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*The listed drawings are included as "General References" only; i.e., refer to the drawings to obtain additional detail or to obtain background information. These drawings are not part of the UFSAR. They are controlled by the Controlled Documents Program.

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M-943	Diagram of Diesel Generator Lube Oil and Intake Air and Exhaust Piping
M-1058	Diagram of High Radiation Sampling System Heating, Ventilation, and Air Conditioning
M-1059	Piping & Instrumentation Diagram Chilled Water System
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M-1530	Flow Diagram and Pneumatic Control of Reactor Building and Drywell Torus Ventilation System

9.0 AUXILIARY SYSTEMS

9.1 FUEL STORAGE AND HANDLING

The equipment and evaluation presented in this section are applicable to either unit. [9.1-1]

9.1.1 New Fuel Storage

9.1.1.1 Design Bases

The design objective of the new fuel storage system is to provide a clean, dry storage vault for new fuel. To achieve this objective, the new fuel storage system is designed using the following bases:

A. New fuel will be received and stored in a manner which precludes inadvertent criticality. [9.1-2]

B. Normal reactor refueling will involve replacement of approximately 20% to 30% of the core.

C. New fuel bundles may be stored in the new fuel vault with or without a fuel channel installed on the bundle.

D. The new fuel storage vault is designed to withstand earthquake loading as a Class I structure.

E. There will be no exposure of personnel to radiation in excess of 10 CFR 20 limits.

9.1.1.2 Facilities Description

A new fuel storage vault is shared by both units. This new fuel storage vault is a reinforced concrete Class I structure, accessible only through top hatches. Racks in the vault can hold 610 fuel bundles in an upright position. The minimum center-to-center spacing of bundles in the racks is 6.625 inches longitudinally by 11 inches between rows. [9.1-3]

The storage racks in the vault are aluminum, unpoisoned, full length, top entry, and designed to prevent an accidental critical array, even in the event the vault becomes flooded.

An open drain in the vault floor prevents possible water collection. Refer to drawing M-7 for the location of the new fuel storage vault.

Prior to installing new fuel assemblies in the reactor core, the fuel assemblies are received, inspected, channeled, and stored in the new fuel vault or transferred to the fuel storage racks in the fuel pool. The fuel assemblies may also be stored in the new fuel vault in an unchanneled condition, if desired.

9.1.1.3 Safety Evaluation

The new fuel storage racks are designed in accordance with Draft General Design Criterion 66 to prevent an accidental critical array, even in the event the vault becomes flooded. [9.1-4]

The spacing of fuel bundles in the new fuel storage vault maintains k_{eff} <0.90 dry and k_{eff} <0.95 flooded. [9.1-5]

The vault floor drain prevents flooding. A radiation monitor at the new fuel storage vault provides warning of any radiation level increase. Since the vault opens only at the top, the new fuel elements are afforded maximum protection. Grating is provided below the hatches such that, with the hatches removed, only one row of stored fuel will be exposed. Seismic design for the new fuel storage vault is described in Section 3.7.

ATRIUM 10XM assemblies can be safely stored in the Quad Cities Unit 1 and Unit 2 new fuel storage vault and meet the criteria of k_{eff} less than 0.90 for the dry condition and less than 0.95 for the fully flooded with un-borated water condition. Reference 18 provides the lattice enrichment and gadolinia loading criteria for ATRIUM 10XM assemblies to be safely stored in the Quad Cities Unit 1 and Unit 2 new fuel storage vault.

In addition, controls have been implemented to further reduce the probability of a criticality occurrence, i.e., the storage array will be in a moderation controlled area. A moderation control area limits the amount of hydrogenous material in the area. Administrative controls as generally defined in SIL 152[9] have been incorporated for the area.

9.1.1.4 Exemption From the Requirements of 10 CFR 70.24 Regarding Criticality Accident Requirements

The NRC issued an exemption from the requirements of 10 CFR 70.24 regarding criticality accident requirements. The exemption states that there is reasonable assurance that irradiated and unirradiated fuel will remain subcritical. [9.1-6]

The special nuclear material that could be assembled into a critical mass is in the form of nuclear fuel. The quantity of special nuclear material other than fuel that is stored on site in any given location is small enough to preclude achieving a critical mass. The Commission's technical staff has evaluated the possibility of an inadvertent criticality of the nuclear fuel and has determined that it is extremely unlikely that such an accident will occur if the licensees meet the following criteria:

Criteria supporting basis for exemption from 10 CFR 70.24:

A. Only three boiling-water reactor new fuel assemblies are allowed out of a shipping cask or a storage rack at one time.

B. The k-effective does not exceed 0.95, at a 95-percent probability, 95-percent confidence level, in the event that the fresh fuel storage racks are filled with fuel of the maximum permissible U-235 enrichment and flooded with pure water.

C. If optimum moderation occurs at low moderator density, the k-effective does not exceed 0.98, at a 95-percent probability, 95-percent confidence level, in the event that the fresh fuel storage racks are filled with fuel of the maximum permissible U-235 enrichment and flooded with a moderator at the density corresponding to optimum moderation. The optimum moderation is not analyzed for Quad Cities Station. To preclude the existence of an optimum moderation condition in the new fuel vault area the following controls are used; the new fuel vault is verified dry; low velocity fog nozzles (fire protection) in the vicinity of the dry storage vault have been removed; and the new fuel storage vault plugs are installed during prolonged work delays.

D. The k-effective does not exceed 0.95, at a 95-percent probability, 95-percent confidence level, in the event that the spent fuel storage racks are filled with fuel of the maximum permissible U-235 enrichment and flooded with pure water.

E. The quantity of special nuclear material, other than nuclear fuel, stored on-site in any given area is less than the quantity necessary for a critical mass.

F. Radiation monitors, as required by General Design Criterion (GDC) 63, are provided in fuel storage and handling areas to detect excessive radiation levels and to initiate appropriate safety actions. Although Quad Cities Station is not licensed to GDC 63, the licensee has radiation monitors that are consistent with these requirements in the fuel storage and handling areas. These radiation monitors are described in more detail in UFSAR Section 12.3.4.

G. The maximum nominal U-235 enrichment is limited to 5.0 weight percent.

9.1.2 Spent Fuel Storage

9.1.2.1 Design Bases

The design objectives of the spent fuel storage system are: [9.1-7]

A. To provide for the underwater storage of a maximum of 7554 fuel assemblies;

B. To provide storage pools for underwater storage of reactor vessel internals; and

C. To provide adequate protection against the loss of water from the fuel pools.

To achieve these objectives, the spent fuel storage system is designed using the following bases:

There will be no release of contamination or exposure of personnel to radiation in excess of 10 CFR 20 limits. [9.1-8]

Storage space is designed for a maximum of 7554 fuel assemblies of irradiated fuel. [9.1-9]

The fuel storage pools of Units 1 and 2 are connected by a double-gated transfer canal. [9.1-10]

D. It is possible, at any time, to perform limited work on irradiated components.

E. Pool storage space is provided for used control rods, flow channels, and other reactor components.

F. The fuel storage pool is designed to withstand earthquake loadings of a Class 1 structure.

The spent fuel assembly racks, with NETCO-SNAP-IN® rack inserts, are designed to ensure subcriticality in the storage pool. A maximum k_{eff} of 0.95 is maintained with the racks fully loaded with fuel of the highest anticipated reactivity and flooded with unborated water at a temperature corresponding to the highest reactivity. The criticality analyses include allowance for uncertainty and are described in a criticality analysis report applicable to the spent fuel pool. [12] Design Basis fuel assembly parameters are included in Reference 12.

9.1.2.2 Facilities Description

The major components of the spent fuel storage system are the spent fuel storage pool, the reactor well, and the dryer-separator pool. These pools are located in the reactor building elevation 690 ft. 6 in. Refer to Section 1.2 for detailed drawings of the pool arrangement. [9.1-12]

9.1.2.2.1 Dryer-Separator Pit

The dryer-separator pit provides a location for underwater transfer and storage of the reactor moisture separator and steam dryer assemblies during refueling operations. [9.1-13]

A raised step is provided at the bottom of the pit to:

- Prevent particulate material from entering the reactor well from the dryer-separator pit, and

- Ensure at least a 6-inch water coverage over the reactor shroud head, which becomes very radioactive during plant operations.

The pit is lined with stainless steel. The space between the liner and the concrete walls and floor forming the storage pit is provided with a drain which may be used to detect liner leakage. This annulus drain flows through "tell-tale" sightglasses to the reactor building floor drain sump.

9.1.2.2.2 Reactor Well

The purpose of the reactor well is to provide a space which can be flooded to permit the removal and underwater transfer of the moisture separators and fuel. Removable shield plugs are installed over the reactor well during normal operation. The plugs are provided to reduce the operating floor radiation during plant operation to insignificant levels. To flood the reactor well for refueling, the refueling bulkhead, in conjunction with a system of bellows seals, provides a watertight barrier to permit flooding above the reactor while preventing water from entering the drywell. The bulkhead is a flat, circumferential plate, which is fixed rigidly to the inside of the containment (Figure 9.1-1). The bulkhead contains ventilation duct hatches, which allow the drywell cooling system to cool the area above the bulkhead (within the drywell head) during normal plant operations.

The drywell to reactor building bellows seal accommodates the differential expansion that occurs between the drywell and the reactor building concrete during plant heatup and cooldown. (Figure 9.1-2) The seal is a cylindrical, one-piece, stainless steel bellows that seals the annulus between the drywell concrete wall and the drywell liner. To facilitate leak detection, a drain line at the low point on the reactor building side of the seal is piped to a flow switch.

The reactor vessel to drywell seal accommodates the differential expansion that occurs between the reactor vessel and the drywell during reactor heatup and cooldown. (Figure 9.1-2) The seal is a cylindrical, one-piece, stainless steel bellows. One end is welded to a special skirt on the reactor vessel, while the other end is welded to the refueling bulkhead. It seals the opening between the reactor vessel head flange and the drywell to allow flooding the reactor cavity above. To facilitate leak detection, a drain line at the low point on the outside of the seal is piped to the drywell equipment drain sump via a flow switch.

