aftercooler	Cools air following compr.					X	X	Tube rupture	Control room high dewpoint	Long term loss of affected subsystem due to loss of air into cooling water, excessive moisture into recvr, possible saturation of dryer dessicant. This results in degradation of air quality to instruments in affected subsystem.	None	
								Water side plugged	Local temp. indicator	Long term loss of affected subsystem due to degradation of air quality from high temp. air to down-stream dryer and instruments in affected subsystem.	None	
7. Trap	Remove moisture from aftercooler or recv'r.					X	X	Fails open	Audible low recvr press.	Loss of affected subsystem due to leakage of air to atmosphere and subsequent loss of pressure in affected subsystem	None	Traps will be inspected and exercised during inservice inspection.

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
								Fails closed	Control room high dewpoint	Loss of affected subsystem due to water accumulation in components, saturation of dryer dessicant and degradation of air quality to instruments in affected subsystem.	None	
8. Check valve	Prevents backflow when compr. is not running.					X	X	Fails open	Local, aux. air compr. start.	None- Aux. air compr. will start and run until reset locally by operator.	None	
9. Receiver tank	Stores air.					X	X	None		None	None	No active failures for this component.
10. Receiver safety vlv	Prevents excess press. in recv'r.					X	X	Fails open	Local, low recv'r press.	Loss affected subsystem due to loss of air supply in affected subsystem. Check valve downstream of after filters prevents backflow.	None	

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
								Fails closed	None	Loss of affected subsystem if pressure is due to reasons other than compr. due to rupture of recvr or downstream components in affected subsystem. If pressure is due to compr., safety vlv on compr. discharge will open.	None	
11. Check valve	Maintains recv'r press. during normal oper. Prevents bypassing of dryer by compressed air. Provides dryer purge air.					X	X	Fails open	Control room high dewpoint	Long term loss of affected subystem due to bypass of wet air around dryer into aux. air system resulting in degradation of air quality to instruments in affected subsystem.	None	
12. Prefilter	Removes foreign particles and mositure droplets.					X	X	Filter plugged	Local high diff. press.	Loss of affected subsystem due to loss of press. downstream of prefilter and subsequent loss of air supply in affected subsystem.	None	Filter would be inspected visually during inservice inspection.

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
								Filter rupture	None	Long term loss of affected subsystem due to partial plugging or damage to dryer.	None	
13. Air dryer	Dries air to 0°F dewpoint.					X	X	Flow path blocked	Control room low header press. Local high P	Loss of affected subsystem due to loss of air supply in affected subsystem.	None	Dryer includes several components (tanks, solenoid operated valves, check valves, and piping) which are purchased as a package. The worst effect of a failure of any single component is considered here for the entire dryer package.
								Dryer open to atmosphere	Control room low header press.	Loss of subsystem due to loss of air supply in affected subsystem.	None	
								Tower switching mechanism fails	Control room high dewpoint	None- Gradual increase in moisture to instrument in the affected subsystem	None	

Table 9.3-7 Failure Mode and Effects Analysis Auxiliary Air Supply Equipment

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	Mode of Oper. 1	2	3	4	5	6	Failure Mode	Method of Det.	Effect On Subsystem	System	Remarks
14. Afterfilter	Filters foreign particles and desicant from the air.					X	X	Filter plugged	Local high diff. press. Low header pressure.	Loss of subsystem due to loss of air supply to affected subsystem.	None	
								Filter rupture	None	Loss of subsystem due to filter particles plugging air lines or instruments in affected subsystem.	None	Filter rupture only due to very high P.
		X	X	X	X				The failure of any of the above components during any of these modes will have no effect on the system unless otherwise indicated above.			

Table 9.3-8 Equipment Supplied With Auxilary Control System Air (Page 1 of 4)

Component ID	OP Mode - Failure Mode	Supplied From
Auxiliary Building Gas Treatment System Dampers		
0-FCO-30-148	(N/A-FC)	Train B
0-FCO-30-149	(N/A-FC)	Train A
0-FCO-30-279	(NC-FC)	Train B
0-FCO-30-280	(NC-FC)	Train A
1-FCO-30-146B	(NC-FC)	Train A
1-FCO-30-146A	(NC-FC)	Train A
2-FCO-30-157B	(NC-FC)	Train B
2-FCO-30-157A	(NC-FC)	Train B
Auxiliary Feedwater Control Valves		
1,2-LCV-3-148	(NC-FO)	Train B
1,2-LCV-3-148A	(NC-FC)	Train B
1,2-LCV-3-156	(NC-FO)	Train A
1,2-LCV-3-156A	(NC-FC)	Train A
1,2-LCV-3-164	(NC-FO)	Train A
1,2-LCV-3-164A	(NC-FC)	Train A
1,2-LCV-3-171	(NC-FO)	Train B
1,2-LCV-3-171A	(NC-FC)	Train B
1,2-LCV-3-172	(NC-FC)	Train A
1,2-LCV-3-173	(NC-FC)	Train B
1,2-LCV-3-174	(NC-FC)	Train B
1,2-LCV-3-175	(NC-FC)	Train A
1-PCV-3-122	(NC-FC)	Train A
1-PCV-3-132	(NC-FC)	Train B
2-PCV-3-122	(NC-FC)	Train A
2-PCV-3-132	(NC-FC)	Train B
Panel 1-L-222B		Train B
1-L-214B		Train A
2-L-222B		Train B
2-L-214B		Train A
Main Steam Pressure Relief Valves		
1,2-PCV-1-5	(NC-FC)	Train A
1,2-PCV-1-12	(NC-FC)	Train B
1,2-PCV-1-23	(NC-FC)	Train A
1,2-PCV-1-30	(NC-FC)	Train B

Table 9.3-8 Equipment Supplied With Auxilary Control System Air (Page 2 of 4)

Component ID	OP Mode - Failure Mode	Supplied From
Panel 2-L-420		Train A
1-L-420		Train A
2-L-423		Train A
1-L-423		Train A
2-L-421		Train B
1-L-421		Train B
2-L-422		Train B
1-L-422		Train B
Reactor Coolant System Valves		
1,2-PCV-68-340B	(NC-FC)	Train B
1,2-PCV-68-340D	(NC-FC)	Train A
Panels 1,2-L-366		Train A
1,2-L-180		Train B
Emergency Gas Treatment System Equipment		
Train A		Train B
2-FCV-65-5		2-FCV-65-4
2-FCV-65-9		2-FCV-65-7
1-FCV-65-10		1-FCV-65-8
0-FCV-65-24		1-FCO-65-27
1-FCO-65-26		0-FCV-65-28A
2-FCO-65-46		0-FCV-65-28B
0-FCV-65-47A		2-FCV-65-29
0-FCV-65-47B		1-FCV-65-30
1-FCV-65-51		0-FCV-65-43
1-FCV-65-52		2-FCO-65-45
1,2-PCV-65-81		1-FCV-65-53
1,2-PCV-65-86		1,2-PCV-65-83
1-PCO-65-80		1,2-PCV-65-87
2-PCO-65-80		1-PCO-65-89
Panel 1-L-44		2-PCO-65-89
2-L-44		Panel 1-L-45
		2-L-45

Table 9.3-8 Equipment Supplied With Auxilary Control System Air (Page 3 of 4)

Control Building Heating, Ventilation, and Air Conditioning Equipment	
Train A	Train B
FCO-31-335	
FCO-31-336	
TCV-31-108	TCV-31-138
TCV-31-112	TCV-31-142
FCV-31-3	FCV-31-4
FCV-31-6	FCV-31-5
FCO-31-8	FCO-31-7
FCO-31-12	FCO-31-11
FCO-31-30	FCO-31-31
Equipment Supplied with Auxiliary Control System Air	
Train A	Train B
TT-31-41	TT-31-54
TT-31-47	TT-31-59
TT-31-82	TT-31-91
TT-31-335	TT-31-337
TT-31-336	TT-31-338
TC-31-82	TC-31-91
TC-31-335	TC-31-337
TC-31-336	TC-31-338
	FCO-31-337
	FCO-31-338
Panel L-523	Panel L-524
L-529	L-530
0-L-535	0-L-536
Radiation Monitoring Sample Isolation Valves	
Train A	Train B
1-FCV-90-107	1-FCV-90-108
1-FCV-90-111	1-FCV-90-109
1-FCV-90-113	1-FCV-90-110
1-FCV-90-117	1-FCV-90-114
	1-FCV-90-115
	1-FCV-90-116

Table 9.3-8 Equipment Supplied With Auxilary Control System Air (Page 4 of 4)

Auxiliary Control Air System	
Train A	Train B
1-FCV-32-80	1-FCV-32-102
2-FCV-32-81	2-FCV-32-103
Air Dryers A-A	Air Dryers B-B

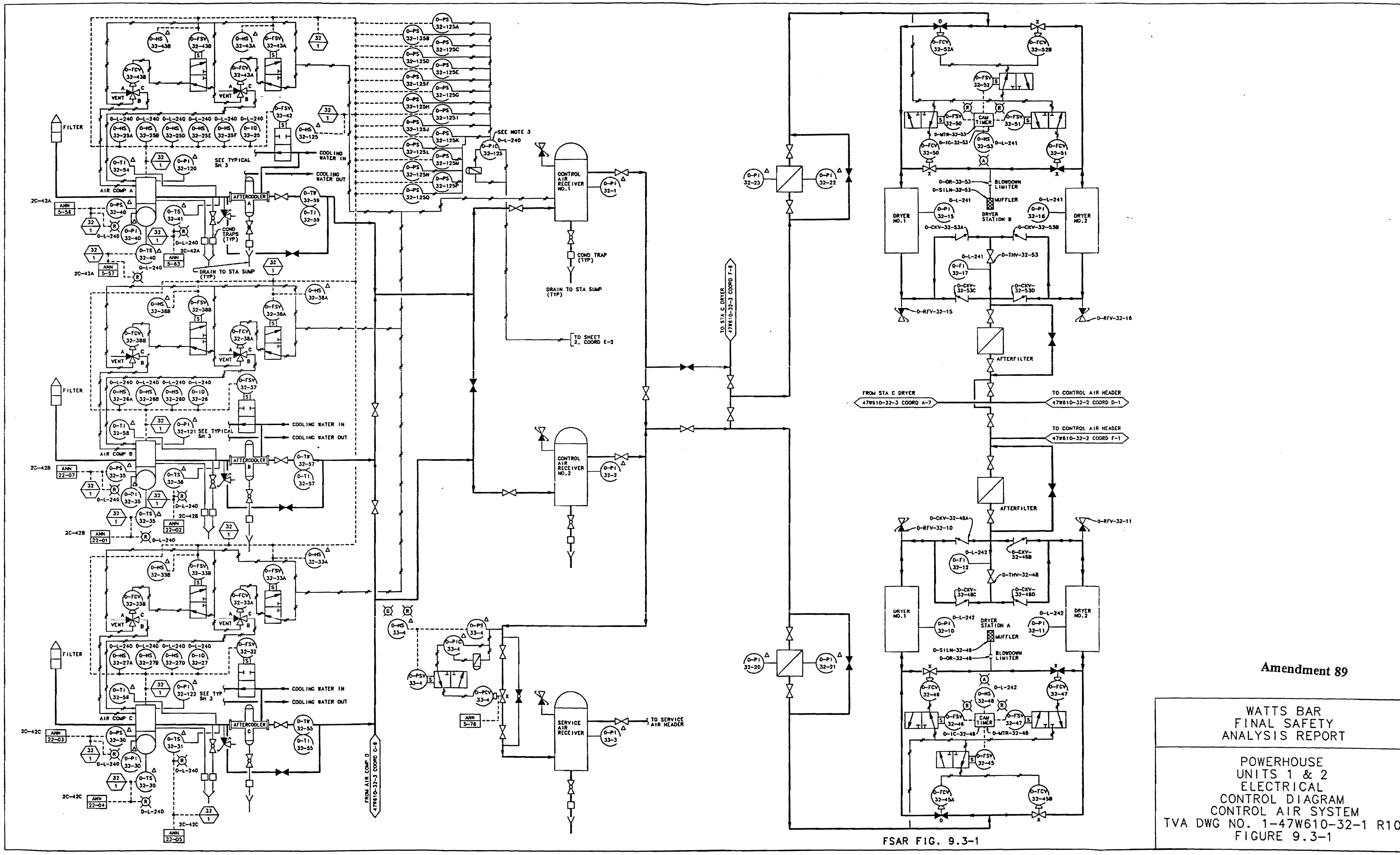

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Figure 9.3-1 Electrical Control Diagram for Control Air System

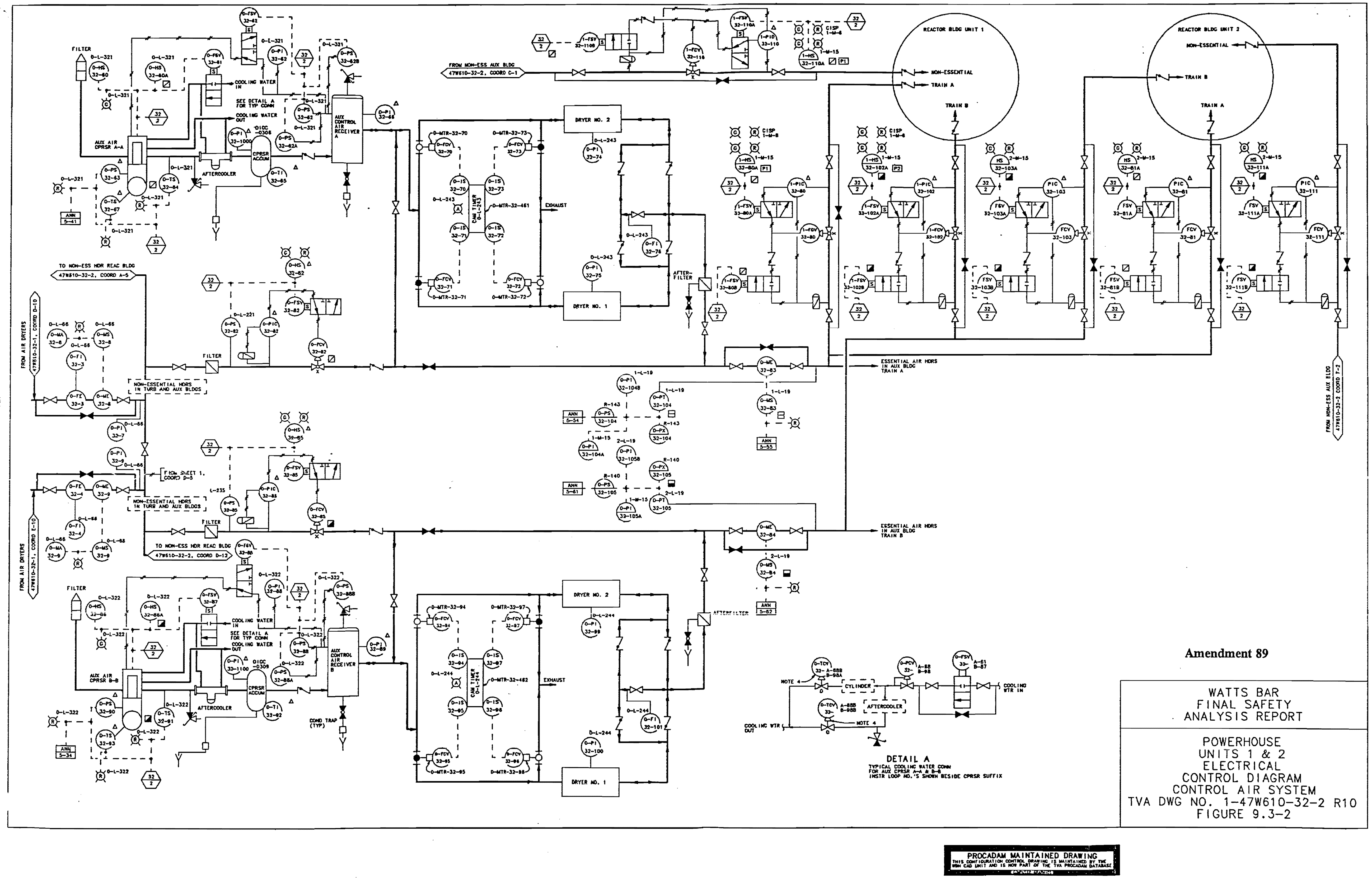

Figure 9.3-2 Electrical Control Diagram for Control Air System

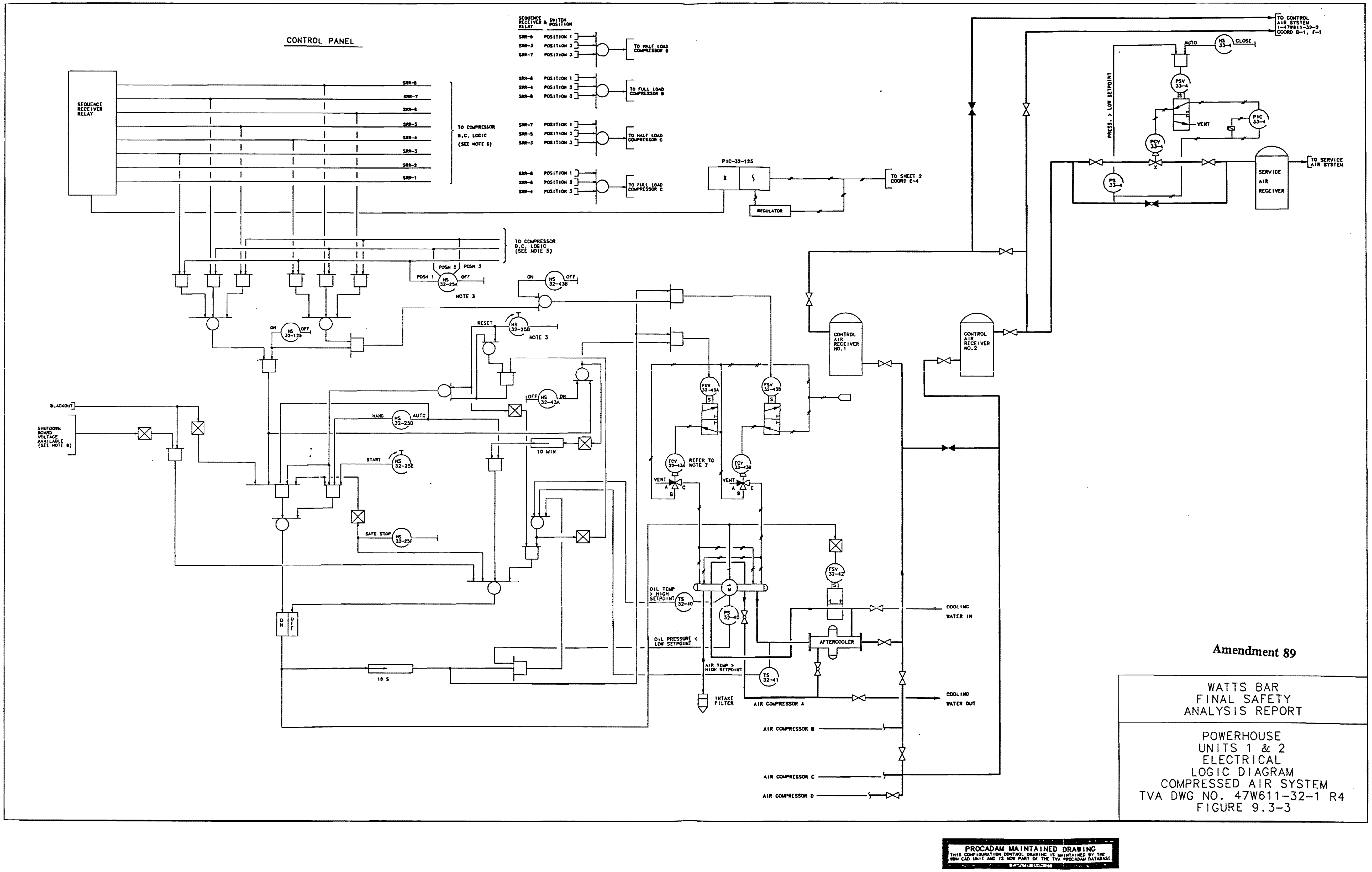

Figure 9.3-3 Powerhouse Units 1 & 2 Electrical Logic Diagram for Compressed Air System