9.1.2.2.3 Spent Fuel Storage Pool

The spent fuel storage pool has been designed to withstand the anticipated earthquake loadings as a Class I structure. Each unit has its own spent fuel pool measuring 33 x 41 feet. The fuel pool is a reinforced-concrete structure, lined with seam-welded, stainless steel plate, welded to reinforcing members embedded in concrete. The 3/16-inch stainless steel liner will prevent leakage in the unlikely event the concrete develops cracks. To avoid unintentional draining of the pool, there are no penetrations that would permit the pool to be drained below a safe storage level. As shown in FSAR Figure 9.1-3 and P&IDs M-38 and M-80, the passage between the fuel storage pool and the reactor well above the reactor vessel is constructed with two, double-sealed gates with a monitored drain between the gates. This arrangement permits detection of leaks from the passage and repair of a leaking gate. The depth of water in the fuel storage pool is approximately 37 feet 9 inches and the depth of the water in the transfer canal during refueling is 22 feet 9 inches. A corner of the Unit 1 pool is reserved for loading a spent-fuel shipping cask. The water in the pool is continuously filtered, demineralized, and cooled by the fuel pool cooling and cleanup system described in Section 9.1.3. [9.1-14]

9.1.2.2.3.1 Spent Fuel Storage Pool Liner and Sumps

The spent fuel pool liner consists of 3/16-inch stainless steel plate wall sections and 1/4-inch stainless steel plate floor sections. The plates are anchored by plug welds arrayed in a 2 x 2-foot grid pattern on backing plates anchored directly to the pool's concrete walls and floor. [9.1-15]

The structural design of the liner plate and the associated liner plate anchors was controlled largely by the postulated thermal load case. The liner was designed for a uniform differential temperature of 80°F, representing the difference between 70°F and the maximum pool water temperature of 150°F. The maximum stress in the liner plate due to this case was 2550 psi. For the design of the plug welds, it was postulated that one panel of the liner was in a buckled condition and the surrounding panels were in an unbuckled state, thus imposing a differential force on the plug welds due to the relaxation of boundary stress in the buckled plate. To determine the final plug weld loads, the deformation of the concrete anchor was considered. The maximum plug weld stress for that condition was calculated to be 8350 psi compared to the allowable working stress value of 13,600 psi.

The liner plate leak detection system for the dryer-separator pools, transfer canals, and spent fuel pools consists of a series of interconnected channels behind the welded connections terminating in four sumps, one in each corner of each pool.

The sumps are drained to the reactor building floor drain sump via the floor drain system. Each sump is connected independently to the floor drain system through a manually operated gate valve with a sightglass downstream of the valve.

This arrangement aids in locating problem areas and controls flow to the reactor building floor drain sumps. These drain sumps are capable of removing any anticipated seam or liner crack leakage. The floor drain system has been designed to prevent airborne contamination by a series of water sealed traps. [9.1-16]

9.1.2.2.3.2 Spent Fuel Storage Pool Racks and NETCO-SNAP-IN® Rack Inserts

In accordance with modification M4-1(2)-81-010, the original fuel storage racks were replaced with high density fuel racks (HDFR) to increase the fuel pool storage capacity. The fuel storage pools will hold, in addition to the fuel assemblies, control rods and small reactor vessel components in the event of a complete core unload. Storage racks have been designed for 7554 fuel bundles, and flow channels. [9.1-17]

The racks are a modular honeycomb arrangement of cells. The cells are constructed of a series of cruciform shaped stainless steel elements to form a modular rack. (Figures 9.1-7, 9.1-8 and 9.1-9) Each cell accommodates a single BWR fuel assembly. [9.1-18]

The high-density racks are engineered to achieve the dual objective of maximum protection against structural loadings (such as ground motion) and the maximization of available storage locations. In general, a greater width to height aspect ratio provides greater margin against rigid body tipping. Hence, the modules are made as wide as possible within the constraints of transportation and site-handling capabilities.

The Quad Cities Unit 1 pool is designed for 19 high-density fuel racks in 9 different module sizes. The module types are labeled A through K in Figure 9.1-12, which also shows their

relative placement. There are a total of 3657 designed storage locations in the Quad Cities Unit 1 pool.

The Quad Cities Unit 2 pool contains 20 high-density fuel racks in 9 different module sizes. The module types are labeled A through K in Figure 9.1-13, which also shows their relative placement. There are a total of 3897 designed storage locations in the Quad Cities Unit 2 pool.

Table 9.1-1 provides details of the various rack modules. [9.1-19]

The rack assembly is supported on four plate-type supports (Figure 9.1-10). The supports elevate the module baseplate 6.5 inches above the pool floor level, thus creating the water plenum for coolant flow. (Figures 9.1-10 and 9.1-11) [9.1-21]

The spent fuel rack modules are not anchored to the pool floor or connected to the pool walls. The minimum center-to-center spacing of fuel bundles in the racks is 6.22 x 6.22 inches (Figure 9.1-9). [9.1-22]

Part of the original design of the racks was to maximize the available storage locations through the use of sheets of neutron absorbing material (Boraflex), which are sandwiched between the stainless steel walls of the adjacent storage cells. Over time, the Boraflex began to degrade in the spent fuel pool environment; therefore, the neutron absorbing function of the Boraflex material has since been replaced by neutron absorbing NETCO-SNAP-IN® rack inserts under modification EC 389362. Though the Boraflex material remains abandoned inside the walls of the racks, it is no longer credited for neutron absorption.

The neutron absorbing rack inserts are manufactured by NETCO using Boralcan, an aluminum and boron carbide composite material produced by Rio Tinto Alcan. An AA1100 series aluminum alloy is used as a metal matrix to homogenously distribute boron carbide. The rack insert material contains 17% by volume of boron carbide and has a Boron-10 minimum certified areal density of 0.0116 g/cm^2.

Figures 9.1-19 and 9.1-20 show two different styles of inserts. Figure 9.1-19 (Style 1) was the original design. Figure 9.1-20 (Style 2) was created to facilitate ease of installation and was used for the majority of the spent fuel pool. The rack inserts are rolled into sheets nominally 0.085 inch thick and approximately the length of a rack cell. A tolerance stack-up and engineering justification in EC 389362 ensure that the rack inserts cover the active fuel region and justify the acceptability of special fuel scenarios.

The rack inserts are formed to have a V-shaped cross section with a greater than 90 degree bend. The rack inserts are designed to abut against the two adjacent faces of the storage cell walls. As the rack inserts are installed, the greater than 90 degree bend compresses, providing a bearing force against the inside of the cell walls. Though retaining the inserts in place is not a seismic requirement, it significantly reduces the likelihood of the insert moving during normal fuel handling operations. Since the rack inserts only provide neutron absorption for two rack cell walls, they are used in combination with the rack inserts in the neighboring storage cells to ensure that rack insert material is between face adjacent bundles. The V-shape of each rack insert in both Unit 1 and Unit 2 pools is positioned southwest to isolate the bundles from each other.

9.1.2.2.4 Low Level Waste (LLW)

The Spent Fuel Pool (SFP) contains storage racks and equipment that are provided to

process and store hardware until a LLW cask storage system is implemented. The storage racks and equipment are designed Category II/I to not impact the SFP liner during a seismic event.

9.1.2.3 Safety Evaluation

The HDFR with NETCO-SNAP-IN® rack inserts (and without crediting neutron absorption from the Boraflex) were designed to assure that a $k_{\{eff\}}$ not greater than 0.95 would be maintained with the racks fully loaded with fuel of the highest anticipated reactivity and flooded with unborated water at a temperature corresponding to the highest reactivity, under normal or abnormal conditions. [9.1-23]

Analyses have been performed for each type of fuel stored in the spent fuel pool to assure compliance with the K_{eff} criteria and the Technical Specifications maximum k-infinite limit of 0.8991 as determined at 4°C (39.2°F) in the normal spent fuel pool in-rack configuration. Critical parameters have been established to evaluate minor variations in the neutronic design of actual bundles of each fuel type. For each new bundle design, these critical parameters are reviewed to ensure the bundle design complies with the criticality analysis for the fuel type.

The spent fuel pool criticality analyses comply with Section 9.1.1 of the Standard Review Plan.

A Boraflex coupon surveillance program was established following the installation of the Boraflex fuel racks. A total of 18 coupons were installed in both spent fuel pools. These coupons were periodically retrieved and examined for evidence of material degradation.[11] [9.1-23a] The Boraflex coupon surveillance program was suspended following implementation of NETCO-SNAP-IN® rack inserts.

The HDFR walls consist of the neutron-absorbing material Boraflex sandwiched between two stainless steel plates. In 1986, it was learned that Boraflex degrades in the spent fuel pool environment.

Boraflex degradation at Quad Cities was monitored through periodic BADGER testing (neutron attenuation testing of a sampling of spent fuel pool rack cell walls) and use of the EPRI developed RACKLIFE computer code (monitoring with BADGER and RACKLIFE was suspended with the implementation of rack inserts). The Rack Insert Surveillance Program is discussed in UFSAR section 9.1.2.3.2.

For the mechanical design of the spent fuel modules containing rack inserts, two sets of criteria have been evaluated. The first established requirements to ensure that adjacent racks will not impact during the safe shutdown earthquake (SSE), assuming the lower bound value of the pool surface friction coefficient. This criterion required that a safety factor against tilting be 1.5 for the operating basis earthquake (OBE) and 1.1 for the SSE. The second set of criteria established requirements to ensure that loading combinations and stress allowables are in accordance with Section III, Subsection NF, of the ASME 1980 Edition.

The result of this analysis indicated that, although the racks, containing rack inserts, slide toward each other during the SSE, sufficient gaps are provided between the modules and between the modules and the pool walls so that inter-rack impact, or rack collision with the pool walls, is precluded.[3]

It has been determined that allowable stress limits for the combined loading conditions are in accordance with the ASME Code, App. XVII. Yield stress values at the appropriate temperature were obtained from Section III of the ASME Code. The quality assurance and criteria for the materials, fabrication and installation of the HDFR are in accordance with accepted requirements of the ASME Code.

The effects of the additional loads on the existing pool's structure due to the HDFR, rack inserts and equipment have been examined. It has been determined that the pool's structural integrity is assured by conformance with the Standard Review Plan Section 3.8.4.

Results of the seismic and structural analyses indicate that the racks containing rack inserts are capable of withstanding the loads associated with all design loading conditions. Also, impact from fuel assembly/cell collision has been considered including dropping a fuel assembly onto the racks, and as a result, no damage to the racks or fuel assemblies would occur.

The HDFR structural analysis included two types of postulated fuel assembly drops onto the racks. The first was a straight drop of a fuel assembly from a maximum of 36 inches above the storage location impacting the base. The second involved a fuel assembly dropping from a maximum of 36 inches above the rack and hitting the top of the rack. In both cases, impact energy is dissipated by local yielding; however, the sub-criticality of the fuel arrays is not violated. The presence of the rack inserts has a negligible effect on this analysis.

Dropping heavy loads onto the protective liner of the pool floor was also analyzed. Although local damage and plastic deformation may occur, the overall structural integrity of the liner is maintained.

The effect of a postulated stuck fuel assembly during an attempted withdrawal was considered and the damage, if any, was required to be limited to the region above the active fuel elements. Results of the stuck fuel assembly analysis show that the actual stress is below that allowed for applicable loading combinations. The presence of the rack inserts has a negligible effect on this analysis.

It has been determined that with respect to structural and mechanical design, the HDFR satisfies the applicable requirements of General Design Criteria 2, 4, 61, and 62 of 10 CFR, Part 50, Appendix A.