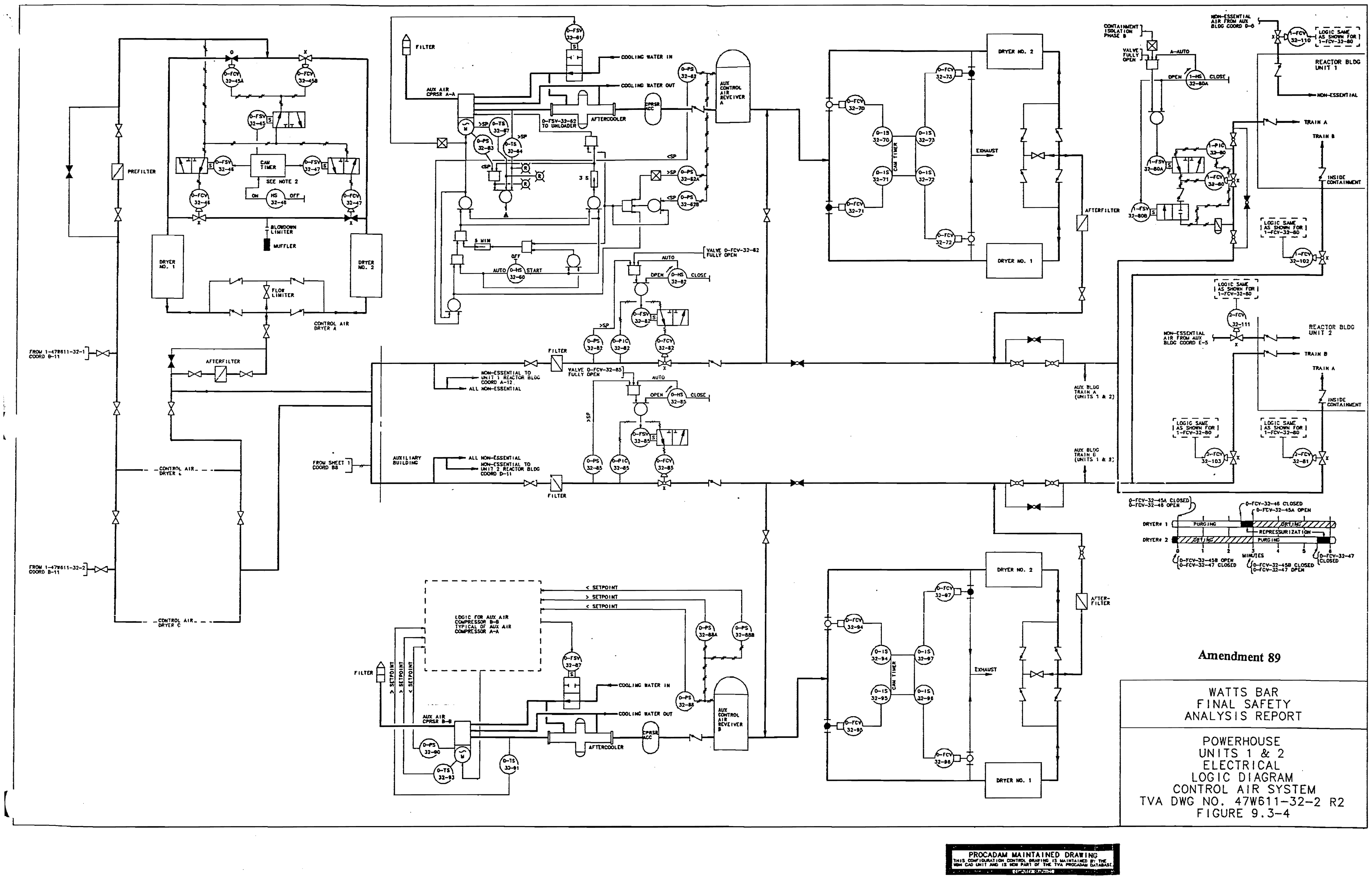

Figure 9.3-4 Powerhouse Units 1 & 2 Electrical Logic Diagram for Control Air System

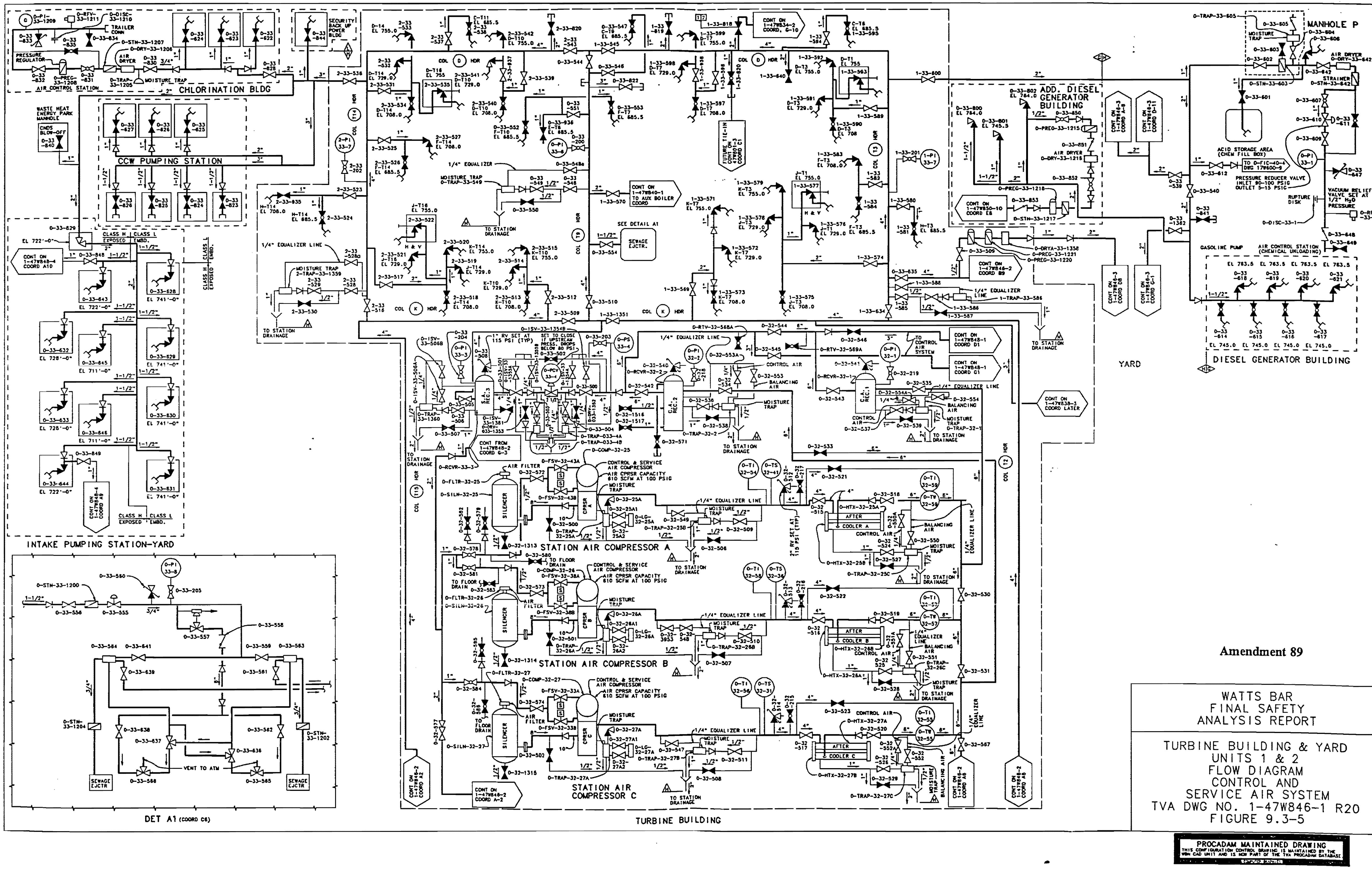

Figure 9.3-5 Turbine Building and Yard Units 1 & 2 Flow Diagram for Control and Service Air System

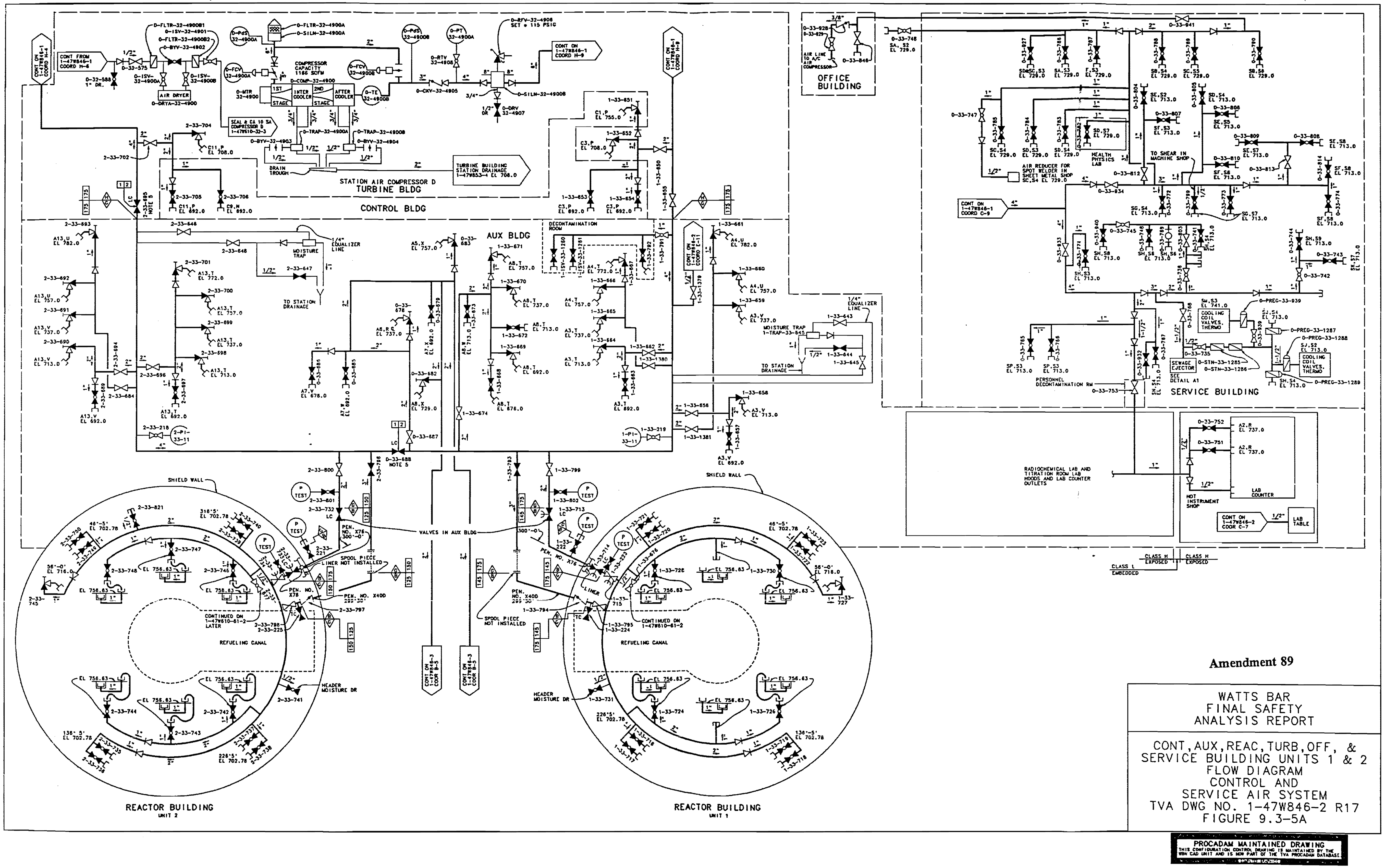

Figure 9.3-5a Control, Auxiliary, Reactor, Turbine, Office and Service Building Units 1 & 2 Flow Diagram for Control and Service Air System

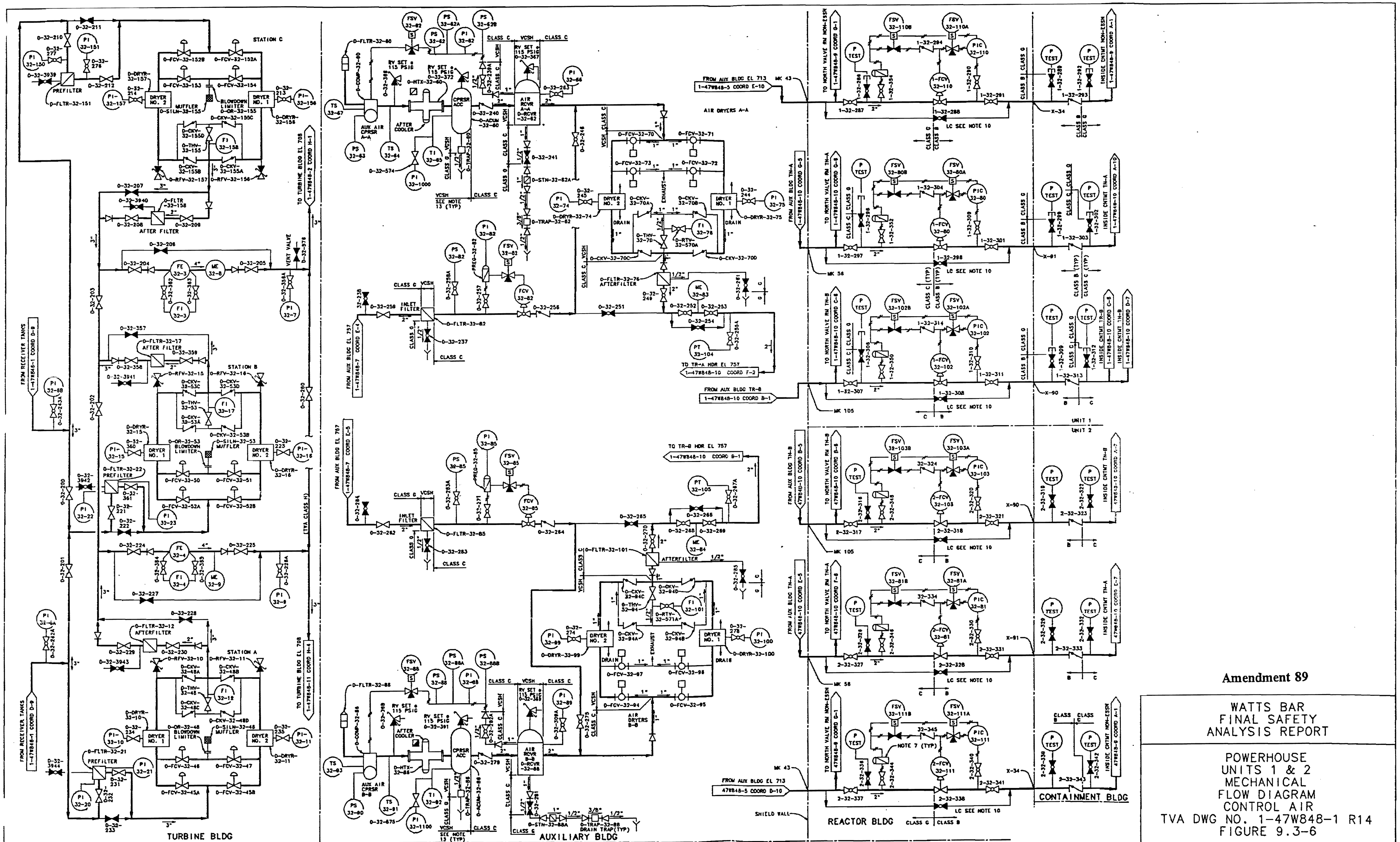

Figure 9.3-6 Powerhouse Units 1 & 2 Mechanical Flow Diagram for Control Air System

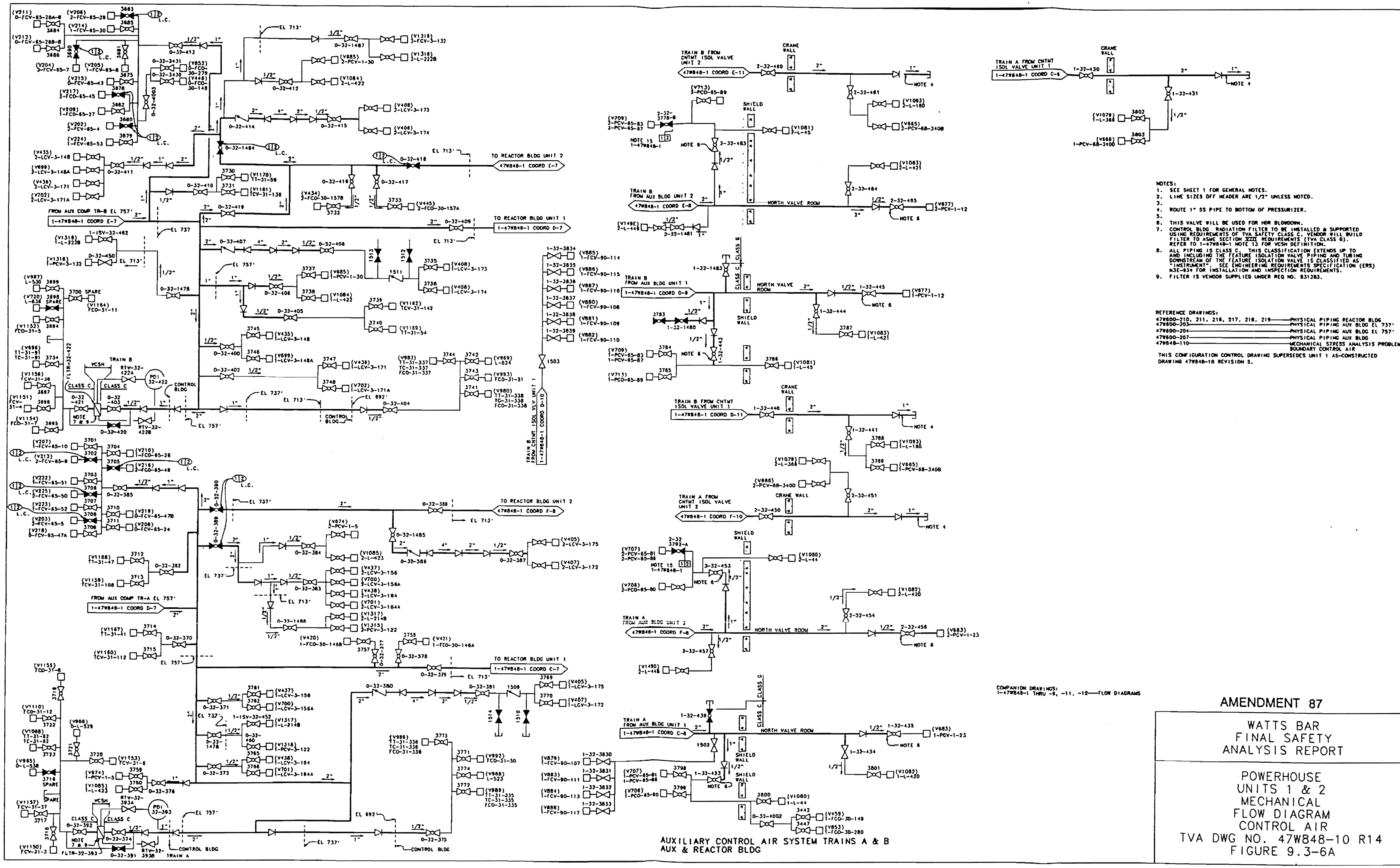

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Figure 9.3-6a Powerhouse Units 1 & 2 Mechanical Flow Diagram for Control Air System

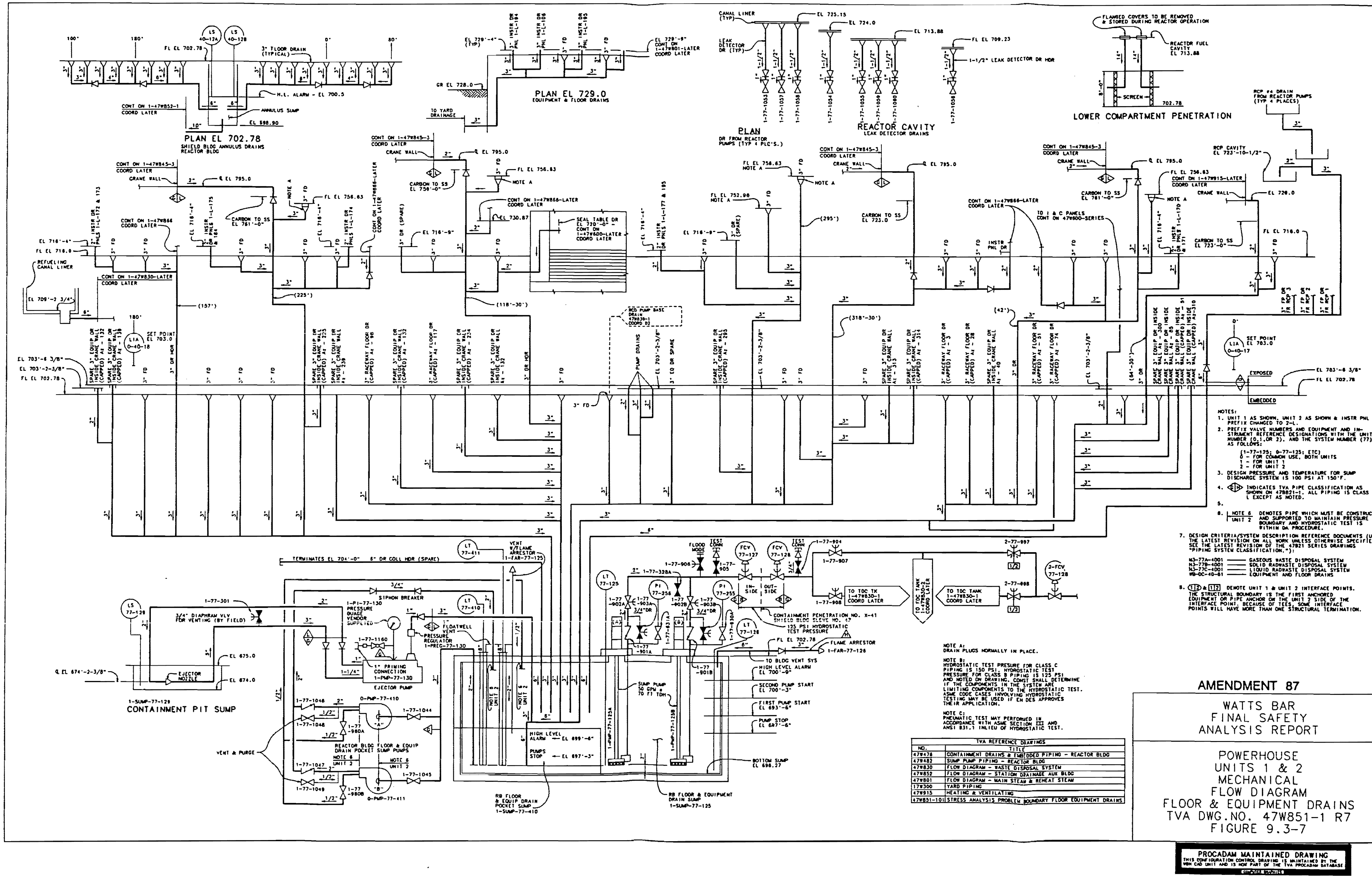

Figure 9.3-7 Powerhouse Units 1 & 2 Mechanical Flow Diagram - Floor and Equipment Drains

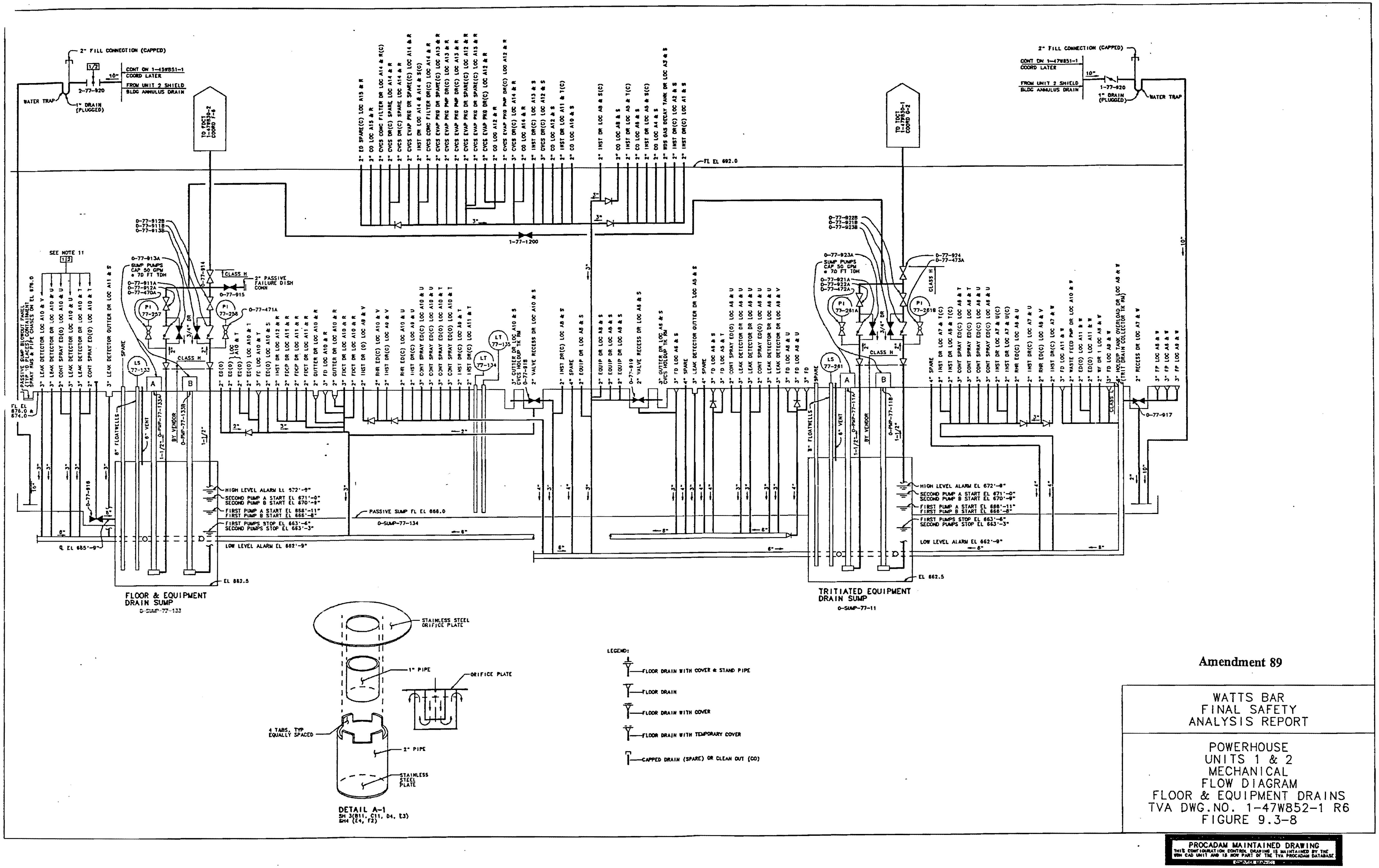

Figure 9.3-8 Powerhouse Units 1 & 2 Mechanical Flow Diagram -Floor and Equipment Drains

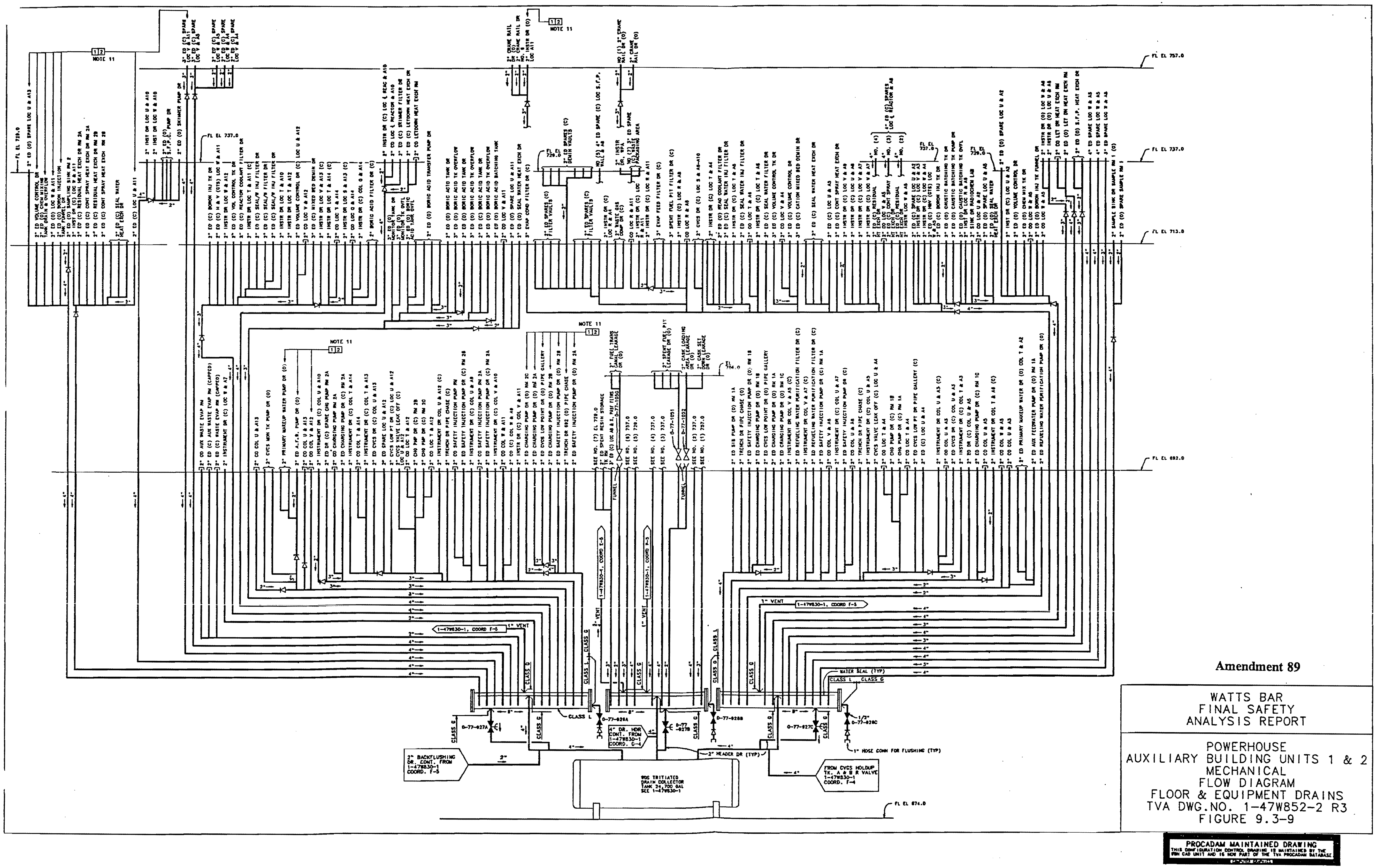

Figure 9.3-9 Powerhouse, Auxiliary Building Units 1 & 2 Mechanical Flow Diagram -Floor and Equipment Drains

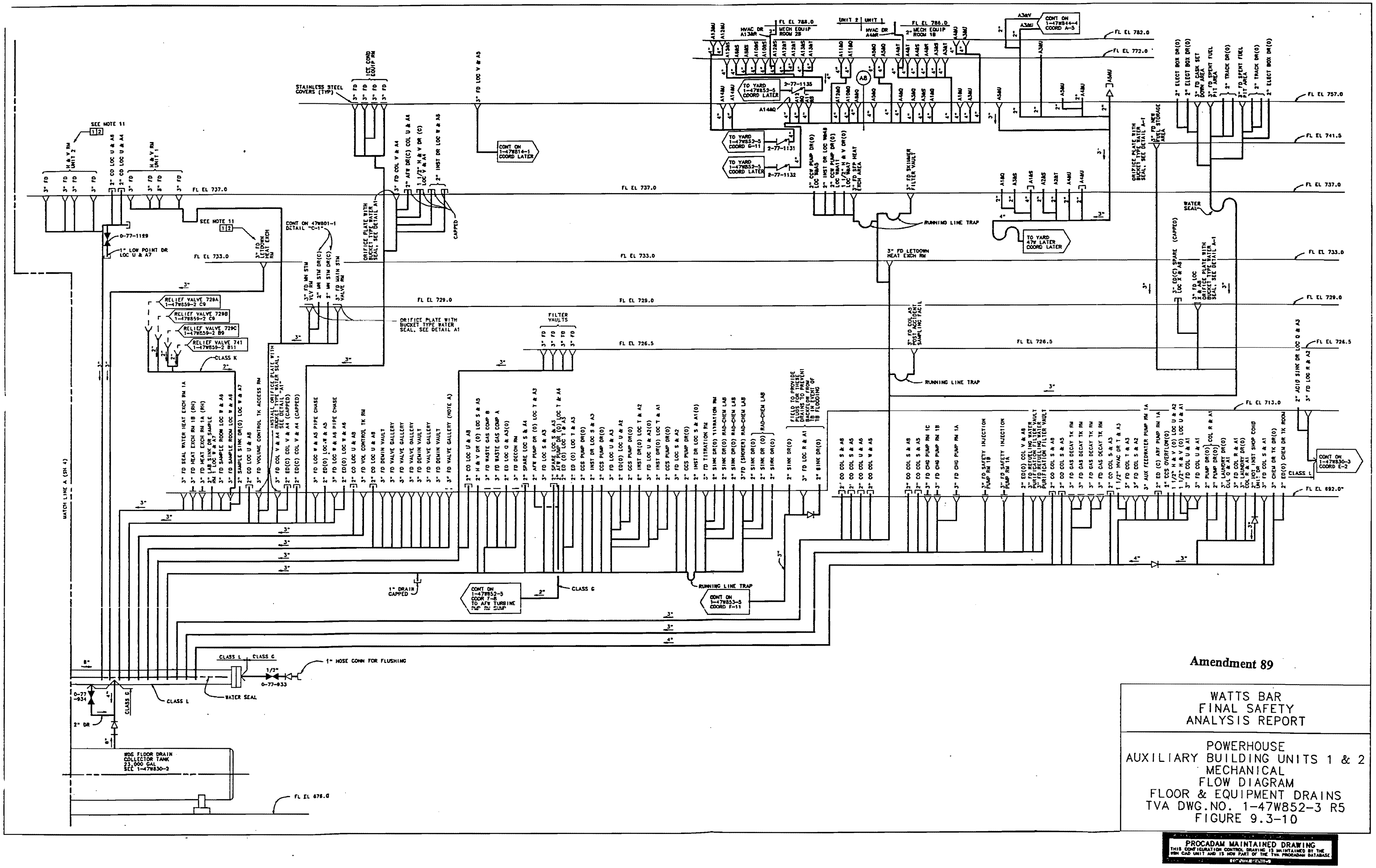

Figure 9.3-10 Powerhouse, Auxiliary Building Units 1 & 2 Flow Diagram - Floor and Equipment Drains