Given that the NETCO-SNAP-IN® rack inserts are integral to the rack, lateral seismic loads from the fuel will transfer through the insert to the rack. Similarly, the lateral seismic loads from the rack will transfer through the insert to the fuel. This will not affect the rack insert’s ability to perform its design function. The peak vertical seismic acceleration is less than 1.0; therefore, rack insert retention force is not required to secure the insert during a seismic event. The retention force is used to reduce the likelihood of displacement during normal operations.

The effects on rack inserts during a heat up event were considered. Temperatures are not high enough to permit distortion of the rack insert’s shape. The insert would remain intact; therefore, the safety function of the insert would not be affected.

The total combined dry weight of all miscellaneous components (including seismic barriers) placed on top of any one fuel rack module (empty or partially full) should not exceed 1250 lbs. [9.1-26]

Once fuel is stored in the spent fuel storage pool it will be covered with sufficient water for radiation shielding. Fuel being moved is at all times covered by a minimum depth of 8.5 feet of water above the active fuel. [9.1-27]

A liquid level switch monitoring pool water level is provided to detect loss of water and permit refilling of the pool from the condensate storage system. Refer to Section 9.1.3.2 for fuel pool level monitoring and control.

Refer to Section 3.7 and 3.8 for the safety evaluation of seismic event effects on the high density spent fuel storage racks and the fuel pool liner and concrete structure. Refer to Section 15.7 for the safety evaluation of the spent fuel cask drop accident. [9.1-28] [9.1-29]

9.1.2.3.1 Safety Evaluation for Fuel

Criticality analyses have been performed for each fuel type stored in the spent fuel pools to ensure that the spent fuel pool design criteria of k_{eff} less than or equal to 0.95 is met. These criticality analyses include allowances for biases and uncertainties, which are described in the criticality analysis report applicable to the spent fuel pool (Reference 12). Critical parameters have been established to evaluate variations in the neutronic design of actual assemblies. A spent fuel storage criticality validation is performed for each reload to demonstrate that the reload fuel assemblies meet these critical parameters and therefore the rack k_{eff} requirements for storage.

With the introduction of ATRIUM 10XM fuel at Quad Cities Units 1 and 2, an analysis (Reference 12) was performed to ensure that the spent fuel pool design criteria of k_{eff} less than or equal to 0.95 is met. This analysis determines the bounding lattice for all fuel types used at Quad Cities Units 1 and 2 and uses this lattice to demonstrate compliance with the k_{eff} criteria and the Technical Specification maximum k-infinity limit (added in Amendment Number 253/248). An Optima2 lattice was determined to bound all earlier fuel designs as well as the ATRIUM 10XM fuel design and is the basis of the Reference 12 criticality safety analysis. The analysis demonstrates that all fuel assemblies used in the Quad Cities reactors through and including Cycle 24 for Unit 1 and Cycle 24 for Unit 2 and ATRIUM 10XM fuel assemblies can be safely stored in the spent fuel pools (with or without a channel) and comply with the Technical Specification in-rack k-infinity limit. The following conditions were analyzed for the spent fuel pool storage racks containing the bounding lattice:

A. Fuel racks fully loaded with bounding lattice at its peak reactivity burnup.

B. Bounding depletion parameters.

C. Most reactive moderator temperature and density.

D. Normal positioning in the spent fuel storage array.

E. Eccentric positioning in the spent fuel storage array.

F. Fuel manufacturing tolerances.

G. Spent fuel storage rack manufacturing tolerances.

H. Bounding NETCO-SNAP-IN rack insert parameters.

I. Fuel burnup induced geometry changes.

J. Clean and unborated water in the spent fuel pool.

K. Fuel rack lateral movement.

L. Dropped fuel assembly.

M. Missing NETCO-SNAP-IN rack insert.

N. Mislocated assembly.

O. NETCO-SNAP-IN rack insert installed on wrong side of cell.

The reactivity of the Quad Cities Units 1 and 2 spent fuel pool storage racks (containing neutron absorbing NETCO-SNAP-IN rack inserts with no credit for Boraflex) has been calculated using the computer codes CASMO-4 and MCNP5-1.51. CASMO-4 was used to determine the exposure-dependent pin-by-pin fuel isotopic compositions utilizing the ENDF/B-V cross-section data library. MCNP5 was used with the CASMO-4 pin-specific fuel isotopic compositions and the ENDF/B-VII cross-section data to compute the exposure dependent peak in-rack reactivity.

In support of the criticality safety calculations, a set of critical experiments were analyzed using MCNP5-1.51 to provide a definitive determination of the methodology bias and bias uncertainty. The critical experiments included a wide range of compositions and geometries that are representative of the spent fuel at Quad Cities.

Reference 12 provides the details of the criticality analysis performed for all fuel types used at Quad Cities including ATRIUM 10XM. This analysis provides a process for demonstrating that ATRIUM 10XM fuel can be safely stored in the spent fuel pool and comply with the Technical Specification in-rack k-infinity limit for a range of enrichment and gadolinia loadings.

9.1.2.3.2 Rack Insert Surveillance Program

The following description of the Rack Insert Surveillance Program was added to meet regulatory commitment RCMT 01548784-01.

The Rack Insert Surveillance Program is designed to monitor the physical properties of the insert material, perform periodic neutron attenuation testing to confirm the physical properties, and observe the inserts for wear. If an abnormal condition is confirmed, the condition would be entered into the corrective action program for disposition. During the NRC review of the License Amendment Request for the rack inserts, the NRC established license conditions related to the Rack Insert Surveillance Program to ensure timely identification and mitigation of degradation of the aluminum boron carbide rack inserts. For more information refer to the current Operating Licenses.

9.1.2.3.2.1 Fast Start Coupon Surveillance Program

The fast start coupon surveillance program was a one-time program implemented at LaSalle County Generating Station to provide early performance data on the NETCO insert material in a SFP environment while maximizing the gamma energy deposition and coupon temperatures. This program consisted of a series of 24 coupons suspended inside of a spent fuel storage rack cell and surrounded in all eight adjacent cells with freshly discharged fuel. Two coupons will be removed from the string approximately every six months for testing, inspection, and a comparison to their pre-installation condition by a qualified laboratory. The results of the inspections of the LSCS fast start coupons 24 through 11 are contained in NETCO reports NET-332-01 and NET-300054-01. There were minimal changes in the coupons from their pre-use characterization values. The corrosion rates were consistent with the accelerated corrosion testing performed in the NETCO material qualification report, NET-259-03. Based on the satisfactory initial results at LaSalle and the similarities of the SFP water chemistry and temperatures, the program was not duplicated for Quad Cities.

The fast start testing program was intended to identify unanticipated insert material performance issues during the demonstration of the first-of-a-kind use of NETCO SNAP-IN inserts in SFPs.

Further details of the Fast Start Coupon Surveillance Program can be found in the LaSalle surveillance procedure. Further details regarding the justification of the similarities of SFP water chemistries and temperature are described in the Quad Cities License Amendment Request, RS-13-148.

9.1.2.3.2.2 Long-Term Coupon Surveillance Program

The long-term coupon surveillance program at Quad Cities will consist of periodic surveillance testing of different types of coupons fastened to two specially designed surveillance "trees." Each surveillance "tree" was placed in a location that is to be surrounded by eight freshly discharged fuel assemblies after each Unit 1 refueling outage beginning with the spring 2013 refueling outage (Q1R22). The trees will reside there as long as the spent fuel storage racks with NETCO-SNAP-IN® rack inserts continue to be used. Periodically, coupons will be removed and sent to a qualified laboratory for testing.

The types and quantities of the long-term surveillance coupons are described in Table 9.1-4. All coupons were manufactured to the same material specification as the full sized Quad Cities rack inserts. Both coupon trees are designed to be inserted into rack cells, taking the place of a fuel bundle. The flat coupon tree is designed to hold general and galvanic coupons. These coupons will be monitored for any changes to their physical properties and especially for any changes to their effective areal density or signs of corrosion, which could indicate neutron absorber material degradation. The bent coupon tree is designed to hold coupons at a 90 degree (nominal) bend angle which is, on average, a 5 degree deflection from their as-manufactured dimension. The bend coupons are intended to monitor the performance of the bend region of the inserts, especially stress relaxation and crack formation under the in-service strain to which the inserts are subjected.

Surrounding the coupon trees with freshly discharged fuel will maximize the thermal load and radiation exposure received so that the radiation effects will bound all other inserts in either pool. The proposed strategy will not adversely impact compliance with B.5.b fuel pool loading commitments. Placing the freshly discharged fuel in the surrounding cell

locations will be administratively controlled. Placing the coupon trees in only one spent fuel pool is acceptable with respect to water chemistry and temperature because there is no worst case or bounding rack cell location in either pool associated with water chemistry and temperature. Substantial SFP water mixing is assured by continuous circulation through each SFP by the SFP cooling system. Also, the double-gated transfer canal is normally connected permitting mixing between the pools.

The general and galvanic coupons will be subject to pre- and post-examination according to Table 9.1-5. The bend coupons will be subject to pre- and post-examination according to Table 9.1-6. Areal density testing will be performed on all coupons except bend coupons. Due to geometry constraints, the bend section of the bend coupons cannot be accurately tested for areal density using neutron attenuation methods.

Coupons will not be re-inserted into the fuel pool after removal for inspection. The removal process and handling of inserts creates the potential for coupon damage and once a coupon is removed from service for inspection, it is exposed to the ambient air environment and would no longer provide a representative sample for future inspections. There are a sufficient number of test coupons installed into the SFP so that coupons will not have to be re-used for future required inspections (see Tables 9.1-4 and 9.1-7). The frequency for coupon inspection under the long-term surveillance program is shown in Table 9.1-7.

9.1.2.3.2.3 Long-Term Full Rack Insert Surveillance Program

9.1.2.3.2.3.1 Insert In-Situ Inspections

Two rack inserts from the Unit 1 SFP will be visually inspected with a camera at the frequency described in Table 9.1-8 to visually monitor for physical deformities such as bubbling, blistering, corrosion pitting, cracking, or flaking. Special attention will be paid to development of any edge or corner defects. The selection of the two inserts will be based on bounding operating conditions for all pool inserts. The parameters that could affect the material properties of the insert are fuel pool water chemistry, pool temperature, and radiation exposure received due to proximity to irradiated fuel.

In the QCNPS SFPs, water chemistry and temperature do not vary among the rack locations throughout the pools. Substantial SFP water mixing is assured by continuous circulation through each SFP by the SFP cooling system. Also, the double-gated transfer canal is normally connected permitting mixing between the pools. Therefore, each insert location is exposed to essentially the same water chemistry and water temperature. There is no worst case or bounding rack cell location associated with water chemistry or temperature.