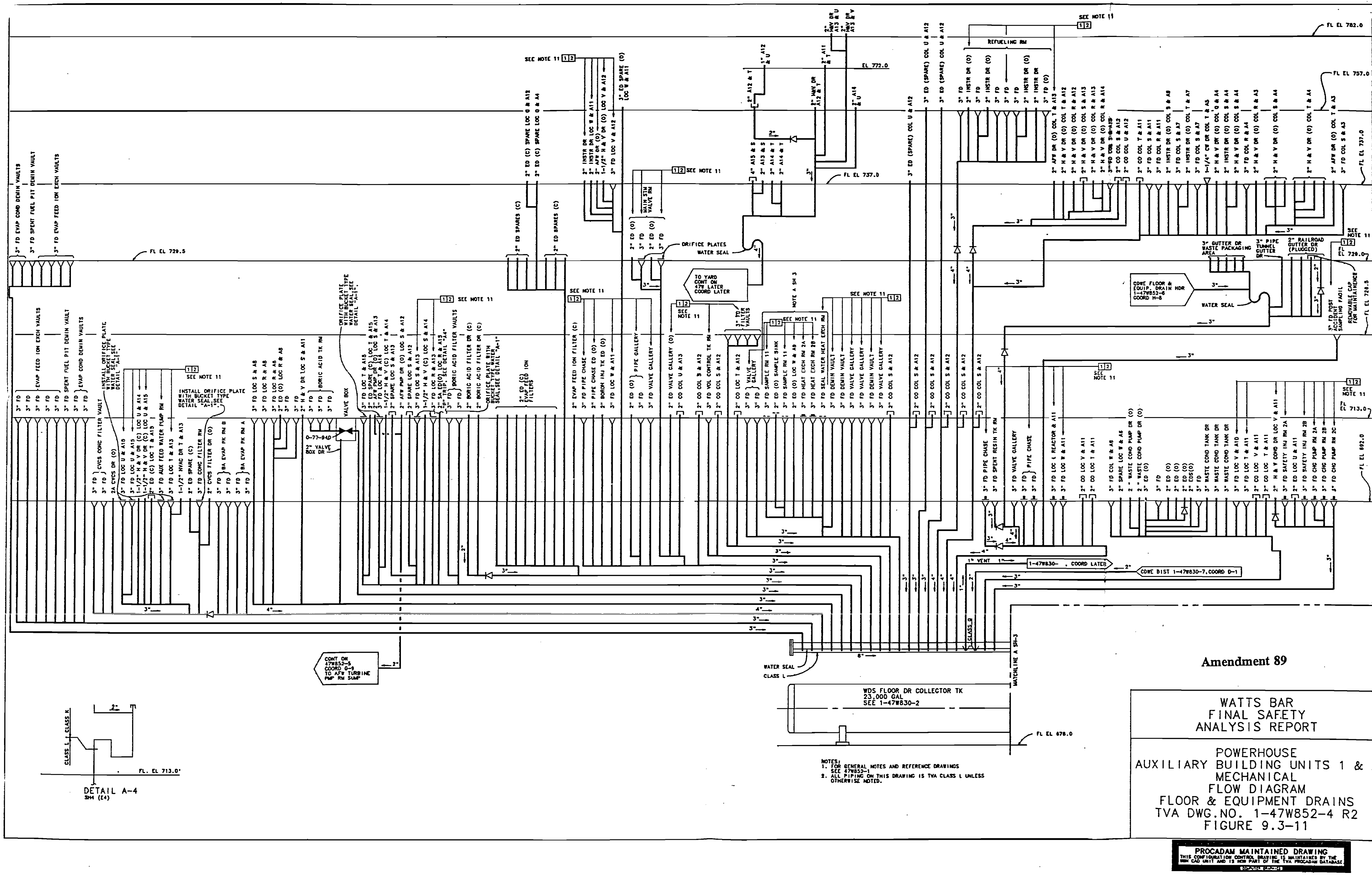

Figure 9.3-11 Powerhouse Auxiliary Building Units 1 & 2 Flow Diagram - Floor and Equipment Drains

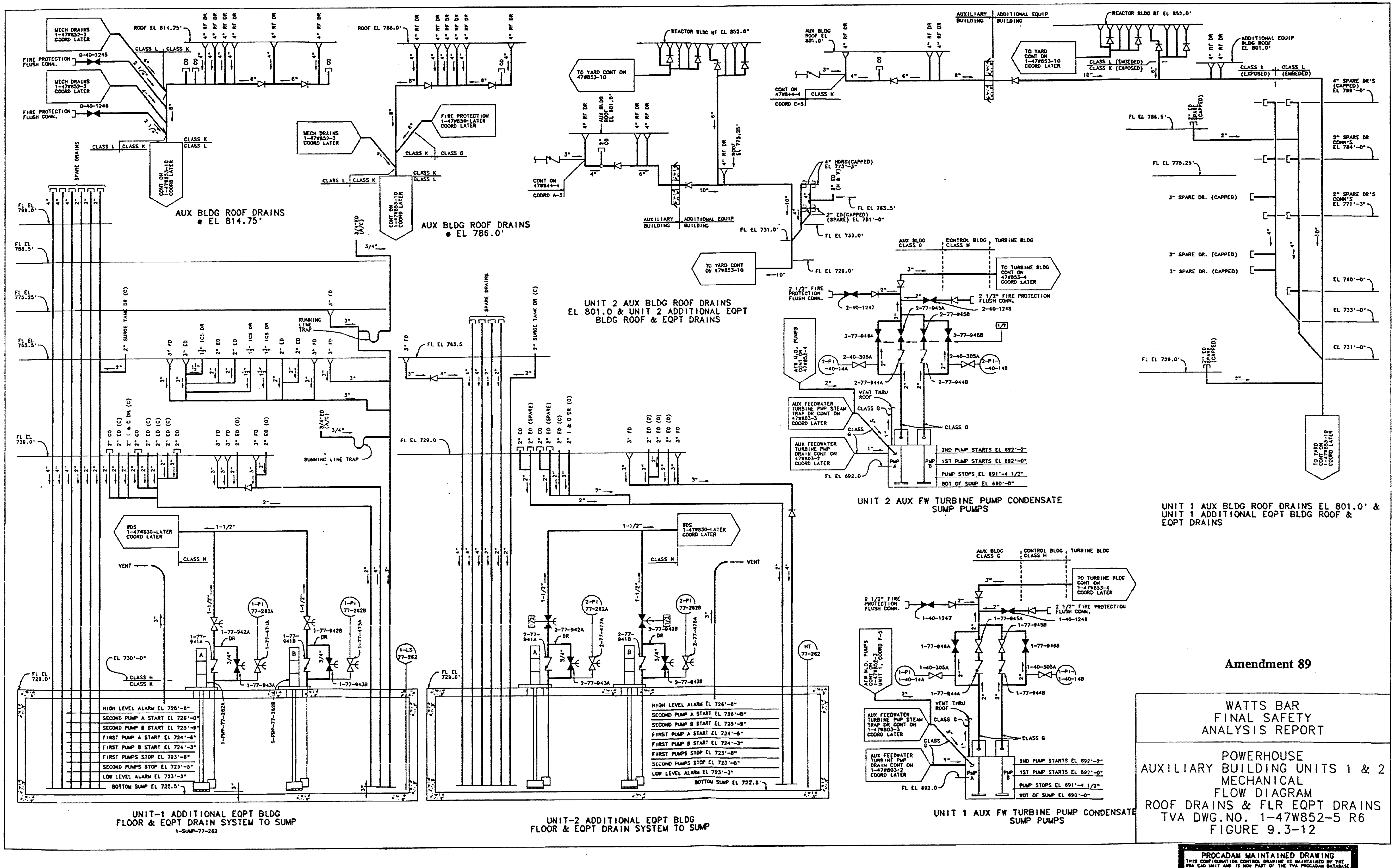

Figure 9.3-12 Powerhouse, Auxiliary Buildings Unit 1 & 2 Mechanical Flow Diagram Roof Drains and Floor Equipment Drains

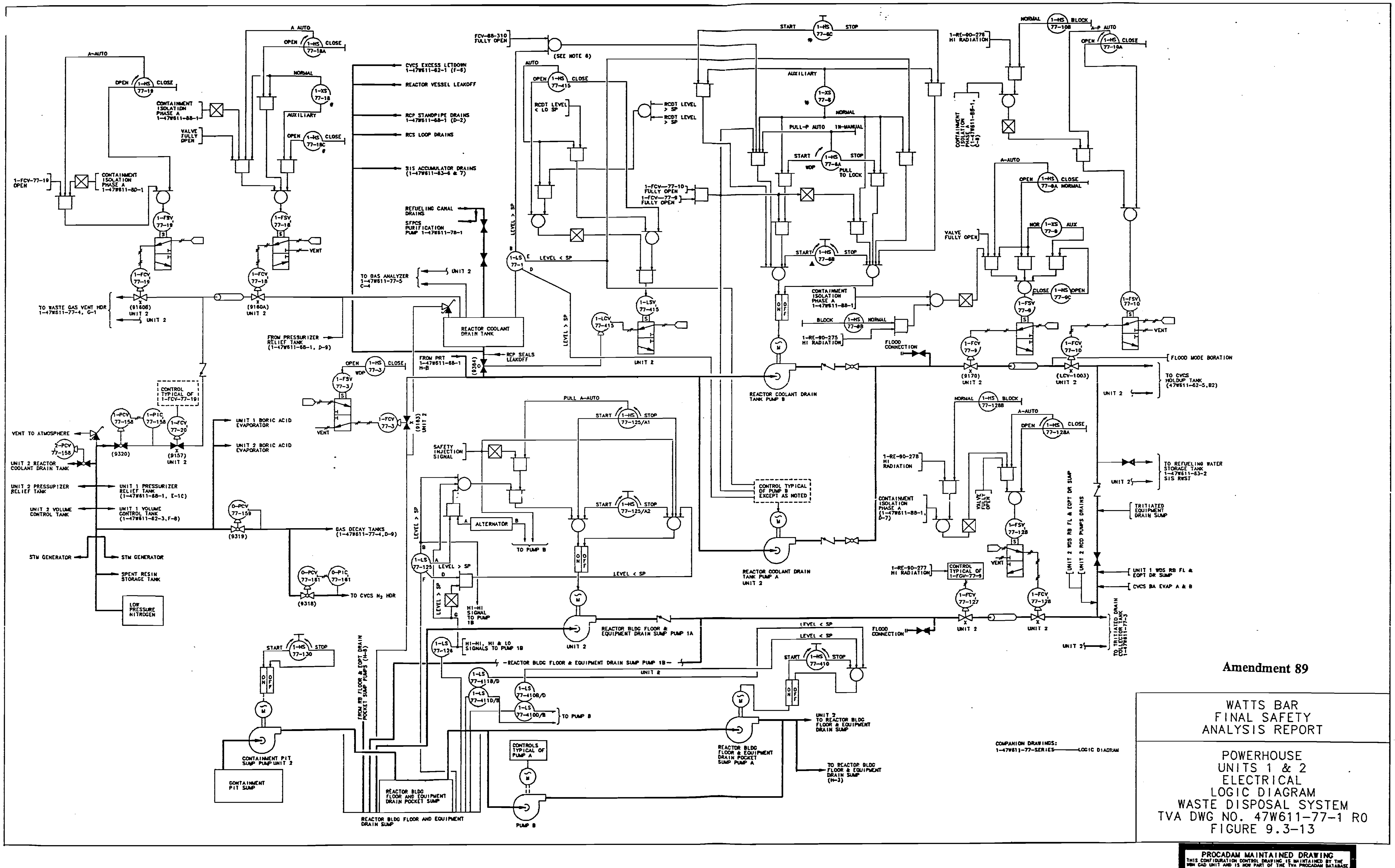

Figure 9.3-13 Powerhouse Units 1 & 2 Electrical Logic Diagram for Waste Disposal System

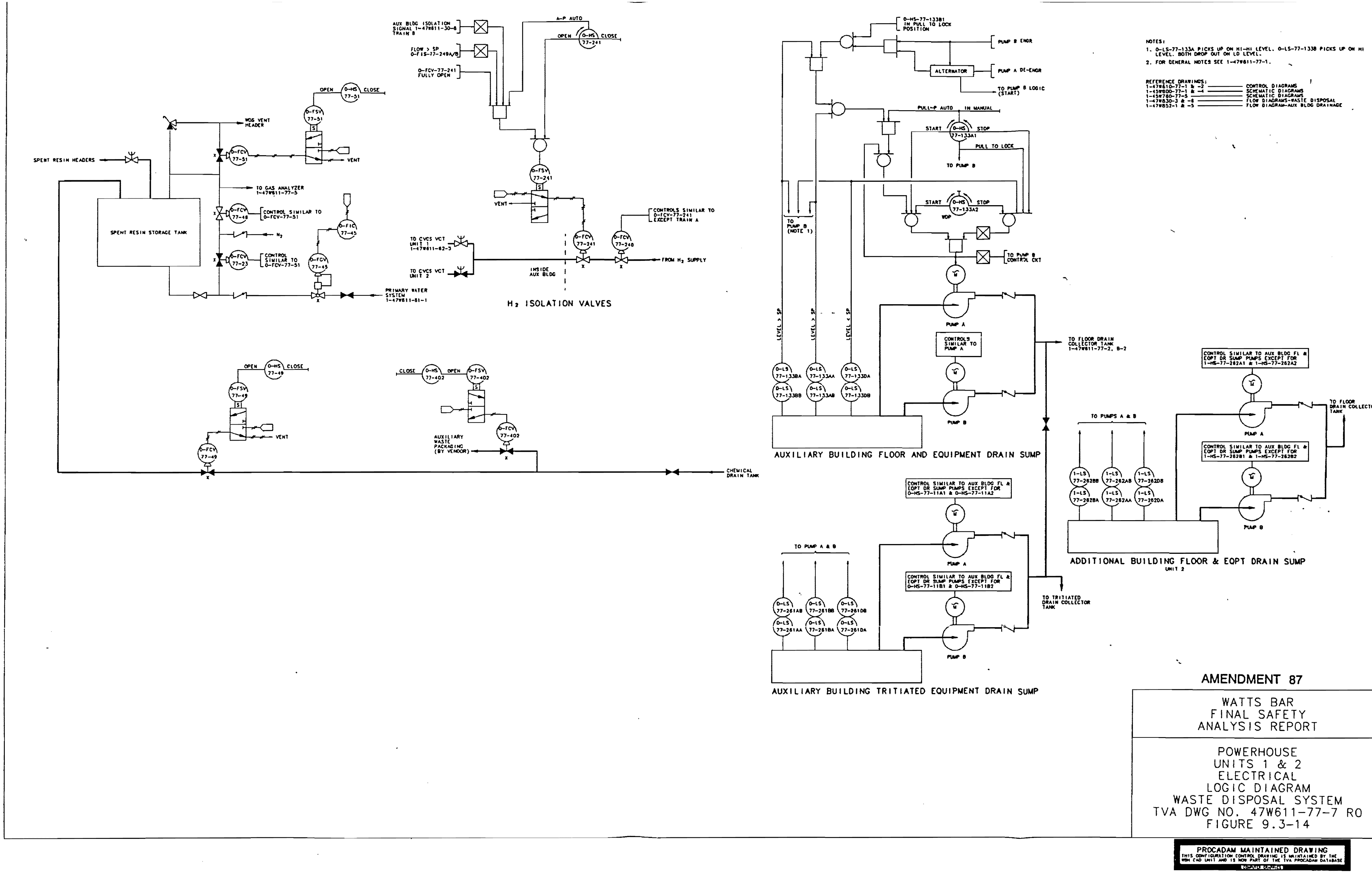

Figure 9.3-14 Powerhouse Units 1 & 2 Electrical Logic Diagram for Waste Disposal System

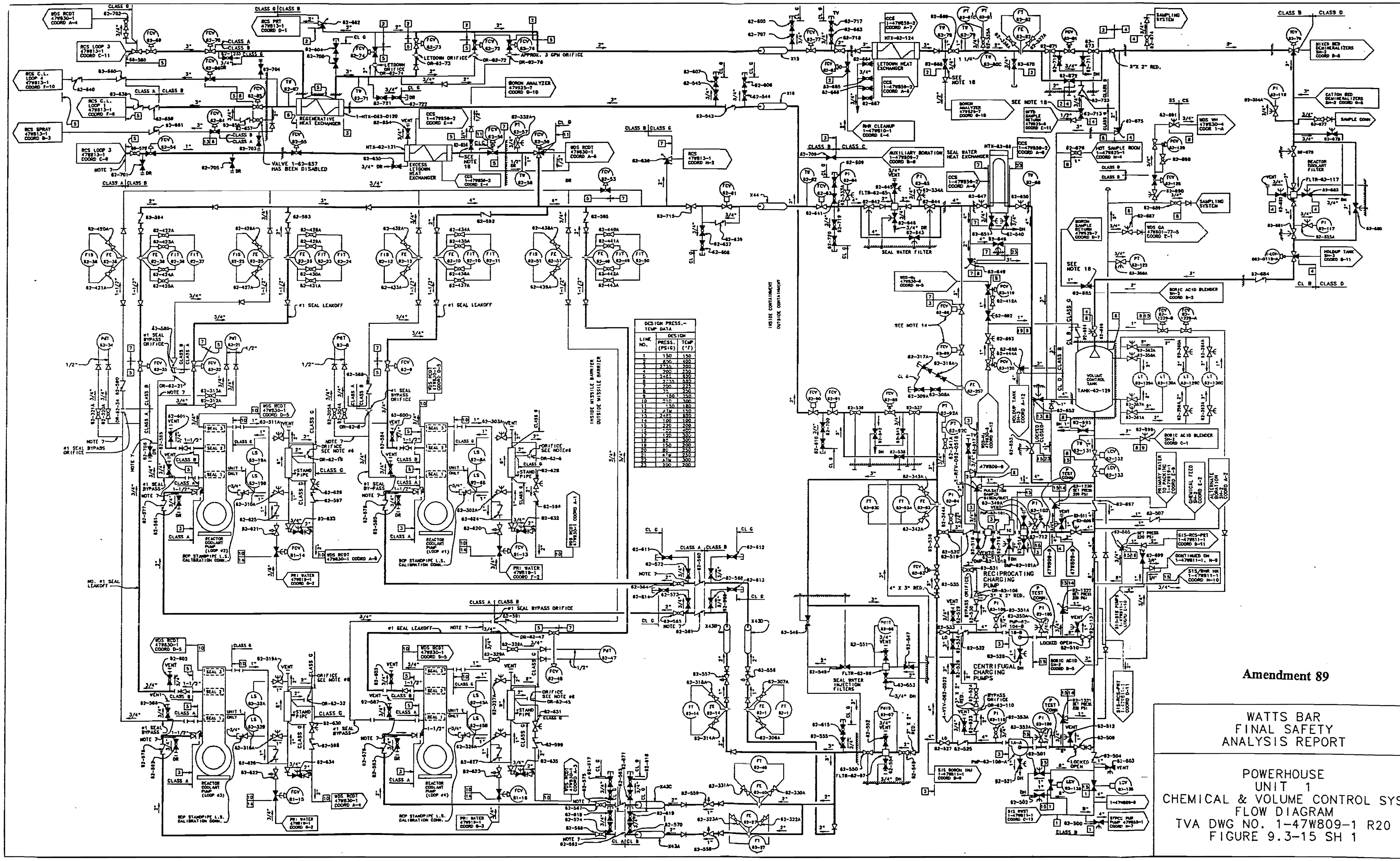

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Figure 9.3-15 Powerhouse Unit 1 Chemical and Volume Control System Flow Diagram (Sheet 1)

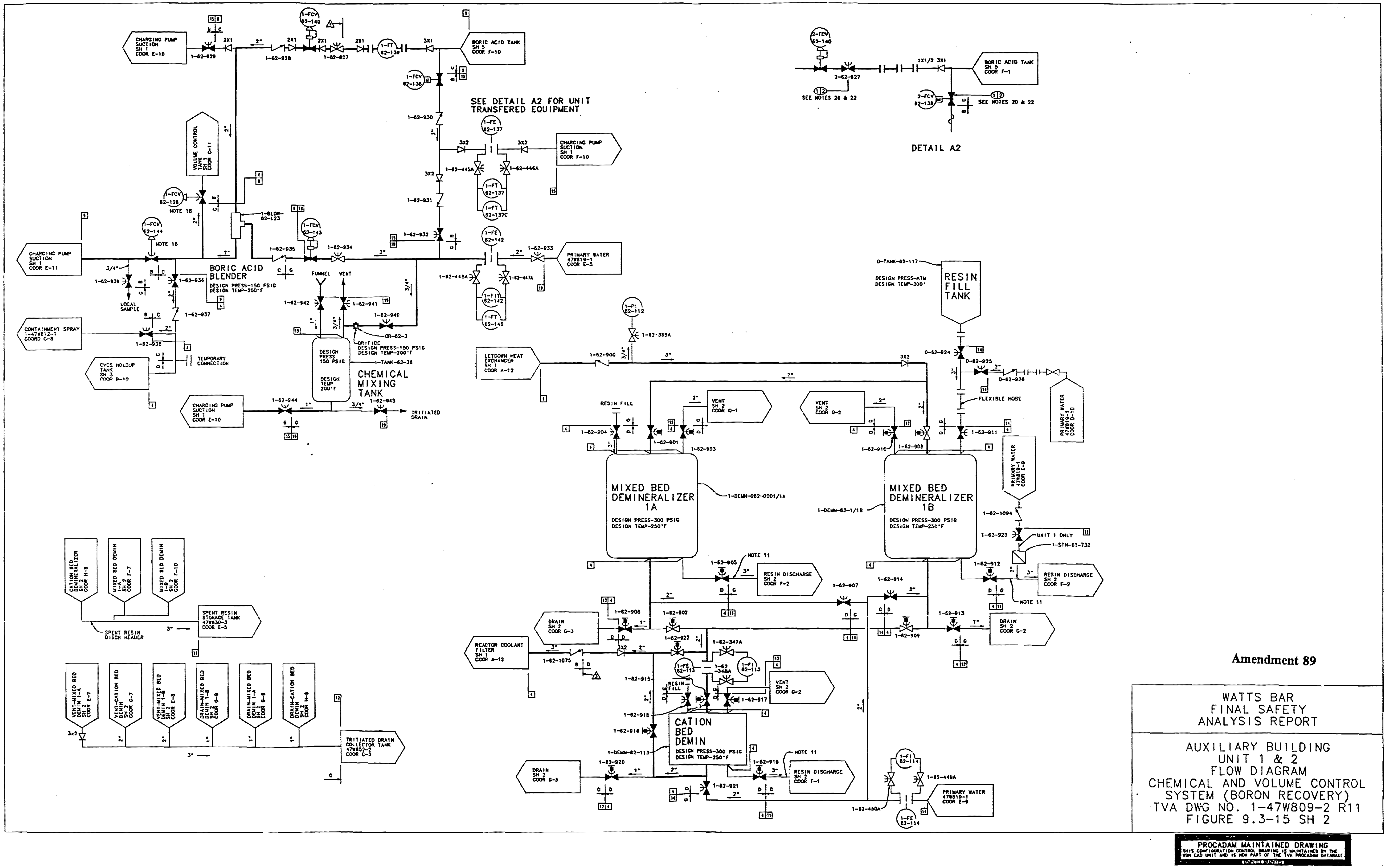

Figure 9.3-15 Auxiliary Building Units 1 & 2 Flow Diagram for Chemical and Volume Control System (Boron Recovery) (Sheet 2)

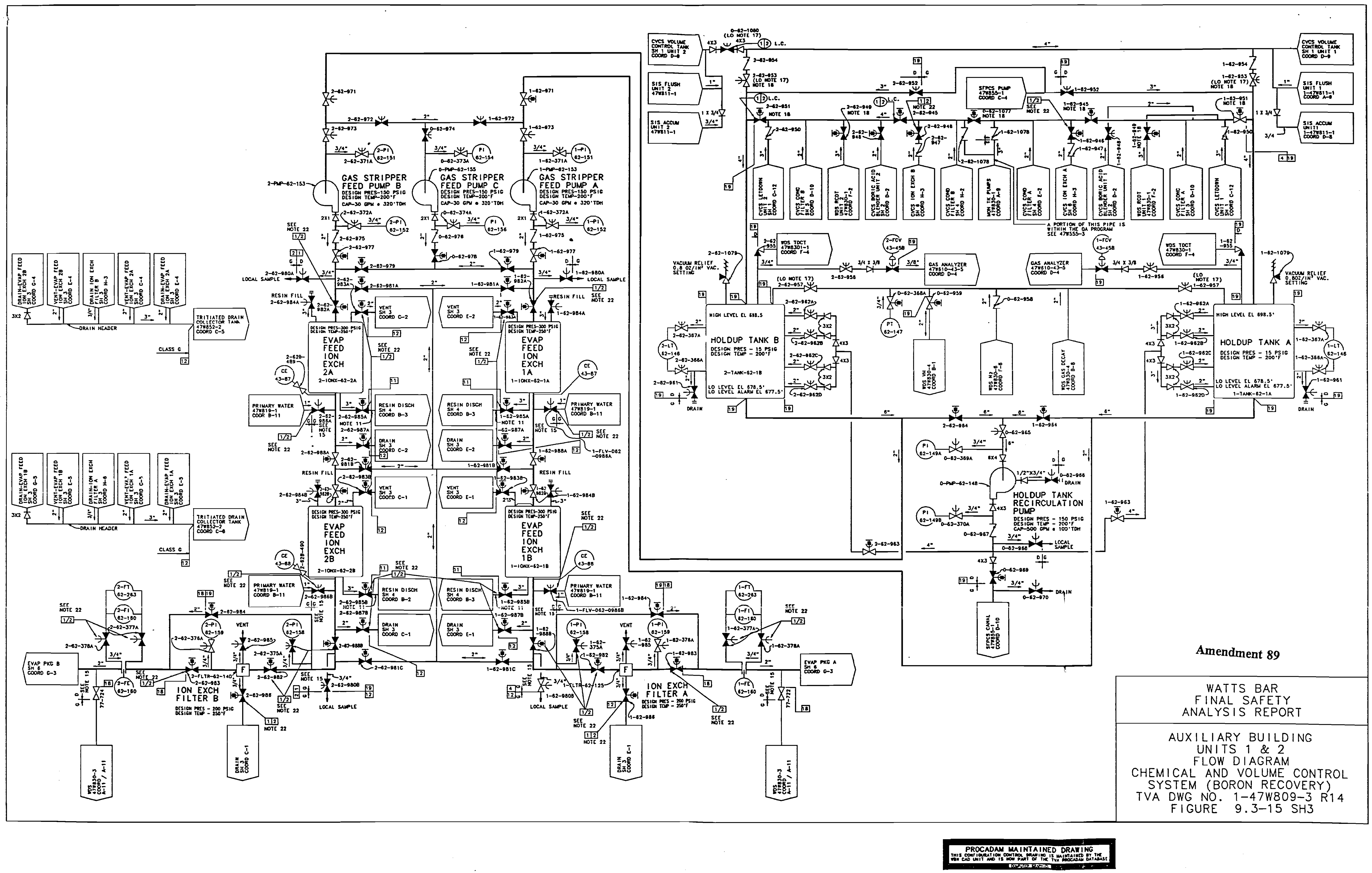

Figure 9.3-15 Auxiliary Building Units 1 & 2 Flow Diagram for Chemical and Volume Control System (Boron Recovery) (Sheet 3)

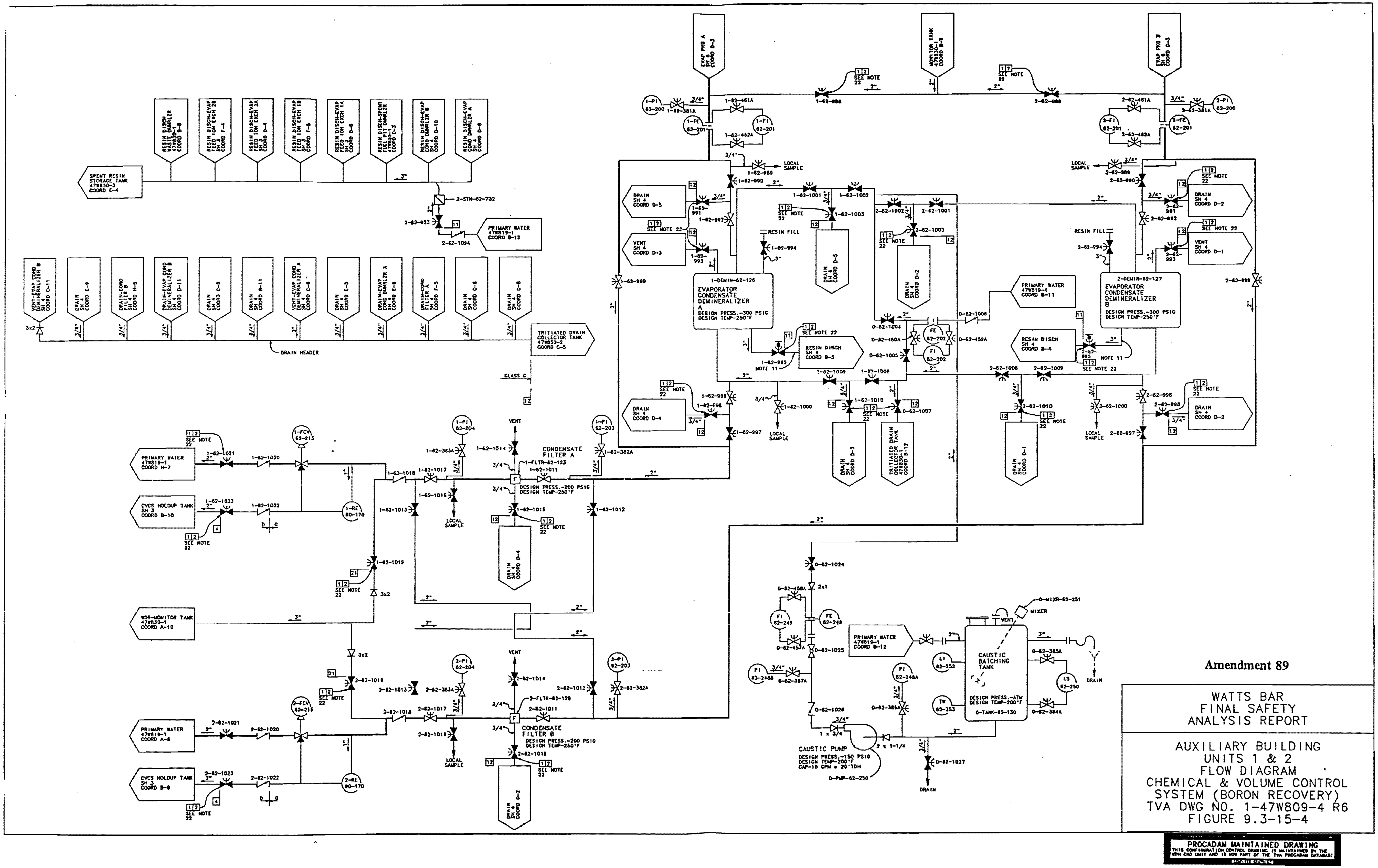

Figure 9.3-15 Auxiliary Building Units 1 & 2 Flow Diagram for Chemical and Volume Control System (Boron Recovery) (Sheet 4)

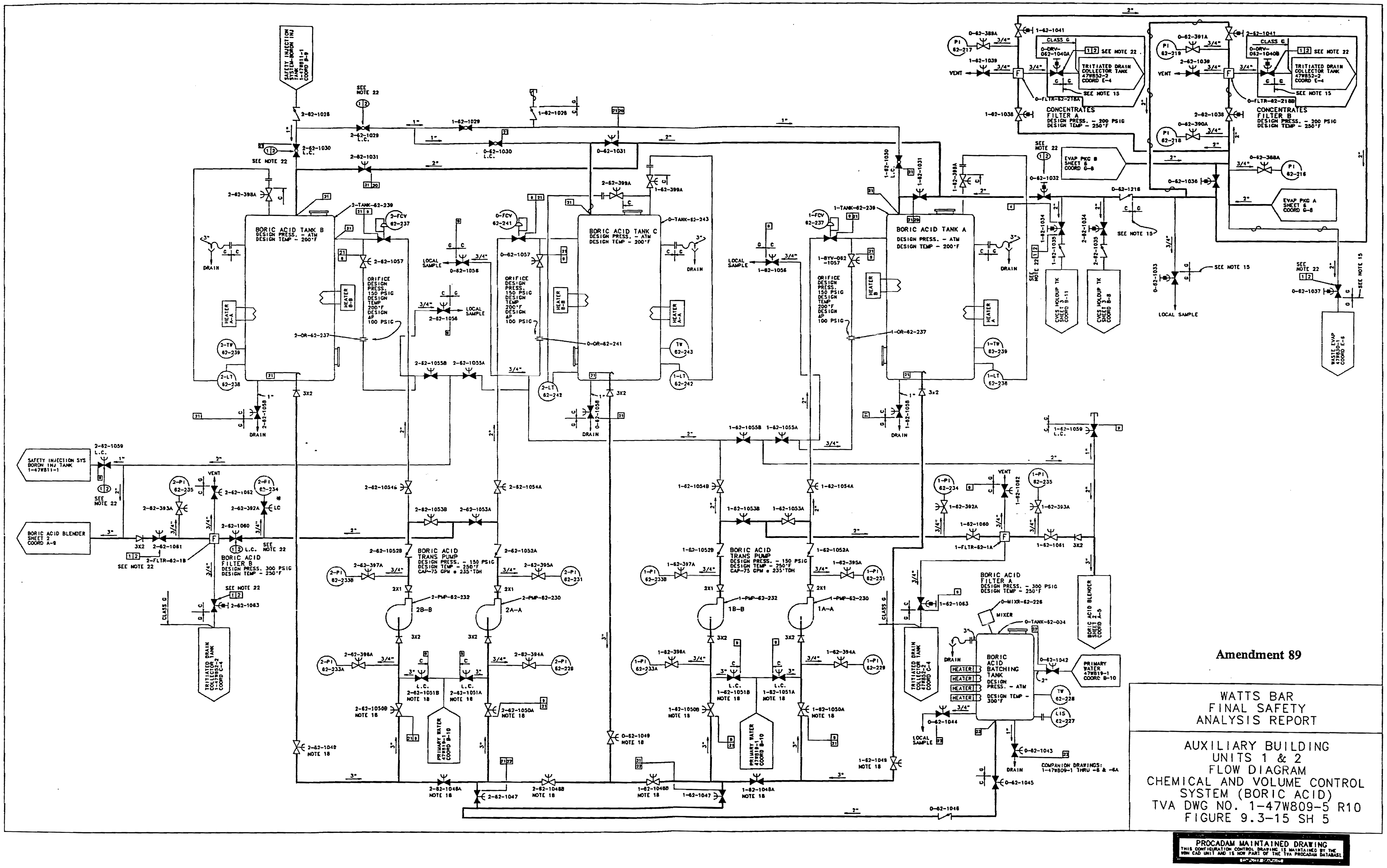

Figure 9.3-15 Auxiliary Building Units 1 & 2 Flow Diagram for Chemical and Volume Control System (Boric Acid) (Sheet 5)