The inserts chosen for inspection from the Unit 1 SFP will be those with the highest radiation exposure received from discharged fuel so that the radiation effects will bound all other inserts in either pool. Quad Cities has designated two rack cells as test locations so that freshly discharged fuel can be placed in the cells. Placing freshly discharged fuel in the test cells after every Unit 1 refueling outage will ensure they are representative with respect to radiation exposure. The proposed strategy will not adversely impact compliance with B.5.b fuel pool loading commitments. Placing the freshly discharged fuel in the test locations will be administratively controlled.

9.1.2.3.2.3.2 Insert Removal for Inspection

The limiting high duty spent fuel storage rack cell locations will be identified for this surveillance program. The locations will be monitored for fuel insertion and removal events to ensure that their service bounds that of the general population of storage locations. Full inserts removed for inspections will be subject to post-examination according to Table 9.1-9 to verify the inserts have sustained uniform wear over their service life. The visual inspections will be compared to high resolution digital photos of generic as-manufactured coupons, which are representative for the purposes of pre-characterization. As described in Table 9.1-8, one insert will be removed every 10 years.

Inserts removed from service for inspection will not be reinstalled. The removal process and handling of inserts creates the potential for insert damage. In addition, once an insert is removed from service for inspection, it is exposed to the ambient air environment and would no longer provide a representative sample for future inspections. Thus, removed inserts will be replaced with new inserts.

Minor wear may occur when the fuel channel clip aligns the bundle in the rack cell due to the increased fuel channel cross section at that elevation. The fuel channel clip protrudes from the channel making this the widest point. If wear were to occur, it is at the top of the insert and above the active fuel region.

Minimal service wear is expected within the active fuel region on the inserts due to adequate clearance between the fuel assembly and the insert. Drag/interference testing confirmed there was no noticeable interference and, therefore, no means of generating additional wear.

If service wear on an insert was to occur, it would occur as the result of the insertion and removal of a fuel assembly in and out of the rack cell. The rack cell with the most fuel assembly insert and removal cycles will represent a bounding case for all the pool rack cells. The number of fuel assembly inserts and removals in and out of each rack cell containing a NETCO-SNAP-IN® rack insert will be tracked and documented. The insert in the rack cell that has the most fuel move cycles will be the insert chosen for inspection. Inspecting the insert that had the most fuel assembly movements will ensure it is bounding with respect to wear for all inserts in the pool.

As discussed in Exelon's response to the NRC's Request for Additional Information (RAI) 1-2 of RS-14-100, the average minimum measured areal density of coupons is approximately six sigma higher than the minimum certified Boron-10 areal density 0.0116 gm/cm^2. In addition, as stated in License Amendment 253/248, the data in the RAI indicates that it would require an additional reduction in the as-built B-10 areal density of about one sigma beyond the lower 95/95 measurement threshold to potentially result in an insert having an actual B-10 areal density below the acceptance criterion. [17] There is considerable margin sufficient to identify wear phenomena that may occur on the inserts before it would affect their intended reactivity hold-down capability.

9.1.2.3.2.4 Timing for Start of Long-Term Surveillance Program

The time clock for the long-term surveillance program starts when the component for the surveillance was installed in the pool and subjected to irradiation. For the surveillances associated with general, galvanic, or bent coupons, the start date for the surveillance time clock is the day the coupon trees were installed in the pool, since fuel was pre-staged around the cells reserved for the coupon trees. The start date for the in-situ inspection of

full inserts is the day irradiated fuel was placed in the specified test cells. For the full rack insert removal surveillances, the start date for the surveillance requiring full insert removal is the day the first permanent insert was installed in the pool since the inserts selected for removal could be any insert that has experienced high duty.

9.1.2.4 Dry Cask Storage

Dry Cask Storage (DCS) system and the Independent Spent Fuel Storage Installation (ISFSI) provide the means for long-term onsite storage of Quad Cities Unit 1 or 2 spent nuclear fuel. The DCS system is the HI-STORM 100 Cask System, including the HI-STORM 100S Overpack, HI-TRAC 100D Transfer Cask and Multi-Purpose Canisters as documented in the QCNPS 10 CFR 72.212 Evaluation Report. The ISFSI includes the storage pad and the security system. Use of the DCS is granted upon issuance of a Certificate of Conformance (CoC) from the NRC. Use of the ISFSI for storage and handling of spent fuel is granted upon compliance with the conditions of the General License issued under 10 CFR 72, Subpart K. Use of the ISFSI for storage and handling of spent fuel shall be in accordance with the Quad Cities Nuclear Power Station Units 1 and 2 10 CFR 72.212 Evaluation Report. Cask handling will be within the single-failure-proof capabilities of the reactor building overhead crane.

9.1.3 Spent Fuel Pool Cooling and Cleanup System

9.1.3.1 Design Bases

The design objective of the fuel pool cooling and cleanup system is to handle the spent fuel heat load and maintain pool water clarity. The fuel pool cooling and cleanup system maintains the fuel and equipment storage pools as well as the reactor well water below a desired temperature, at an acceptable radiation level, and at a degree of clarity necessary to refuel and service the reactor. The system cools the pools by transferring the decay heat from the spent fuel to the reactor building closed cooling water system. Water purity and clarity is maintained by filtering and demineralizing the circulated water. [9.1-30]

The pool water temperature is maintained at or below 125°F to maintain a comfortable working environment in the pool area when removing the Normal Discharge heat load from the pool and when the reactor building closed cooling water temperature is at maximum design temperature (105°F). The pool temperature is maintained at or below 150°F while draining the reactor well and dryer-separator pit, or when removing the maximum heat load from the pool during the Full Core Discharge mode of refueling activity.

The heat load of spent fuel stored in the pool is calculated prior to each fuel offload based upon the number of fuel assemblies to be discharged, the time between reactor shutdown and the start of fuel offload and the rate of fuel offload. The calculated heat load includes decay heat from all previously discharged fuel assemblies in the fuel pool. Based upon the results of the decay heat load analysis, an analysis of expected fuel pool temperature is performed based on conservative values for service water temperature and Reactor Building Closed Cooling Water temperature. For operation at 2957 MWt, the analysis of fuel pool temperature during a Planned Core Discharge condition (modeled as a partial core discharge) requires an expected temperature less than or equal to the Normal Core Discharge acceptance limit of 140°F assuming a single failure of a cooling pump. The analysis of temperature during an unplanned Full Core Discharge condition requires an expected temperature less than or equal to the Full Core Discharge acceptance limit of 150°F. Assumptions and inputs for the analyses at 2957 MWt are described in Reference 14, and include the effects of evaporative cooling and refuel floor conditions of 100°F and

100% humidity. Administrative controls will be procedurally implemented to ensure compliance with the analysis assumptions described above throughout the offload.

For planned refueling conditions that exceed the evaluated heat loads from Reference 14, such as a planned Full Core Discharge, Quad Cities will perform a cycle-specific analysis of pool cooling capability. The results of this analysis will ensure that the Normal Core Discharge acceptance limit of 140°F assuming a single failure of a cooling pump will be met.

The Full Core Discharge condition is a potential refueling activity which may be used to assure an overall increase in plant safety during the refuel outage, such as to allow core internals component repairs or replacements, repair and removal from service of Emergency Core Cooling Systems, or other activities such as vessel service or inspection. Cycle Specific evaluations for a refuel cycle may be performed to determine when the RHR Fuel Pool Cooling Assist mode may be removed from service at a point where the offload fuel's decay heat can be adequately removed by the normal Fuel Pool Cooling system.

9.1.3.2 System Description

System equipment consists of circulating pumps, heat exchangers, filter-demineralizers, surge tanks, skimmers, and associated piping, valves, and instrumentation. All of the major equipment, with the exception of the filter-demineralizers, is located in the reactor building. The filter-demineralizers are located in concrete cells within the radwaste building.

The fuel pool cooling and cleanup system is shown in FSAR Figure 9.1-3 and P&IDs M-38, M-45, M-80, and M-86. Water from the spent fuel pool overflows via scuppers and an adjustable weir into a pair of crosstied skimmer surge tanks. [9.1-31]

The skimmer surge tanks of Units 1 and 2 are crosstied via an equalizing line to help prevent overflow of one tank while the other is low. [9.1-32]

Skimming water from the surface of the spent fuel pool helps maintain water clarity.

Foreign material entering the pool will either sink to the bottom and be removed by a portable vacuum cleaner, or float in the pool and enter the skimmer surge tanks and filtering loop. The pumps take suction from the skimmer surge tanks and circulate the water through the heat exchangers and filter-demineralizers before discharging the water through two lines back to the fuel pool. During refueling operations, the fuel pool cooling system may be aligned to discharge into the reactor refueling cavity through manual isolation valves. The reactor cavity is isolated from the fuel pool cooling return prior to placing a fuel pool demineralizer back online following a backwash and precoat. The reactor cavity may then be valved back into the return, after the return line flow has been visually verified to be clear of any resin or other material.

Antisiphon devices are installed on the return lines approximately one foot below normal water level to prevent any line rupture outside the fuel pool from draining the pool by more than one foot of water. [9.1-33]

There are two filter-demineralizers provided for each unit. Rated at 700 gal/min each, these units are of the pressure-precoat type utilizing powdered ion exchange resins.

Each pump and heat exchanger loop is rated at 700 gal/min and 3.65 x 10^6 Btu/hr (assuming a pool water temperature of 125°F) for a total design flow of 1400 gal/min and heat load of 7.3 x 10^6 Btu/hr. Either one or both loops are used dependent upon the spent fuel heat load in the pool. [9.1-34]

Decay heat is rejected to the reactor building closed cooling water system (RBCCW) via the fuel pool cooling heat exchangers.

The filter elements in the fuel pool cleanup filter/demineralizers are constructed of Type 304 stainless steel wire mesh screen overlaid on a Type 304 stainless steel perforated core. The elements have a minimum design differential pressure of 80 psi, but have been pressure tested to 300 psi without collapse. The elements are undergoing a crushing force since the liquid flows from the outside towards the center of the tube. This type of flow takes advantage of the inherent geometrical strength of the cylindrical element. [9.1-35]

The filter/demineralizer vessels were designed, fabricated, tested and inspected in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. The vessels were designed for a pressure of 200 psi at 200°F, fabricated of SA-285C carbon steel, with an interior lining (8—10 mils) of epoxy phenolic resin, using full penetration welds and 100% radiograph on all circumferential and longitudinal welds. The vessels were hydrotested to 300 psig and carry a "U" stamp in accordance with Section VIII of the ASME code.