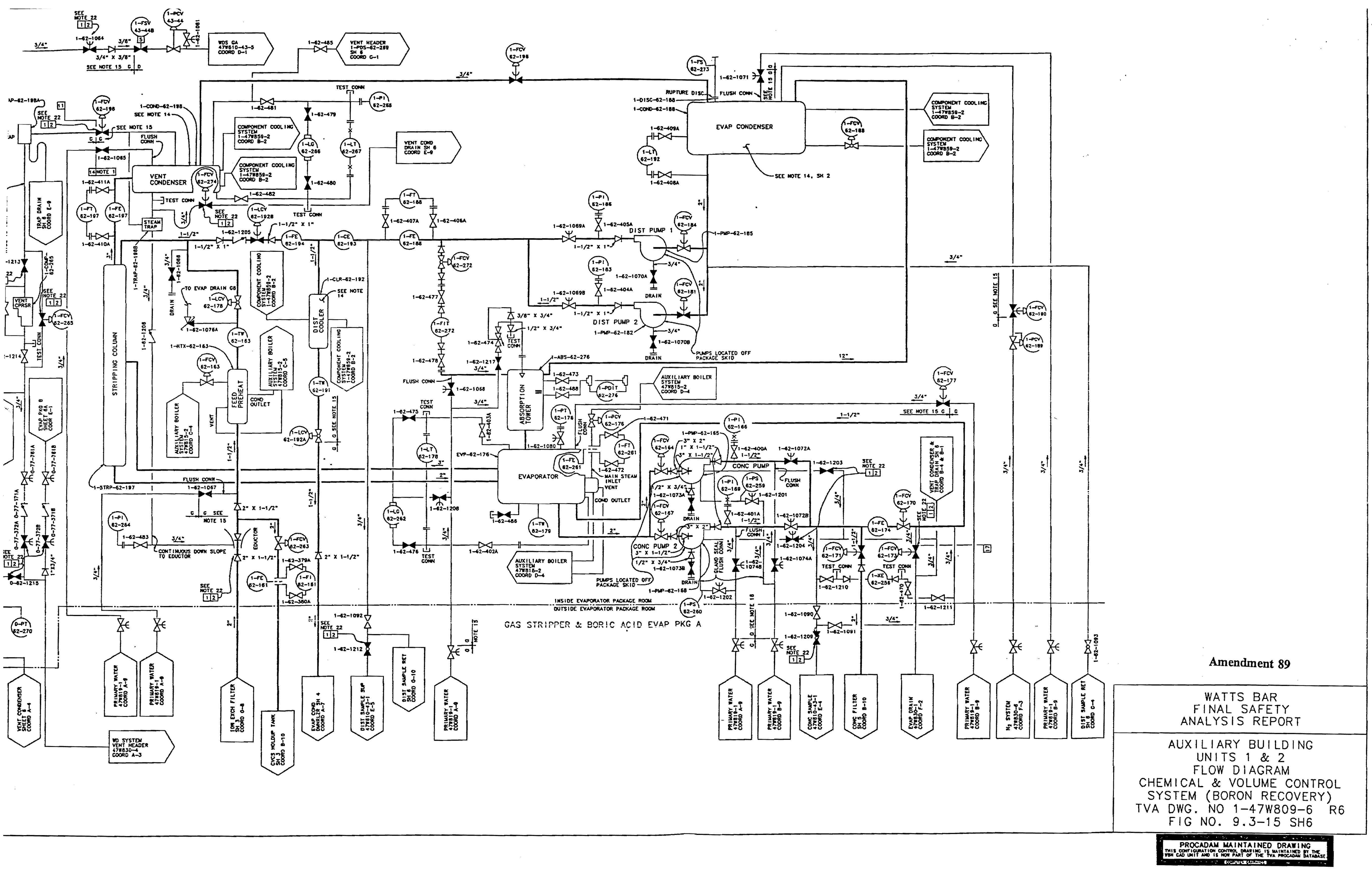

Figure 9.3-15 Auxiliary Building Units 1 & 2 Flow Diagram for Chemical and Volume Control System and (Boron Recovery) (Sheet 6)

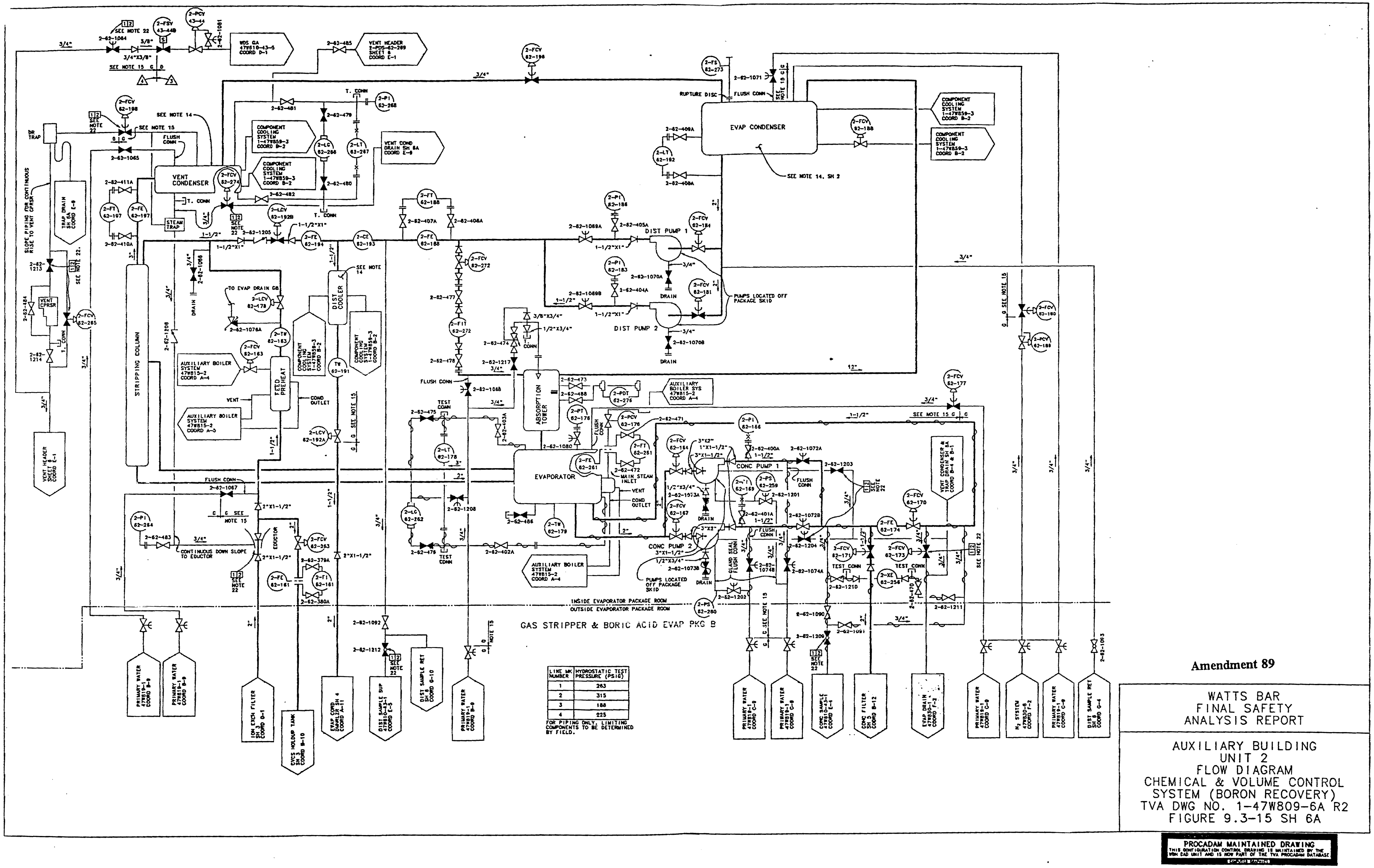

Figure 9.3-15 Auxiliary Building Unit 2 Flow Diagram for Chemical and Volume Control System (Boron Recovery) (Sheet 6a)

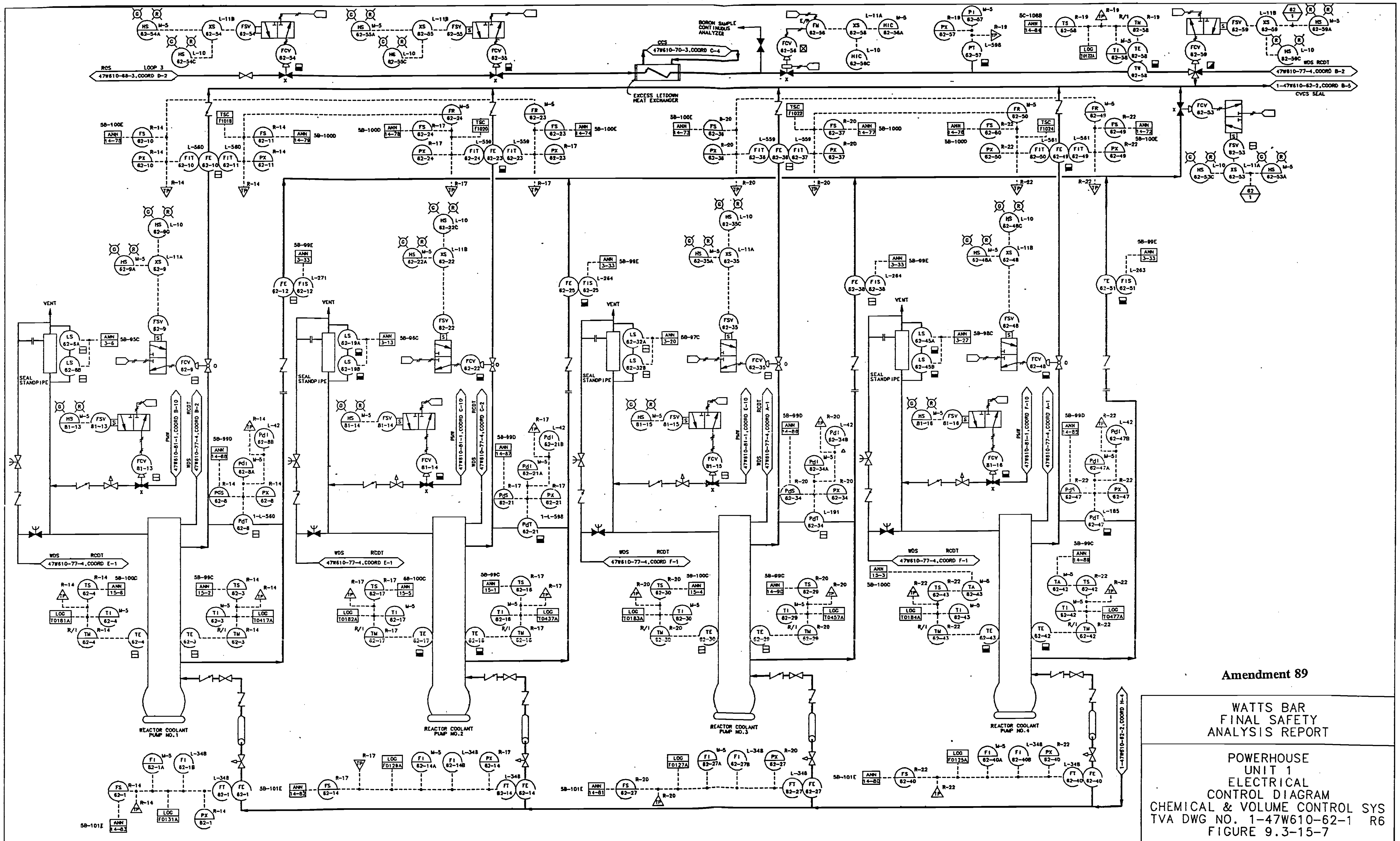

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Figure 9.3-15 Powerhouse Unit 1 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 7)

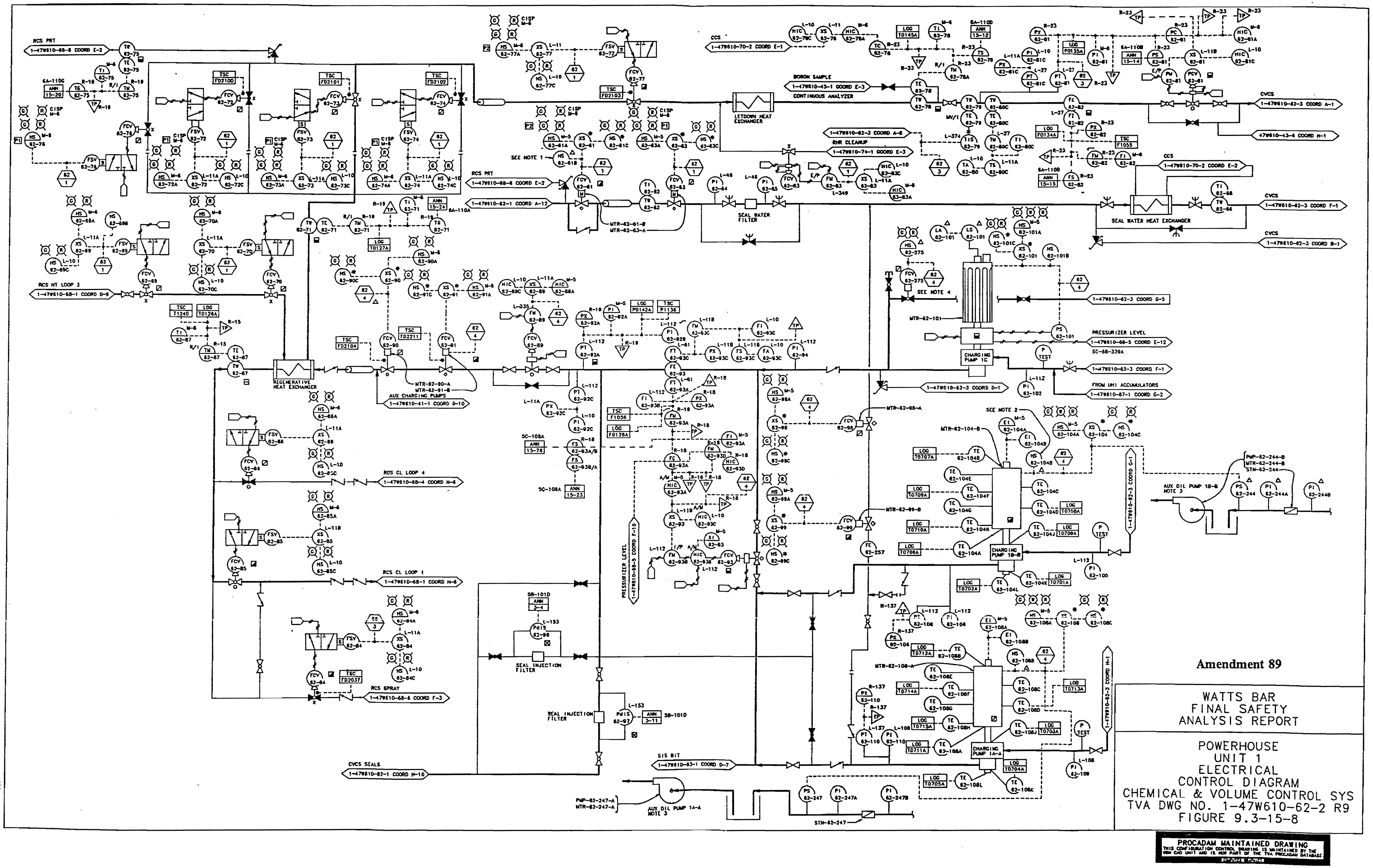
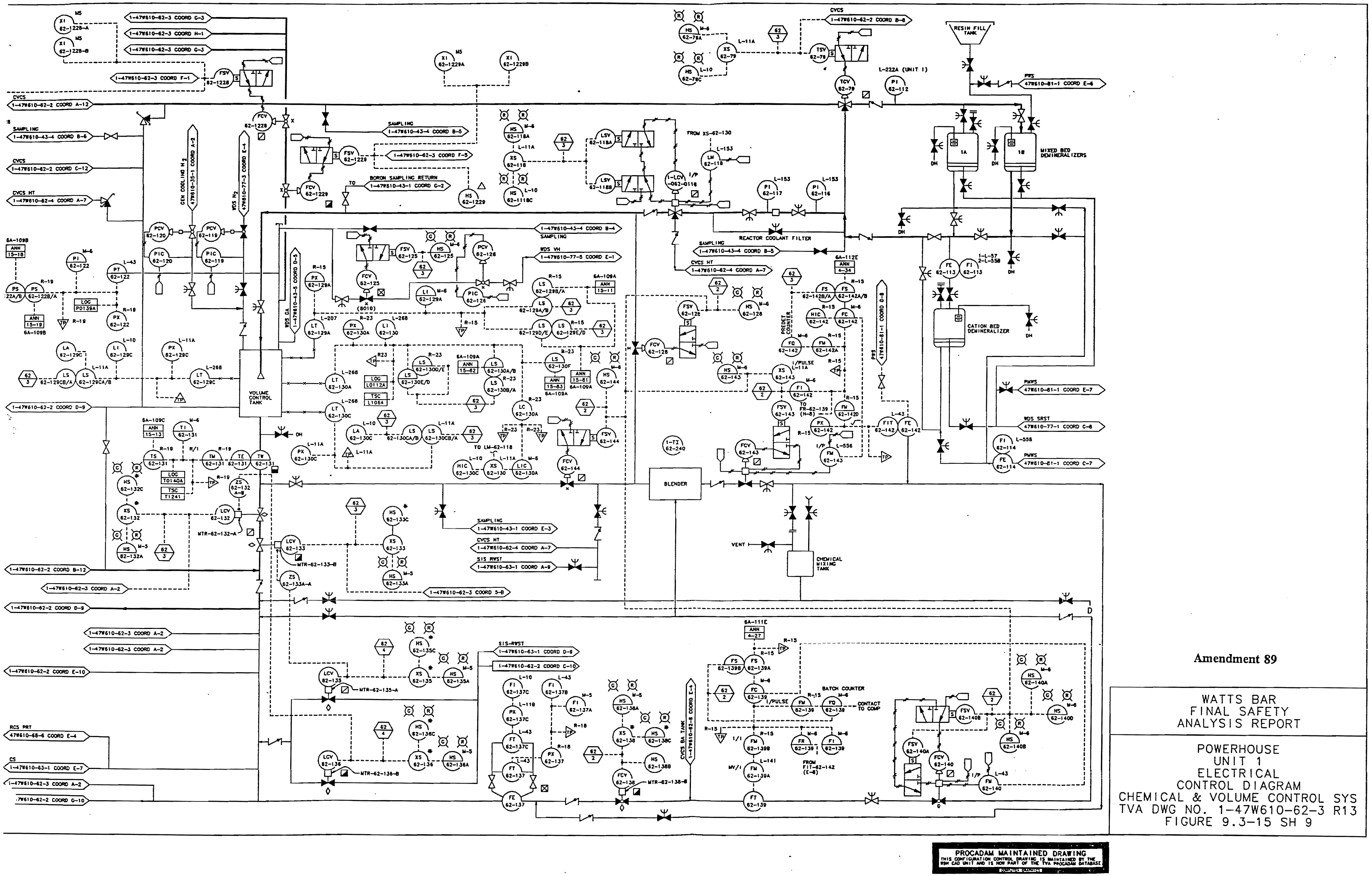


Figure 9.3-15Powerhouse Unit 1 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 8)



Amendment 89

Figure 9.3-15 Powerhouse Unit 1 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 9)

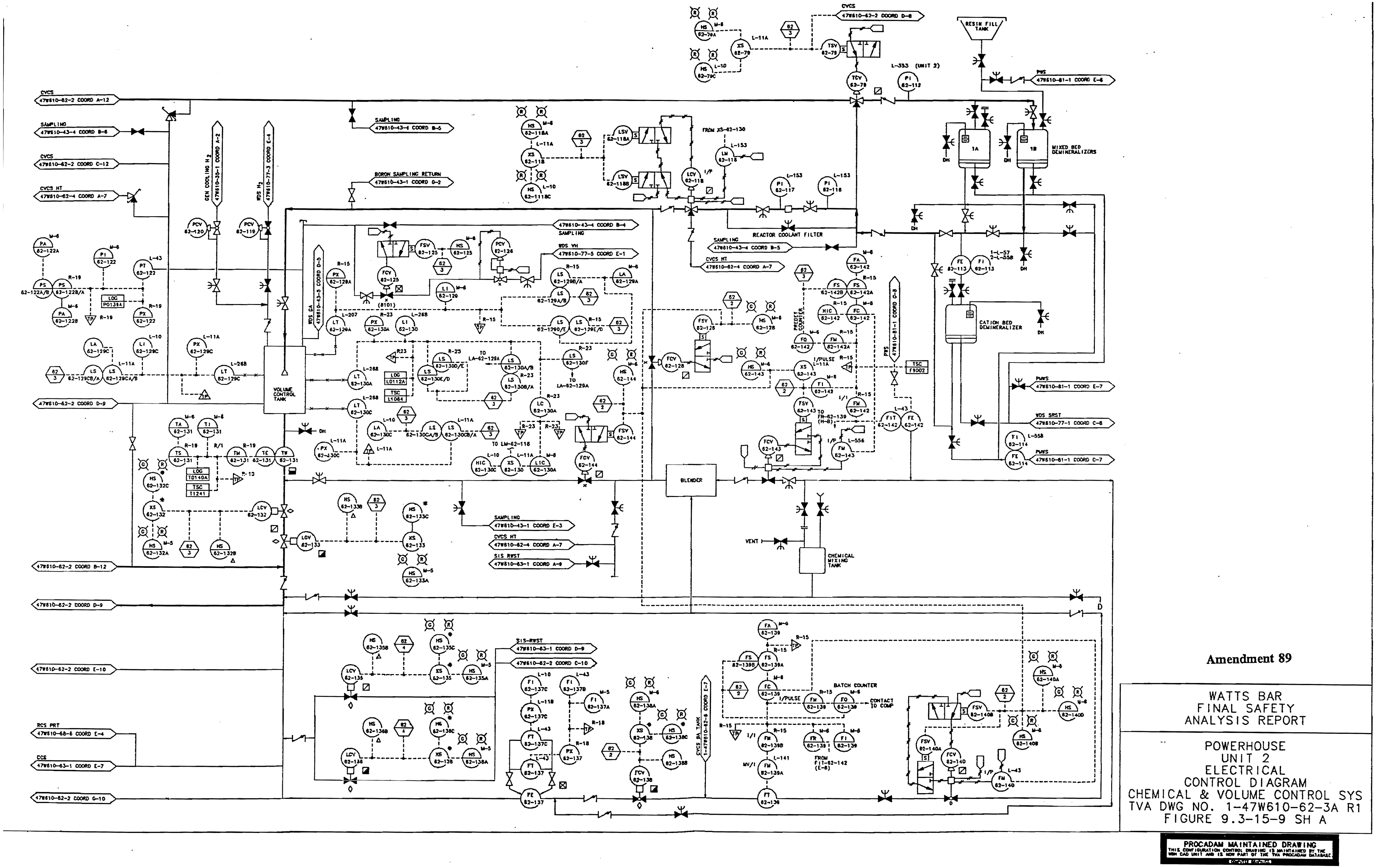


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Figure 9.3-15 Powerhouse Unit 2 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 9a)

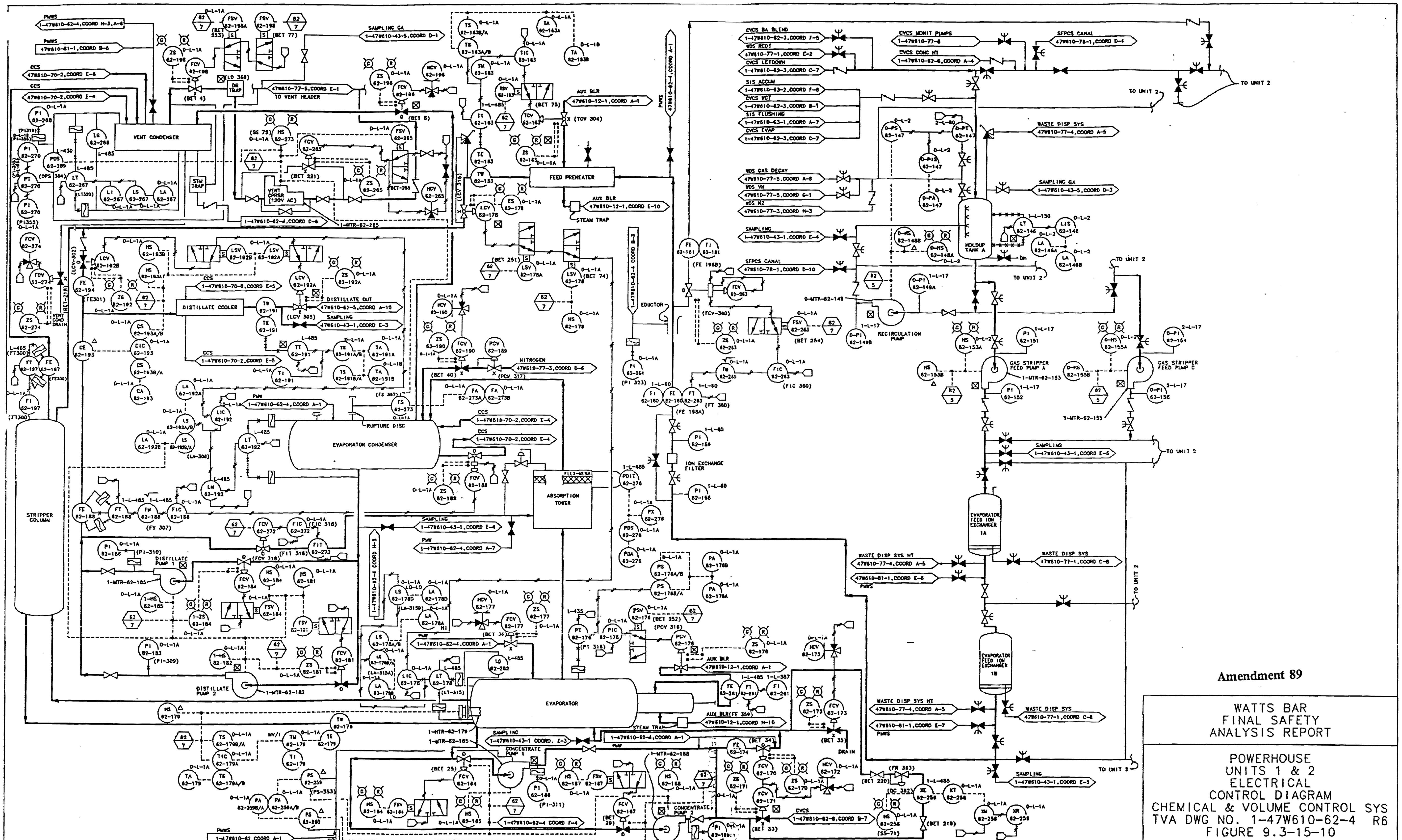
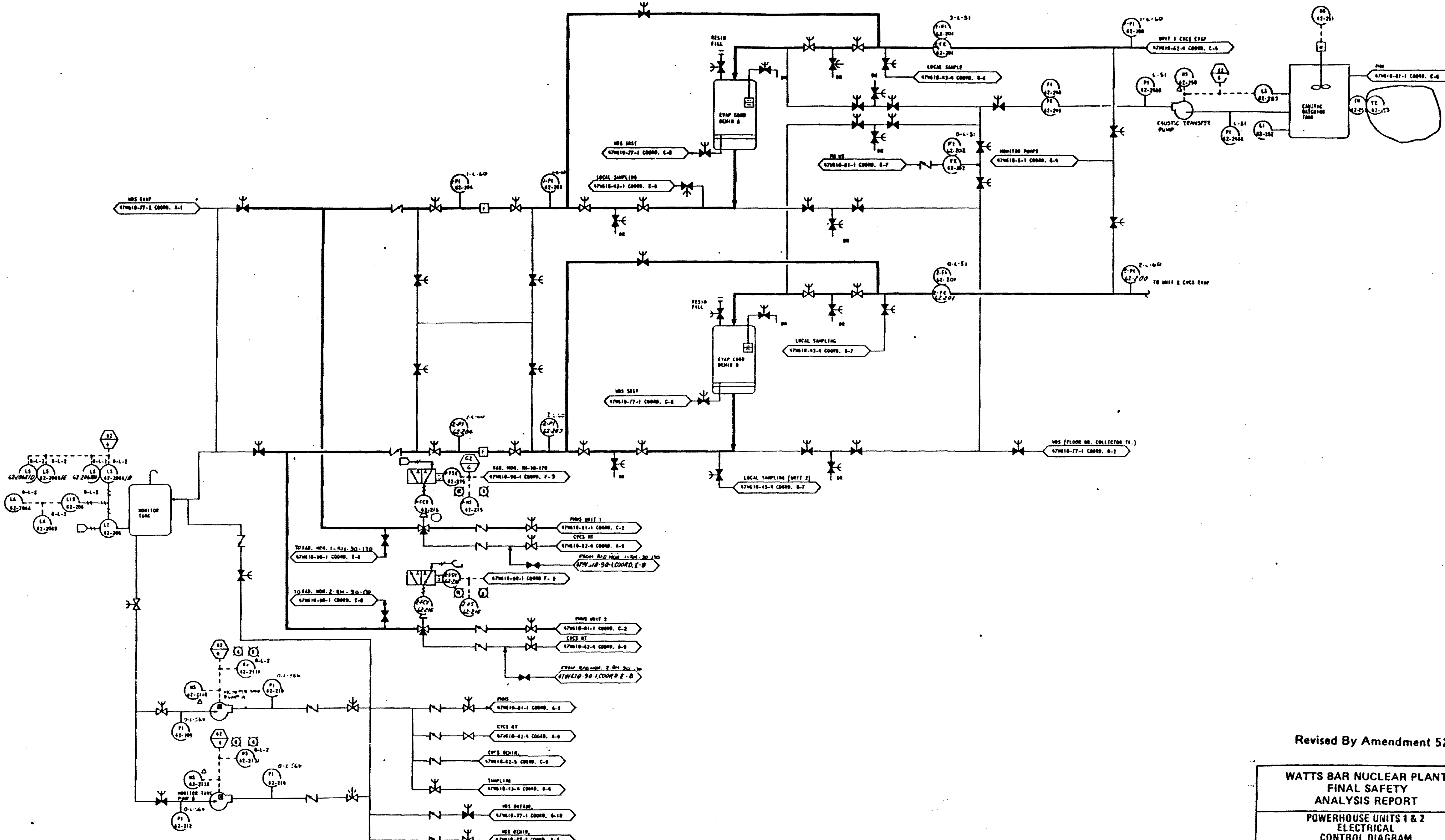


Figure 9.3-15 Powerhouse Units 1 & 2 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 10)



Revised By Amendment 52

WATTS BAR NUCLEAR PLANT FINAL SAFETY ANALYSIS REPORT
POWERHOUSE UNITS 1 & 2 ELECTRICAL CONTROL DIAGRAM CHEMICAL & VOLUME CON SYS TVA DWG NO. 47W610-62-5 R6 FIGURE 9.3-15 SHEET 11

Figure 9.3-15 Powerhouse Units 1 & 2 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 11)

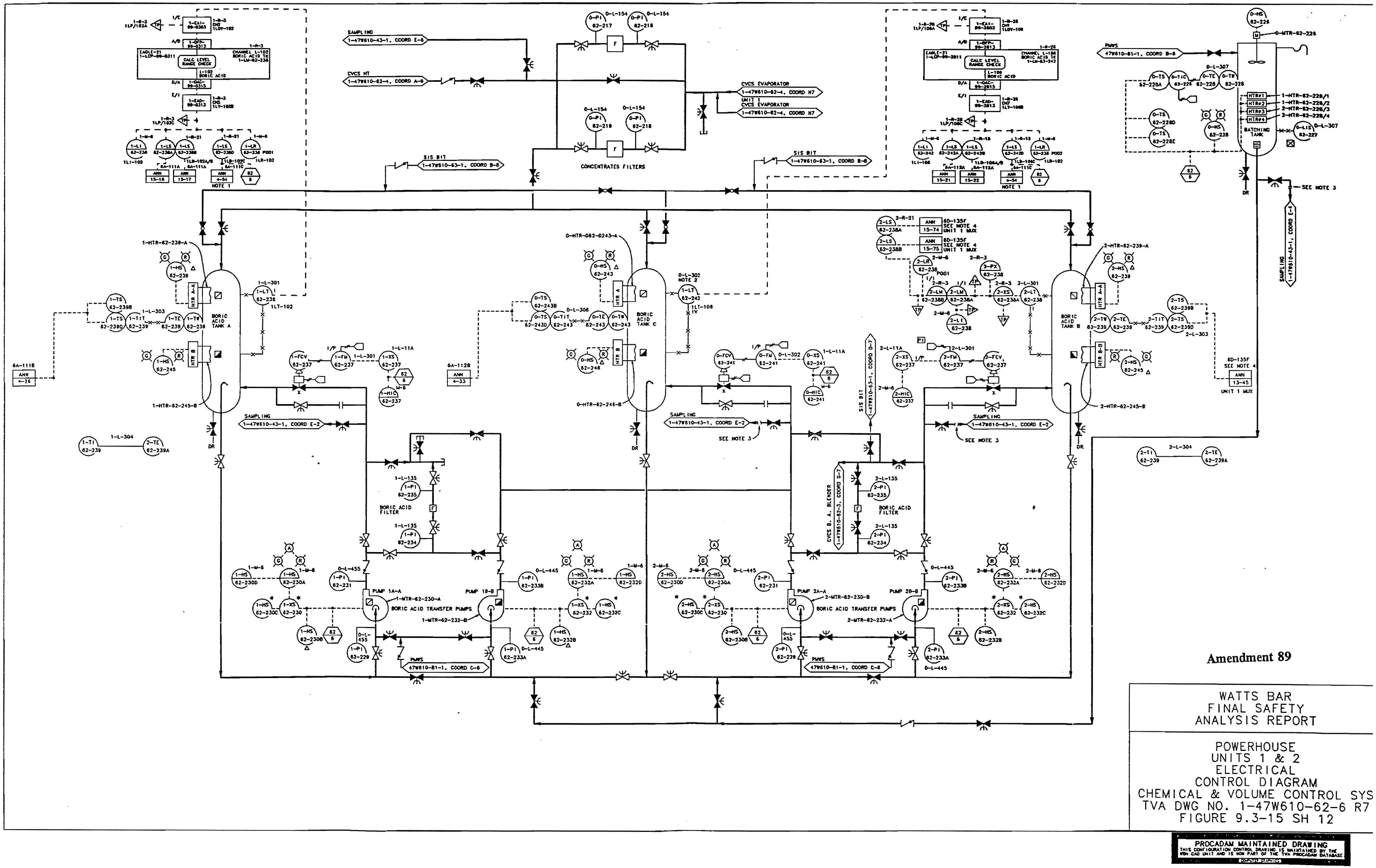


Figure 9.3-15 Powerhouse Units 1 & 2 Electrical Control Diagram Chemical & Volume Control Sys (Sheet 12)