Aside from its normal function of cooling and purifying the fuel storage pool water, the system is also used after reactor refueling to drain the dryer-separator storage pit and head cavity. Drain lines allow transport of the water to either the condensate storage tank or to the radwaste disposal system for processing, depending upon water condition. During refueling operations, the fuel pool cooling system can be aligned to take suction directly from the reactor cavity. [9.1-36]

Provisions have been made to crosstie the residual heat removal system to the fuel pool cooling system to handle the maximum heat load as defined in Section 9.1.3.1. There is no permanent connection of this crosstie during normal plant operation. In order to accomplish the paralleling of the two systems, it is necessary to install a removable section of pipe (spool piece) in each crosstie line. If decay heat load in the spent fuel storage pool is too great for the fuel pool cooling heat exchangers or if both fuel pool cooling pumps are inoperative, the RHR system can be aligned to take a suction from the skimmer surge tanks. This can provide an additional spent fuel pool cooling water flow of 3,000 gal/min, i.e., 1,500,000 lbm/hr. In this alignment, the selected loop of RHR would be rendered unavailable for use in any of the safety functions. Refer to Section 5.4.7 for a description of the RHR system fuel pool cooling assist function. [9.1-37]

In addition to the capability for supplemental cooling from RHR, procedural measures are available to reduce the impact from potential fuel pool cooling malfunctions by:
1) contingency procedures to crosstie the opposite unit's fuel pool cooling system, and
2) removal of the canal gates between the two units' pools.

In the event that the reactor water cleanup system is incapable of maintaining the reactor water turbidity within limits during refueling, the fuel pool cooling and cleanup system can also be aligned to discharge, via a manually installed spool piece, into either RHR loop and into the vessel via the low pressure coolant injection (LPCI) valves. [9.1-38]

The skimmer surge tanks are shielded with concrete to give a design radiation level of not more than 5 mR/hr outside the shielded area. [9.1-39]

The fuel pool cooling system is controlled from a radwaste control room panel. A local control panel provides controls for starting and stopping the pumps locally as well as indicating pump discharge pressure, demineralizer flow, and conductivity. The level in the spent fuel pool is monitored by separate narrow range and wide range level instrumentation systems. The narrow range level system provides a high/low alarm in the main control room. The wide range level instrumentation provides local indication, installed on the 639' elevation in the U1 (2) Turbine Building, of the spent fuel pool water level down to just above the top of the fuel racks.

Additionally, the skimmer surge tanks have high and low level alarms in the main control room. Temperature of the spent fuel pool water from the skimmer surge tanks to the fuel pool cooling pumps and temperature of the fuel pool cooling heat exchangers effluent are recorded in the main control room. Each fuel pool pump alarms the control room on low discharge pressure when the pump breaker is closed. Effluent of the fuel pool cleanup filter demineralizers is monitored for conductivity and high conductivity is annunciated in the main control room. The filter/demineralizer differential pressure is monitored and alarms in both the Main Control Room and the radwaste control room.

Low flow through either filter/demineralizer will also actuate an annunciator on the radwaste control room panel as well as the main control room. [9.1-40]

9.1.3.3 Safety Evaluation

The spent fuel pool system is designed to minimize the loss of water from the pool and to prevent the water level from falling below a safe level above the stored fuel. For example all penetrations into the pool, except for valved drains, are located at a height such that there will always be a safe level of water above the fuel. Each pool has a high and low water level monitor. Both monitors actuate local annunciators and the low level monitor also actuates a control room low level annunciator. In the event makeup water is needed, two sources are available, namely, the condensate storage tanks and the fire water system. Within a few minutes approximately 550 gal/min of condensate water can be delivered to the pools via the condensate transfer pumps and skimmer surge tanks. Secondly, as much as 1,000 gal/min of condensate storage tank water can be supplied to the pools using the RHR system through the spent fuel pool cooling system. Three hours or more would be required to install the spool piece. [9.1-41]

In the event that the above identified sources of water become unavailable, the fire system hoses are capable of providing makeup water from the river within approximately 30 minutes. The fire protection water supply system can provide water to the pool far in excess of any reasonable need.

Using a conservative thermal hydraulic circulation model of pool water flowing down along the walls, laterally across the pool floor in the water plenum and up through the stored fuel assemblies, the maximum calculated water temperature at the outlet of the fuel assemblies was shown not to exceed 167°F. The saturation temperature at this point is 240°F. Due to the margin between these two temperatures, nucleate boiling will not occur.

The minimum time before boiling occurs and the maximum boil-off rate were established assuming that:

1. The heatup follows a full core discharge in Unit 2 storage pool (i.e., the pool with the smaller water inventory of 44,471 ft^3 of water);

2. The pool water bulk temperature is at its maximum temperature of 150°F;

3. There is exchange of water between Pool 1 and Pool 2;

4. All pool cooling is lost; and

5. No credit is taken for heat lost to the pool walls and floor.

Under the above conditions about 13.5 hours would elapse before bulk boiling would occur. The maximum boiloff rate would be 78.5 gal/min.

The minimum time to boil and the maximum boil off rate are calculated for each refuel outage based on actual heat load for the proposed offload rate. The calculations are performed utilizing operational temperature limits and conservative values of heat transfer to fuel pool structures. The calculations for each outage demonstrate that the acceptance limits are satisfied.

Based on the above, the available sources of makeup water are adequate, the time required to activate the makeup system is sufficiently less than the time required to reach boiling, and the makeup rates from both makeup sources exceed the boil off rate.

Pool water purity is monitored by a continuous conductivity meter installed on the inlet to the fuel pool demineralizer, and by periodic grab samples for laboratory analysis. Fuel pool chemistry limits are maintained within EPRI BWR Water Chemistry Guidelines. Fuel pool radioactivity analysis is performed in accordance with company chemistry procedures.

The criterion for a demineralizer backwash and precoat is a consistent excursion from the chemistry limits, or high differential pressure across the demineralizer.

The NRC has evaluated the fuel pool cleanup system and has concluded that it: [9.1-42]

A. Provides the capability and capacity of removing radioactive materials, corrosion products, and impurities from the pool and thus meets the requirements of General Design Criterion 61 in Appendix A of 10 CFR Part 50 as it relates to appropriate systems to fuel storage;

B. Is capable of reducing occupational exposures to radiation by removing radioactive products from the pool water, and thus meets the requirements of Section 20.1(c) of 10 CFR Part 20, as it relates to maintaining radiation exposures as low as is reasonably achievable; (Note that 10 CFR 50 Appendix I superseded the ALARA requirements of 10 CFR 20.1[C].)

C. Confines radioactive materials in the pool water into the filters and demineralizers, and thus meets Regulatory Position C.2.f(2) of Regulatory Guide 8.8, as it relates to reducing the spread of contaminants from the source; and

D. Removes suspended impurities from pool water by filters, and thus meets Regulatory Position C.2.f(3) of Regulatory Guide 8.8, as it relates to removing crud from fluids through physical action.

9.1.4 Fuel Handling System

9.1.4.1 Design Bases

The design objective of the fuel handling equipment system is to provide equipment for handling both new and irradiated fuel. To achieve this objective the fuel handling equipment is designed to handle fuel assemblies and other reactor components of the size and weight given in Chapter 4.

The reactor building cranes were designed such that all crane parts are equal to, or exceed design criteria as established by Crane Manufacturers Association of America (CMAA) Specification 70, and are compatible with the requirements of the Occupational Safety and Health Act of 1970 and as amended in 1971, as well as ANSI B30.2.0. [9.1-43]

The bridge rail classification is non-safety-related, seismic category I. The refueling bridge rails were constructed and installed in accordance with ASME II and ASME IX. (The mast and grapple are non-safety-related.) The refueling bridge structure is classified as safety-related and is capable of performing its intended function and sustaining an SSE seismic event without failure. The criteria for the seismic design of the refuel bridge structure is delineated in PAR Systems Report TR-01607-03 (Quad Cities Refueling Platform Finite Element Seismic Analysis).

9.1.4.2 System Description

The major components of this system for each unit are the refueling platform and the reactor building overhead crane. Underwater vacuum-cleaning equipment is available for removal of dirt and small particles from the pool and a variety of tools for remote handling of fuel and reactor internals and flow channel exchange are provided. See Section 1.2 for a complete layout of the operating floor.

9.1.4.2.1 Refueling Platform

Each unit is provided with a refueling platform, each equipped with a refueling grapple and two 1/2-ton auxiliary hoists. Either of these hoists can be positioned for servicing the reactor cavity or the fuel storage pool.

The refueling platform equipment assembly consists of the refueling platform, fuel grapple, and associated equipment. The refueling platform equipment assembly provides a rigid superstructure which moves on parallel tracks to the location of components either in the spent fuel pool or the reactor well. Using the fuel grapple or designated accessories, a component can be grappled and transported to a storage or installation position. [9.1-44]

The refueling platform consists of a track-mounted bridge which includes an electric motor drive and the controls, instrumentation, and service facilities required to support the operation of the fuel grapple or the handling equipment used at the auxiliary hoists. The refueling platform bridge includes a walkway, railings, and a trolley-mounted control cab located on the forward (fuel pool) side, a main grapple hoist, the adjacent frame mounted

auxiliary hoist, a reverse (reactor side) mounted monorail auxiliary hoist, a hinged jib arm power winch, and the reels, drives, pulleys, and sheaves required for the hoist cables and the service air lines from the self contained, refueling platform mounted air compressor. Service connections include power and communication receptacles. Bridge motion is in the "x" (north-south) direction. Trolley motion is in the "y" (east-west) direction. Bridge and trolley motion controls are provided for jogging, fixed speed and variable speed operation. The jogging control can be used to reposition either the bridge or trolley at 2 ft/min. The fixed speed control is preset at 10 ft/min. The variable speed control permits operation up to 50 ft/min.

9.1.4.2.1.1 Main Hoist

The main hoist is attached to the trolley and is positioned horizontally by the bridge and trolley motion controls. The fuel grapple consists of a mast and head assembly, and accessories. The sectional, telescopic mast is gimbal mounted to a bearing and hanger assembly installed in the upper floor of the control cab trolley, and suspended through the slot, thus providing for lateral (y-axis) movement. The primary equipment controls, except for the monorail auxiliary hoist, are mounted to the tower section in the operator's cab. The position of the main fuel grapple is measured by machine-mounted transducers and digitally displayed to the operator. To prevent raising the mast to an overhoist position, prohibitive interlocks are established on the mast. Two lever-actuated limit switches are installed on the upper mast section. One of these switches is the normal-up limit and the other the overhoist limit. The grapple normal up limit may be overridden to allow raising the hoist approximately two additional feet to the overhoist limit. A mechanical stop at the top of the mast provides a hard-stop capability. The mast is powered from the main hoist motor assembly. Grapple vertical movement is controlled either by a jog or variable speed circuit. Jogging operates the hoist at a preset speed equal to or less than 4 ft/min. The variable speed controller permits operation up to 40 ft/min.

The main hoist drive is mounted on a base located above the operator cab but below the main trolley upper deck (Figure 9.1-14). In addition to the motor brake, a second safety brake is provided. The cable drum is reeved for two cables, single-layered, for attachment to the grapple; the two-cable hoist is provided for safety, as either cable will carry the full grapple and fuel load.

The main hoist reduction gearbox has the same manual operation capability as the bridge and trolley drive system.

The hook assembly at the end of the telescoping mast includes counteracting primary and secondary hooks integrated to double-latch the fuel bundle bail from both sides (Figure 9.1-15). The two hooks are pinned between the parallel side plates which are provided at the lower, or grappling, end with a head guide. Two switches are mounted on the outside of one of the two parallel side plates. One switch signals the closed condition (air valve solenoid de-energized). The second signals the open position. The circuitry requires the grapple to be fully engaged when a load is on the hoist before it will permit the main hoist to be raised. If the hoist is to be operated and no load is indicated, the grapple must indicate open or closed. Each hook is provided with an eye-lug on its spine for manual operation by means of the actuator pole and J-hook attachment.

9.1.4.2.1.2 Auxiliary Hoists

There are two auxiliary hoists on the refueling platform. The first, known as the frame-mounted hoist, is mounted on the main trolley along with the main fuel hoist. The second, known as the monorail auxiliary hoist, is mounted on its own trolley which travels the length of the platform and works over the side of the platform opposite the main and frame-mounted hoists.

The hoist cable has a travel of approximately 90 feet. The hoist has a 1000-pound load interlock on raising. Control is a dual-speed, momentary-contact control at 10 and 30 ft/min. The raising motion of the hoist is blocked by a drum revolution counter switch at a point about 8 feet below the bridge rails. Raising the hoist above that point can only be accomplished by simultaneously pushing the HOIST RAISE and the RAISE OVERRIDE pushbuttons.

The hoist raising motion is also blocked by an adjustable jamming button, which is a cylinder-shaped weight with tapered ends, which is bolted onto the hoist cable. It is designed to lift a hairpin limit switch mounted alongside the cable, on the underside of the trolley upper deckplate. In the event the hairpin limit switch does not block the raising of the hoist electrically, the jamming button will mechanically jam the hoist and stall the motor.

The hoist lowering motion is blocked at a point about 85 feet below the personnel walkway handrail by the drum revolution counter switch. The hoist is also supplied with dual air hoses with a spring motor take-up reel to follow the hoist cable up and down under tension.

The monorail hoist is mounted on the monorail trolley which traverses on a rail which is attached to the backside of the upper walkway. It is operated from the personnel walkway by means of a control pendant suspended from the monorail hoist trolley. Its line of traverse is parallel to the personnel walkway, opposite the operators cab.

The monorail hoist moves left and right alongside the personnel walkway at 30 ft/min controlled by two single-speed, momentary-contact pushbuttons. The other functions and controls are identical to those of the frame mounted hoist.

9.1.4.2.1.3 Refueling Platform Instrumentation and Control

Control of the refueling bridge and hoists can be attained at only one of the three control stations at any one time. Which station is controlling is selected at the main hoist operator's console. Platform control can be from either the main console, the frame mounted auxiliary control pendant or the monorail auxiliary control pendant. The refueling platform can also be moved manually by use of handwheels on the bridge. [9.1-45]

The main hoist on the refueling bridge uses an electronic load weighing system as shown in Figure 9.1-14. The load cell supplies a variable output signal proportional to the hoist load to the electronic weighing panel located in the hoist power panel. The electronic weighing panel processes the signal and is adjusted to provide hoist loaded indication for the rod block interlock and bridge reverse motion block, hoist jam and slack cable indication. The electronic weighing panel also provides the input signal to the operator's hoist load readout.

The monorail hoist and frame-mounted hoist use electronic load cells, similar to the main hoist, for all load weighing functions.

The main hoist grapple position in the horizontal and vertical planes are displayed on three digital readouts:

1. Bridge position — Provides X-X axis (north-south) position.
2. Trolley position — Provides Y-Y axis (east-west) position.
3. Hoist position — Provides Z-Z axis (up and down) position. This indication is used to verify proper fuel bundle/blade guide seating prior to attempting to release the fuel bundle/blade guide.

The bridge and trolley digital readouts are designed to provide reactor core coordinates to the platform operator.

9.1.4.2.2 Reactor Building Overhead Crane

The operating floor is serviced by the reactor building crane, which is shared by both units and is equipped with a 125-ton main hoist and a 9-ton auxiliary hoist. These hoists can reach any major equipment storage area on the operating floor. [9.1-46]

The overhead crane handling system consists of an overhead, bridge-type crane, spent fuel cask lifting devices, and controls (Figure 9.1-16). The overhead crane handling system is used for lifting and transporting the spent fuel shipping cask between the spent fuel pool and the cask decontamination/shipping area and other equipment and reactor components accessible from the refueling floor. The overhead crane is located in the reactor building in a controlled environment. The crane hoist system consists of a dual load path through the hoist gear train, the reeving system, and the hoist load block along with restraints at critical points to provide load retention and minimization of uncontrolled motions of the load in the event of failure of any single hoist component. Redundancy has also been designed into the hoist and trolley brakes, the spent fuel cask lifting devices, and crane control components. [9.1-47]

Both the bridge and trolley of the crane meet the Crane Manufacturers Association of America's (CMAA) fatigue loading requirements. These requirements are stated in Table 3.3.3.1.3-1 on page 15 of CMAA Specification No. 70. The service classification for this crane is class A1 which is designed for 100,000 loading cycles. The weldments fall into categories B and C which permit a stress range of 28,000-33,000 psi. [9.1-48]

The crane is classified as Safety Class II equipment and is not seismically qualified.

The main and auxiliary hoists have power control braking as well as two holding brakes. The two holding brakes provided on each hoist are dc magnet-operated electric shoe-type each with a maximum torque rating of 100% of motor torque. The brakes are applied whenever the dc solenoids are de-energized. One dc brake is provided to stop the bridge when de-energized. A manually operated hydraulic brake is also capable of stopping the bridge. [9.1-49]

Spring bumpers effective for both directions of travel are provided on the outboard ends of the bridge trucks. Crane runway stops with four, spring-type trolley bumpers are mounted on runway girders at the ends of the runway rails. The reactor building crane has stops which hook under both the bridge and trolley rails to prevent derailment. The stops also would prevent the reactor building crane trolley from falling into the fuel pool.

The reactor building crane is provided with three remote emergency shutdown switches. Two of these switches are located on the west reactor building wall (690 ft. 6 in. Elevation). The third switch is located on the east stairway enclosure. When any of these switches are pressed, power to the crane is disconnected. [9.1-50]

A cable train equalizer feature guards against lifting loads that are not positioned directly beneath the main hook or when the center of load is off balance. If, during crane operation, the respective lengths of the redundant cable trains become excessively different, the equalizer circuit will disable all crane functions and activate a rotating red light. Following such a trip, the bridge, trolley and main hoist lower (slow speed only) functions may be restored by operating the EQUALIZER BYPASS keyswitch located in the cab.

The main hoist and auxiliary hoist each have two upper limit switches for the lifting circuit and one limit switch for the lowering circuit which inhibit the operation of the hoist in either direction when the upper or lower limit is reached. [9.1-51]

A digital-type weight indicator for the main hoist is provided. The main hoist load limit is set manually on the unit to control output contacts. When a load being lifted reaches the load limit setpoint, the output contacts will operate to stop the upward motion of the main hoist and activate a strobe light on the trolley. The main hoist may be lowered to remove the load. This will re-enable the main hoist raise function and de-activate the strobe light.

Limit switches are provided for both bridge and trolley forward and reverse directions of travel. When the limits are reached, the limit switches de-energize the control circuits. These limit switches restrict bridge and trolley to movement in a fixed path while carrying a critical load.

A primary upper limit switch and one redundant upper limit switch is provided for the main hoist. These switches are used to restrict lifting to a predetermined limit in the crane's restricted mode.

The crane is also interlocked with a local radiation monitor. A radiation monitor reading of less than 0.1 mR/hr will give a low radiation alarm indicating equipment malfunction. This will actuate an interlock which prevents further upward movement of the hoist. A radiation monitor reading of 15 mR/hr or greater will give a high radiation alarm and actuates an interlock which prevents further upward hoisting movement. This will prevent upward hoisting movement if a highly radioactive component is lifted too close to the surface of the pool water. [9.1-52]

This interlock may be bypassed via a keylock switch in the crane cab. In the bypass position, movement of a high radiation load after it had stopped the crane is permitted. The local radiation monitor continues to provide a reading with this keylock in bypass.
[9.1-53]

The crane can be operated in either a "normal" or "restricted" mode. In the "restricted" mode the crane movement is restricted by a network of limit switches that ensure the crane remains within a predefined pathway. In the "normal" mode the pathway limit switches are bypassed. Fuel cask handling with the bottom of the cask above the 623-foot level of the reactor building is considered a "Restricted Load" and must be performed in the restricted mode. [9.1-54]

Fuel cask handling in other than restricted mode is permitted only in emergency or equipment failure situations and to the extent necessary to move the cask to the closest acceptable stable location.

Operation with a failed controlled area limit switch is permissible for 48 hours providing an operator is on the refueling floor to assure the crane is operated within the restricted zone painted on the floor. [9.1-55]

A RESTRICTED MODE/NORMAL MODE key selector switch activates the restricted pathway limit switches and the main hoist restricted mode upper limit switch. The main hoist must be centered over the pathway when the restricted mode is selected. Once on the pathway the main hoist must also be raised to engage the restricted mode upper limit switch before the bridge or trolley will move. The restricted mode upper limit switch must be adjusted so that the critical load (spent fuel cask) will be lifted 9 inches above the refuel floor. This adjustment will depend on the height of spent fuel cask to be lifted. [9.1-56]

A brief description of the mode of operation of the crane while carrying a restricted load is given as follows:

For carrying the restricted load, the RESTRICTED MODE/NORMAL MODE selector switch should be turned to restricted mode. This disables the main hoist fast speed circuitry and sets the speeds for the main hoist, bridge and trolley to their respective "slow" speeds. The restricted load will be lifted by the main hoist motor to the set limit. The two main hoist restricted area upper limit switches will open and will prevent the critical load from being lifted above the set limit. Unless both the limit switches are open, neither the bridge nor the trolley can be moved. Either one of the two limit switches failing to function properly would prevent movement of the bridge or trolley.

Limit switches on the hoist equalizer bar will shut off power to the bridge, trolley, and the hoist when they open. Any one of the two limit switches will open the power circuit for the crane.