Figure 9.3-16 Gross Failed Fuel Detector Flow Diagram

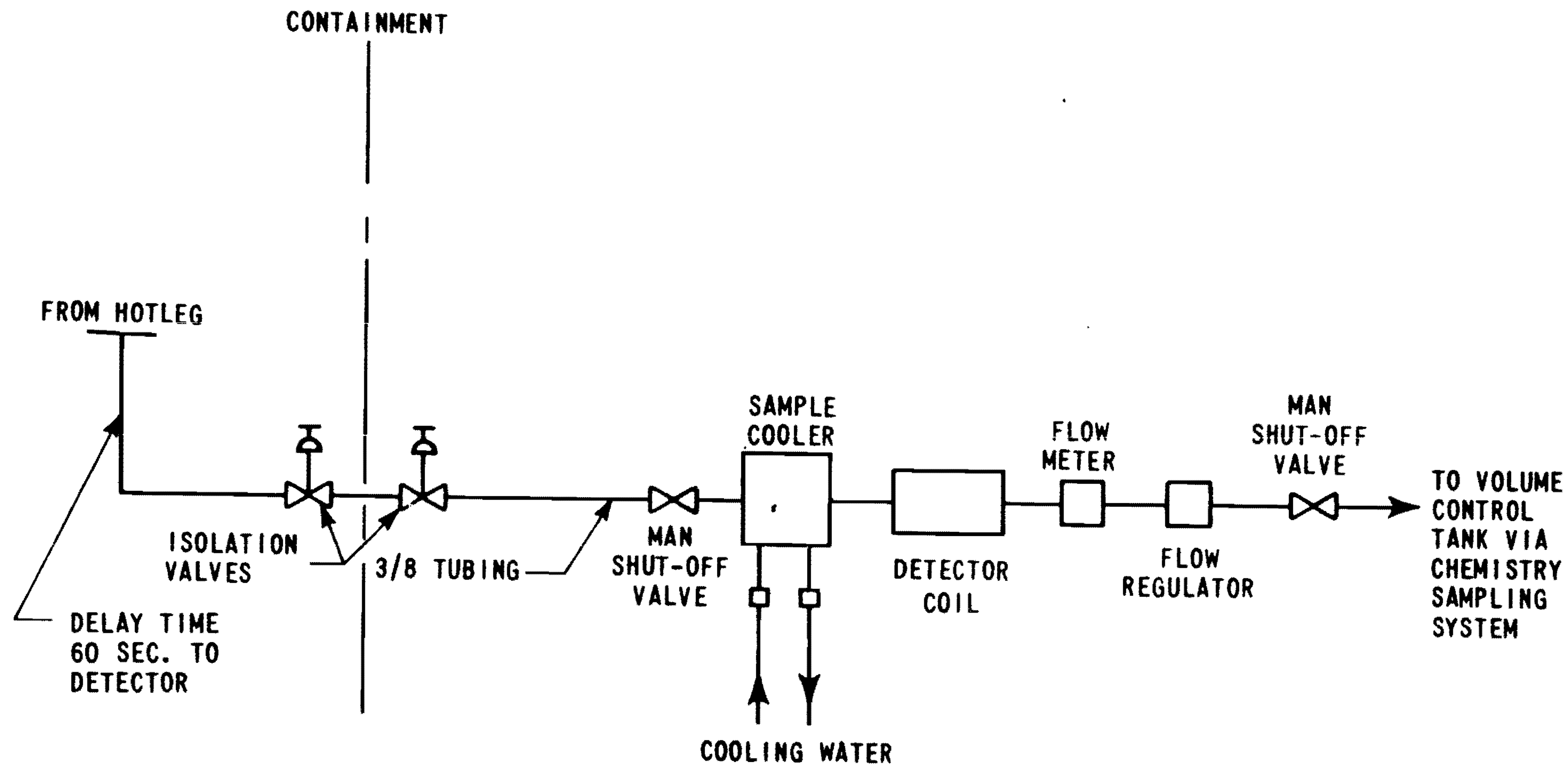


Figure 9.3-16 Gross Failed Fuel Detector Flow Diagram

Figure 9.3-17 Gross Failed Fuel Detector Electronics Diagram

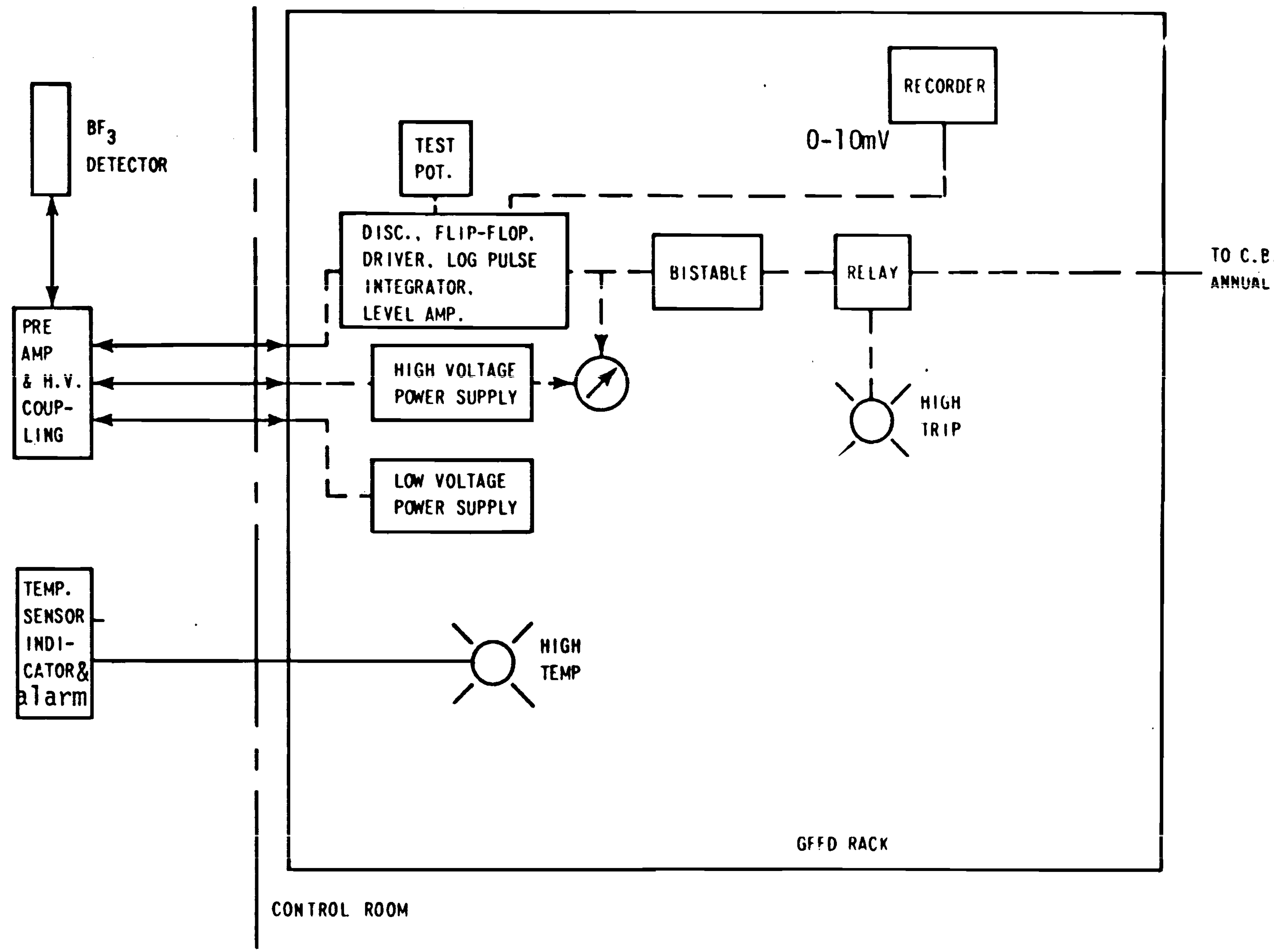


Figure 9.3-17 Gross Failed Fuel Detector Electronics Diagram

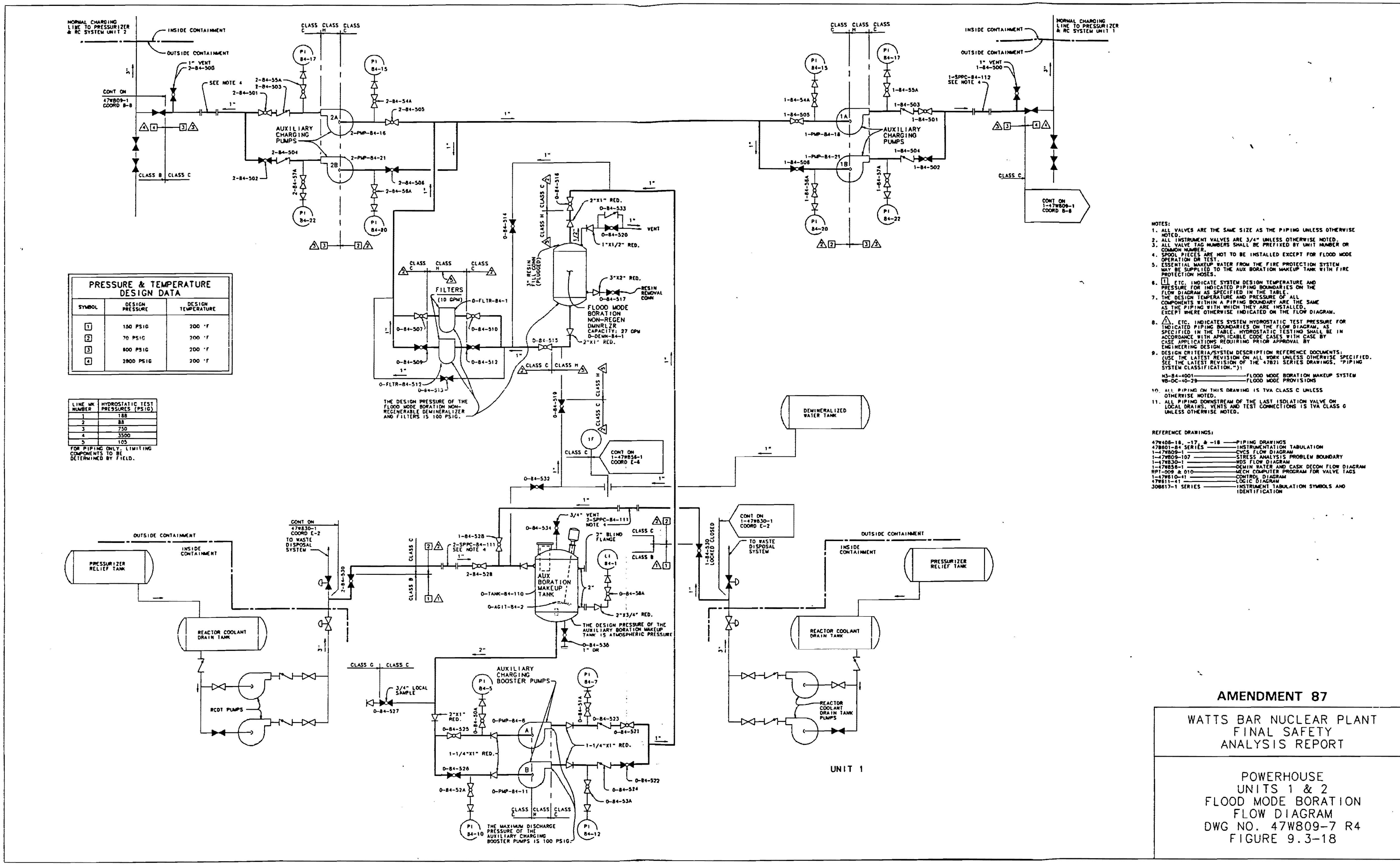


Figure 9.3-18 Powerhouse Units 1 & 2 Flow Diagram for Flood Mode Boration

Figure 9.3-19 Deleted by Amendment 52 (Sheets 1 through 3)

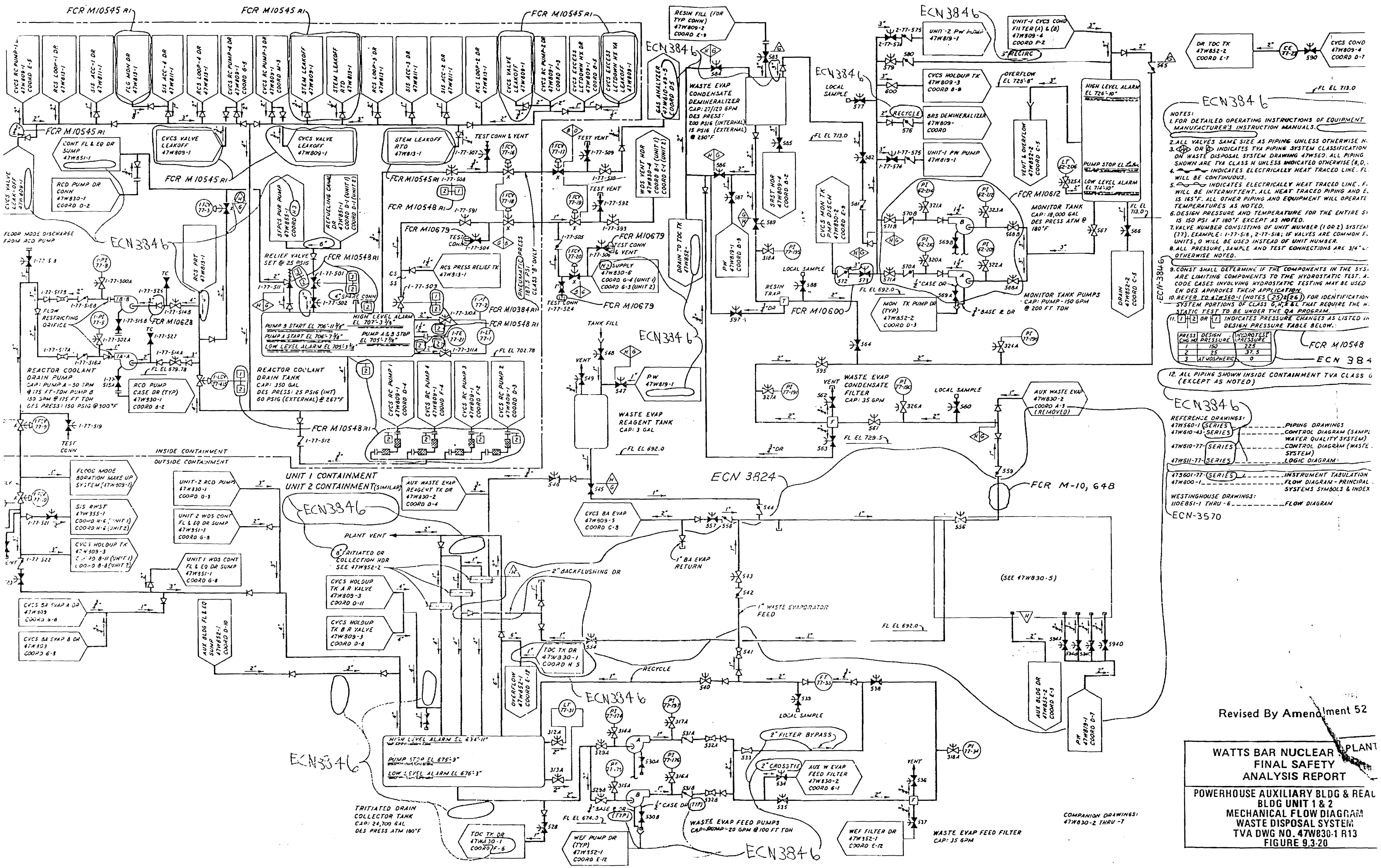


Figure 9.3-20 Powerhouse, Auxiliary Building, and Reactor Building Unit 1 & 2 - Mechanical Flow Diagram for Waste Disposal System

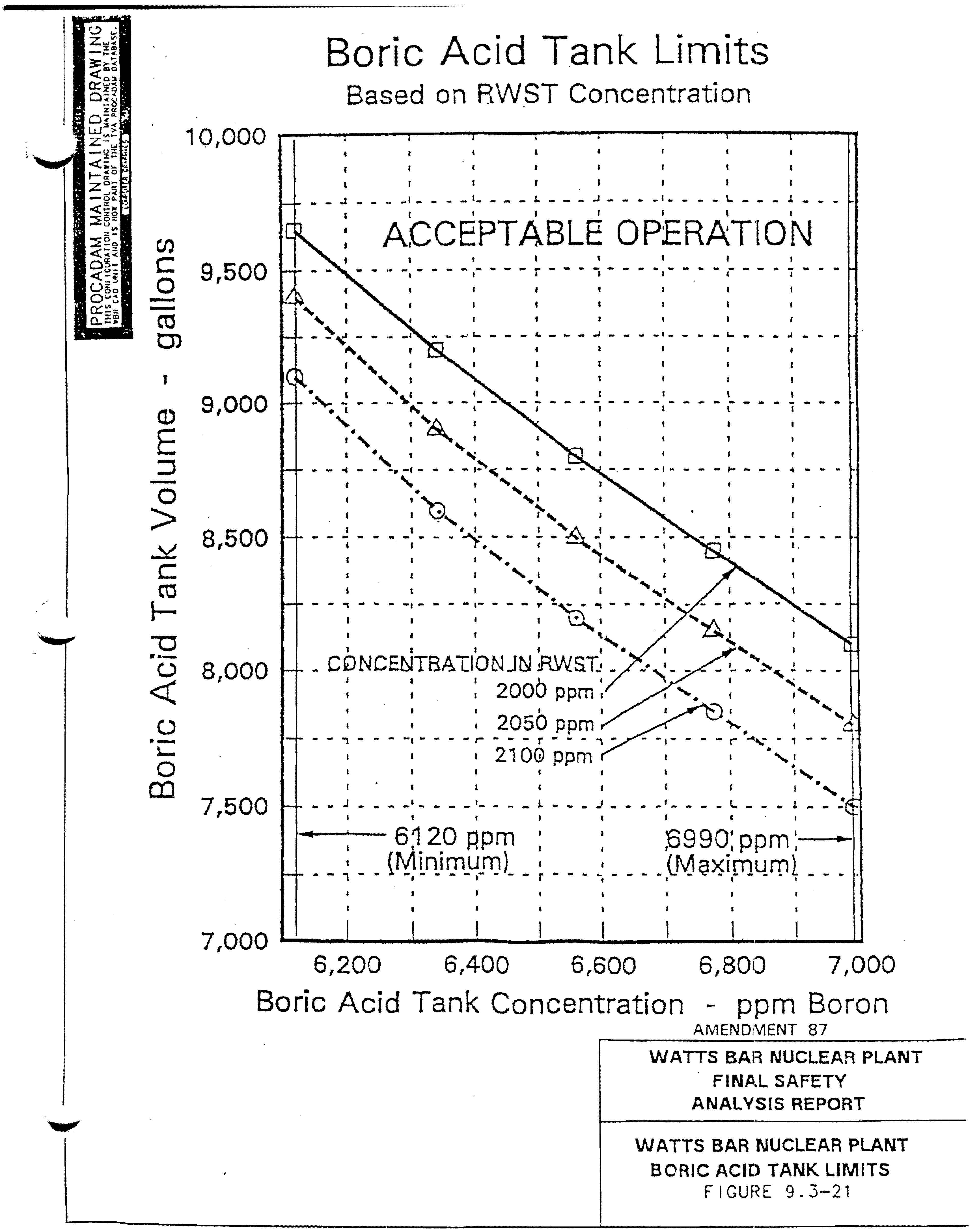


Figure 9.3-21 Watts Bar Nuclear Plant Boric Acid Tank Limits