The brakes for the hoist will set for any one of the following conditions and keep the load in a safe position:

A. Incoming power supply failure,

B. Either one of the two limit switches on the equalizer bar open,

C. Main hoist restricted area upper and final upper limit switches open after reaching the set limit,

D. Main hoist weight upper limit switch,

E. Main hoist area upper limit switch,

F. High load contact of the digital indicator control panel,

G. Main and auxiliary hoist motor overload trip, and

H. Main and auxiliary hoist motor overspeed trip.

In the restricted mode of operation, the bridge and trolley can be operated only in the restricted path. The bridge and travel trolley are controlled by the limit switches. Administrative control is exercised by the key-operated restricted mode switch and the key-operated bypass switch for the equalizer bar limit switches. The circuitry is designed such that during restricted mode the bridge and trolley cannot be operated simultaneously.

The bridge and trolley brakes will set for any one of the following conditions and keep the critical load in a safe position:

A. Incoming power supply failure,

B. Either one of the two limit switches on the equalizer bar open,

C. Main hoist restricted area upper and final upper limit switches open after reaching the set limit,

D. Field loss relay trip,

E. Instantaneous overcurrent relay trip,

F. Bridge or trolley forward/reverse limit switch open,

G. Bridge or trolley motor overload trip, and

H. Bridge or trolley motor overspeed trip.

9.1.4.2.3 Fuel Handling Operations

A variety of specialized tools and servicing equipment are utilized for fuel handling. Table 9.1-2, Tools and Servicing Equipment, is a typical list of equipment used at Quad Cities. Use of this equipment for fuel handling is outlined below. New fuel is brought into the reactor building through the equipment entrance. A jib crane is provided for handling new fuel after it is brought to the refuel floor. The main crane auxiliary hoist is used for removal of new fuel from trucks and for movement of the multi-assembly transfer basket which is capable of handling eight assemblies. The new fuel is hoisted to the upper floor for storage utilizing the reactor building crane. The new fuel bundles are removed from the inner container, inspected in the new fuel inspection stand, channeled, and stored in the new fuel storage racks. New fuel may be stored in the spent fuel pool. [9.1-57]

Initial plant startup preoperational tests were conducted to verify proper installation of various plant components used for fuel handling operations. Prior to initial reactor fueling, the fuel storage pool, reactor head cavity, and reactor internals storage pit were filled with water and checked for leakage. Dummy fuel assemblies were run through a complete cycle from the new fuel storage vault to the fuel storage pool.

Prior to fuel handling, all hoists, cranes and tools and the refueling interlocks are inspected and tested to assure safe operation. In preparation for refueling, the concrete shield plugs in the reactor head cavity and the transfer canals are removed by the reactor building crane. The drywell head, head insulation, and reactor vessel head are removed, using the same crane. The steam dryer assembly is placed in the dryer-separator storage pool. The steam separator assembly is then unbolted from the core structure.

Demineralized condensate is pumped into the reactor until the head cavity and the dryer-separator storage pit are flooded to the normal level of the fuel storage pool. The steam separator assembly is transferred to the dryer-separator storage pit. The fuel storage pool gates are removed.

Spent fuel is removed from the reactor and placed in racks in the fuel storage pool using the main fuel grapple attached to the refueling platform. The same equipment is used to transfer the new fuel from the fuel storage pool to the reactor. Channeling of unirradiated fuel is normally performed using the new fuel inspection stand, but may be done using the fuel prep machines. Channeling and dechanneling of irradiated fuel is performed using the fuel prep machines. The rack in which spent fuel assemblies are placed is designed and arranged to ensure sub-criticality in the pool.

When reactor refueling is complete, the steam separator assembly is returned to the reactor. The fuel storage pool gates are set back in place. The water in the dryer-separator storage pit and reactor head cavity is pumped down to the reactor vessel flange. The steam dryer assembly, reactor vessel head, insulation, drywell head, and concrete shield blocks are then replaced.

After refueling, the flow channels may be removed from the fuel underwater, and the spent-fuel bundles are temporarily stored in fuel storage pool racks. The used flow channels may be stored in the fuel storage pool racks or may be installed onto new fuel bundles, but normally are stored in the fuel pool control rod storage racks. If the station needs to ship spent fuel, a spent-fuel shipping cask is set into the pool using the reactor building crane. The spent fuel is loaded into the cask under water. The cask is closed and removed from the pool. After decontamination, the spent fuel shipping cask is lowered by the reactor building crane to a truck or railway car in the equipment access area.

There are two modes of travel for the reactor building crane, normal and restricted. The spent fuel shipping cask is moved in the restricted mode following a predefined route. Referring to Section 1.2, general arrangement drawing M-7, the route to be taken is as follows: [9.1-58]

1. From Unit 1 equipment hatch (690 ft. 6 in. Elevation) the cask will be positioned on the decontamination pad.

2. From the decontamination pad the cask will be moved to the southeast corner of the spent fuel pool where it will be lowered into the pool for loading.

3. The loaded cask will take the reverse route back to the decontamination pad.

4. From the decontamination pad the cask will be moved to the equipment hatch and lowered to ground elevation.

9.1.4.3 Safety Evaluation

9.1.4.3.1 Refueling Platform

Protective interlocks with the refueling platform prevent handling of fuel over the reactor when a control rod is withdrawn and another set of interlocks prevents control rod withdrawal when fuel is being handled over the reactor. Circuitry is provided which senses the following conditions: [9.1-59]

A. All control rods are inserted;

B. Refueling platform is positioned near or over the reactor vessel;

C. Refueling platform hoists are loaded (fuel grapple, frame-mounted hoist; and monorail hoist), and

D. Fuel grapple is not full up.

The refueling interlocks, in combination with core nuclear design and refueling procedures, limit the probability of an inadvertent reactor criticality.

The nuclear characteristics of the core assure that the reactor is subcritical even when the highest worth control rod is fully withdrawn. Refueling procedures are written to avoid situations in which inadvertent criticality is possible. The combination of refueling interlocks for control rods and the refueling platform provide redundant methods of preventing inadvertent criticality if procedural violations should occur. The interlocks to the reactor manual control system (RMCS) causing control rod blocks are discussed in more detail in Section 7.7.

A limit switch on the refueling platform hoists interrupts power to the hoists when active fuel is raised to a point 8.5 feet below the surface of the pool water. This primary stop position is called the "normal up" position and it ensures an adequate depth of water shielding during normal fuel movement. A pushbutton is provided to manually override the "normal up" position limit switch and allows raising the hoist until a second limit switch actuates. The operator must continuously depress the override pushbutton while actuating the hoist raise lever to raise the hoist up to the second limit switch. This second limit switch is called the "overhoist" limit switch and is located 16 inches above the "normal up" limit switch and three inches below the point where the telescopic mast assembly will mechanically jam. The mechanical jam prevents raising active fuel to a point less than 6.75 feet below the normal water level. The potential exists for the dose rate to exceed 100 mR/hr when irradiated fuel is raised above the "normal up" position and this situation is therefore controlled by procedure. Spent fuel will not be handled with an inadequate depth of water shielding. [9.1-60]

The brakes on all equipment lock upon loss of power. Should an emergency stop occur during lowering of any of the three hoists, the emergency brake of that hoist will set without delay and take the hoist load on its ratchet-pawl arrangement. [9.1-61]

The main hoist is rigged with two cables for safety as either cable will carry the full grapple and fuel load. [9.1-62]

Positive indication of closure of the grapple hook is provided to reduce the probability that an improperly loaded bundle will be lifted and possibly dropped. [9.1-63]

An additional electrical interlock prevents raising the main hoist while the hoist is loaded unless the grapple is fully closed and in the engaged position. [9.1-64]

To prevent accidental damage to fuel or fuel handling equipment, a slack cable interlock prevents lowering the refueling platform main hoist with less than a nominal load on the cable. Should the hoist jam, further upward-motion is blocked by a load cell force switch which operates at the maximum permissible load. [9.1-65]

9.1.4.3.2 Reactor Building Overhead Crane

The reactor building crane is designated as a single failure proof crane for 110-ton loads. Within the dual load path, the design criteria are such that all dual elements comply with the CMAA Specification No. 70 for allowable stresses, except for the hoisting rope which is governed by more stringent job specification criteria. All single element components, within the load path, have been designed to a minimum safety factor of 7.5 based on the ultimate strength of the material. For component failure design margins, refer to calculation C10780.26. [9.1-66]

All analyses performed relative to the overhead crane handling system loads have been based on the National Lead 10/24 spent fuel shipping cask which weighs 100 tons (Figure 9.1-17). The HI-TRAC 100D transfer cask will be used during Dry Cask Storage (DCS) activities. A fully loaded HI-TRAC 100D weighs a maximum of 100 tons. If larger casks are used, additional analyses will be required to assure safety margins are maintained.

Cask handling is performed in accordance with the heavy loads program. During cask handling maneuvers above the 623-foot elevation, the reactor building overhead crane is operated in the restricted mode of operation. These administrative controls and installed limit switches restrict the path of travel of the crane and fuel cask to a specific controlled area. The controls are intended to assure that a controlled path is followed in moving a cask between the shipping area and the spent fuel pool. Although the fuel cask may extend slightly over the spent fuel pool or new fuel vault during transfer operations, the restricted mode path limits the distance between the cask (center of gravity) and spent fuel pool/new fuel vault to prevent a fuel cask from being lowered onto fuel. Furthermore, a postulated cask drop is not considered credible considering the single-failure-proof design of the reactor building overhead crane (see Section 15.7.3).

Station procedures prohibit movement of heavy loads over the spent fuel storage pools or open reactor cavity except under special procedures that have been reviewed and approved by an on-site designated committee. [9.1-67]

In addition, procedural controls have been established which suspend crane operations under the following conditions. [9.1-67a]

- When irradiated fuel assemblies are in the spent fuel storage pool, the storage pool level must be maintained within the Technical Specification limit or crane operations with loads in the spent fuel storage pool area will be suspended after placing the crane load in a safe condition.

- When a unit is in MODES 4, 5 or when handling irradiated fuel in the secondary containment, the Technical Specification AC Source requirements must be met or crane operation over the spent fuel storage will be suspended if fuel assemblies are stored in the pool.

The crane reeving system does not meet the recommended criteria of Branch Technical Position APCSB 9-1, for wire rope safety factors and fleet angles. The purpose of these criteria is to assure a design which minimizes wire rope stress wear and thereby provides maximum assurance of crane safety under all operating and maintenance conditions. [9.1-68]

Because the crane reeving system does not meet these recommended criteria, there is a possibility of an accelerated rate of wire rope wear occurring. Accordingly, to compensate in these design areas, a specific program of wire rope visual inspection and replacement is in place. The inspection and replacement program assures that the entire length of the wire rope will be maintained as close as practicable to original design safety factors at all times. This inspection and replacement program provides an equivalent level of protection to the methods suggested in our wire rope safety and crane fleet angle criteria and will assure that accelerated wire rope wear will be detected before crane use.[4]

"Two blocking" is an inadvertently continued hoist which brings the load and head block assemblies into physical contact, thereby preventing further movement of the load block and creating shock loads to the rope and reeving system. To provide adequate protection against "two blocking" in the event of a fused contactor in the main hoist drive, two contacts of the mechanically operated Paddle Upper Power Limit Switch (PUPLS) are wired in series in the main hoist drive emergency stop circuit. The opening of either PUPLS contact will break the main hoist drive emergency stop circuit. The main hoist drive will interrupt power to the main hoist motor by stopping the firing of the drive and will set the holding brakes prior to "two blocking."

The reactor building refueling floor has been designed for a live load of 1000 psf. The entire reactor building refueling floor (with the exception of the fuel pool and open reactor cavity) is considered a safe load path zone. [9.1-69]

A 9-ton load drop has been analyzed and the results show that the refueling floor can survive a drop from 7 feet without scabbing damage. Procedures limit the 9-ton lift height to a maximum of 7 feet. Existing procedural controls limit both the height of a lift to clear obstacles and require the use of the most direct path to laydown areas.

The reactor building overhead crane meets the single-failure criteria stated in NUREG-0612 for heavy loads for 110 tons. As required by CMAA-70, the maximum crane load weight plus the weight of the bottom block, divided by the number of parts of rope does not exceed 20% of the manufacturer's published breaking strength.

A detailed analysis of the possibility of horizontal displacement of the cask in the event one of the redundant rope trains fails has been conducted. It has been confirmed that the horizontal load displacement will not exceed 2 1/2 inches throughout the critical elevations of lift. At the high point of the lift, with the cask above the operating floor, the static displacement of the load is approximately 1/2-inch with a total static plus dynamic displacement of approximately 1 inch. The total horizontal displacement of the load when the cask is submerged in the fuel pool is approximately 2 1/2 inches. A larger total horizontal displacement, approximately 9 inches, can occur with the load at its lowest elevation, that is with the load at the grade elevations. The equipment hatchway has a minimum 20-foot 1-inch square opening. (Figure 9.1-18) Local protrusions of ductwork along the vertical path of the cask through the hatchway reduce the cross section to approximately 19 feet 6 inches. Since the path of the cask is controlled by limit switches which restrict the position of the cask in the hatchway, lateral clearances of 4 feet are available. [9.1-70]

If a tornado warning is received during refueling operations, new fuel assemblies in the process of being inspected will be placed in the new fuel storage vault and the concrete cover will be installed. All fuel movements in the storage pools and reactor cavities will be terminated and any fuel in process of being transferred will be placed in the pool storage racks. No fuel assemblies will be left on the hooks of the jib cranes or the refueling grapple cranes. Small tools will be secured in their storage position. [9.1-71]

Spent fuel will be protected in the event of a tornado warning by moving the reactor building crane to either the north or south end of the building against the rail stops and securing it in this position. The refueling platform grapple crane will be moved over the reactor cavity, with the grapple in the full up position, and then shutdown. This will deter falling objects from entering the reactor. [9.1-72]

9.1.4.4 Inspection and Testing Requirements

Surveillance requirements are summarized below.

9.1.4.4.1 Refueling Platform

The refueling interlocks are functionally tested prior to any fuel handling with the head off the reactor vessel. They are tested periodically thereafter until the refueling interlocks are no longer required.[5] The refueling interlocks are tested following any repair work or maintenance associated with the interlocks.

9.1.4.4.2 Reactor Building Overhead Crane

To minimize the potential of a cask dropping into the fuel storage pool, a detailed procedure of inspection and load testing of the reactor building crane will be performed at the time of a fuel cask transfer. In addition, fuel cask handling will be performed with the reactor building overhead crane in the restricted mode. The restricted mode path limits the distance between the cask (center of gravity) and spent fuel pool/new fuel vault to prevent a fuel cask from being lowered onto fuel. [9.1-73]

Prior to cask lifting operations, a detailed visual inspection is made of all mechanical and electrical components of the crane. Following the visual inspection, an operational test will be conducted with no load on the hook. This test will verify that all controls are operating correctly. Following these tests, a load test will be conducted by raising the fuel cask approximately 1 foot.[4] The prime purpose of this test is to verify that there is no load movement after a fixed period of time. Maximum lifting heights will be set and after confirmation of the operational acceptability of the crane, the fuel cask will be hoisted to the refueling floor and moved over a controlled path to the decontamination pad. From there it will be moved via a controlled pathway to its position in the fuel storage pool.

9.1.5 References

1. Licensing Input on High Density Spent Fuel Racks for Quad Cities Project, TM-600, January 1981.

2. Deleted.

3. Rabinowicz, E., Friction Coefficients of Water Lubrication Stainless Steel for a Spent Fuel Rack Facility, Massachusetts Institute of Technology, November 1976.

4. Quad Cities Technical Specifications, 3.10/4.10 Refueling, Surveillance Specifications F with associated Bases.

5. Quad Cities Technical Specifications, 3.9.1 Refueling Equipment Interlocks.

6. Deleted.

7. Deleted.

8. Licensing Report on High-Density Spent Fuel Racks for Quad Cities Units 1 and 2, Docket Nos. 50-254, 50-265, June 1981.

9. GE SIL No. 152, "Criticality Margins for Storage of New Fuel," dated March 31, 1976.

10. Deleted.

11. LaSalle, Quad Cities, Byron and Braidwood, J. Hosmer letter to NRC dated November 6, 1996 – Response to NRC GL 96-04 – Boraflex Degradation in Spent Fuel Pool Racks.

12. Design Analysis HI-2125245, Revision 6, “Licensing Report for Quad Cities Criticality Analysis for Inserts”, November 2016.

13. Deleted.

14. GE-NE-A22-00103-49-02, Rev. 1, Project Task Report Dresden and Quad Cities Extended Power Uprate, Task T0603, Quad Cities – Fuel Pool Cooling and Cleanup System, March 2001.

15. Deleted.

16. Deleted.

17. Letter from B. Mozafari (US NRC) to M. Pacillio (Exelon), “Quad Cities Nuclear Power Station, Units 1 and 2 – Issuance of Amendments Regarding NETCO Inserts,” dated December 31, 2014.

18. QDC-0000-N-2129, Revision 0, “New Fuel Vault Criticality Analysis for ATRIUM 10XM Fuel”, September 2014.

Table 9.1-1

HIGH DENSITY FUEL RACKS MODULE DATA

TYPE	QUANTITY	NUMBER OF CELLS/MODULE	ARRAY SIZE
A	8	210	14 x 15
B	6	196	14 x 14
C	8	182	14 x 13
D	4	135	9 x 15
E	3	224	14 x 16
F	2	256	16 x 16
G	1	192	12 x 16
H	4	195	13 x 15
J	1	208	13 x 16
K	2	169	13 x 13

Table 9.1-2

TOOLS AND SERVICING EQUIPMENT
(TYPICAL)

FUEL SERVICING EQUIPMENT

Fuel preparation machines
New fuel inspection stand
Channel bolt wrenches
Channel handling tool
Fuel pool sipper
Channel gauging fixture
General purpose grapples
Fuel inspection fixture
Channel transfer grapple
Channel storage adapter
Westinghouse SVEA Optima2 Receipt Tooling

IN-VESSEL SERVICING EQUIPMENT

Instrument strongback
Control rod grapple
Control rod guide tube grapple
Fuel support grapple
Grid guide
Control rod latch tool
Instrument handling tool
Control rod guide tube seal
Incore guide tube seals
Blade guides
Fuel bundle sampler
Peripheral orifice grapple
Jet pump service tools
Peripheral fuel support plug
Peripheral orifice holder
360 Degree Work Platform

SERVICING AIDS

Pool tool accessories
Actuating poles
General area underwater lights
Local area underwater lights
Drop lights
Underwater TV monitoring
Underwater vacuum cleaner
Viewing aids
Light support brackets
Incore detector cutter
Incore manipulator
Underwater viewing tube

REFUELING EQUIPMENT

Refueling equipment servicing tools
Refueling platform equipment

STORAGE EQUIPMENT

Spent fuel storage racks
NETCO rack inserts
Channel storage racks
Storage racks (control rod/defective fuel)
In-vessel racks
New fuel storage rack
Defective fuel storage containers

NETCO RACK INSERT EQUPIMENT

NETCO rack insert installation tool
NETCO rack insert removal tools (long and short)

Table 9.1-4

LONG-TERM SURVEILLANCE COUPONS
FOR LONG-TERM COUPON SURVEILLANCE PROGRAM OF NETCO RACK INSERTS

Coupon Type	**Number**	**Objective**
General	48	(See Table 9.1-4)
Bend	24	Track effects along bend radii
Galvanic (bi-metallic)	24	Trend galvanic corrosion with 304LSS, Inconel 718 and Zircaloy coupons

Table 9.1-5

LONG-TERM SURVEILLANCE GENERAL AND GALVANIC COUPON CHARACTERIZATION FOR LONG-TERM COUPON SURVEILLANCE PROGRAM OF NETCO RACK INSERTS

Test	Pre-Characterization	Post-Characterization	Acceptance / Rejection Criteria
Visual (high resolution digital photo)	√	√	Evidence of visual indications
Dimension	√	√	Min. thickness: 0.005 inch less than nominal thickness * Length Change: Any change of +/- 0.02 inch * Width Change: Any change of +/- 0.02 inch Thickness Change: Any change of +0.010 inch / - 0.004 inch
Dry Weight	√	√	Any change of +/- 5 percent
Density	√	√	Any change of +/- 5 percent
Areal Density	√	√	Any change of +/- 5 percent
Areal Density	√	√	0.0116 Boron-10 g/cm^2 minimum loading
Acid Cleaning		√	N/A
Weight Loss		√	Any change of +/- 5 percent
Corrosion Rate		√	< 0.05 mil/yr
Microscopy		√ **	At the discretion of the test engineer

* Acceptance criteria for length and width change are for general coupons only.
** At the presence of anomalies

Table 9.1-6

LONG-TERM SURVEILLANCE BEND COUPON CHARACTERIZATION
FOR LONG-TERM COUPON SURVEILLANCE PROGRAM OF NETCO RACK INSERTS

Test	Pre-Characterization	Post-Characterization	Acceptance / Rejection Criteria
Visual (high resolution digital photo)	√	√	Evidence of visual indications
Thickness	√	√	Min. thickness: 0.005 inch less than nominal thickness Thickness Change: Any change of +0.010 inch / - 0.004 inch
Dry Weight	√	√	Any change of +/- 5 percent
Bend Stress	√	√	Change in stress greater than a rate of 50% / 20yrs**
Acid cleaning		√	N/A
Weight Loss		√	Any change of +/- 5 percent
Microscopy		√ *	At the discretion of the test engineer

* At the presence of anomalies
** Stress relaxation rate is not linear. Stress relaxation will be re-evaluated if 50% is exceeded.

Table 9.1-7

FREQUENCY FOR COUPON INSPECTION
FOR LONG-TERM COUPON SURVEILLANCE PROGRAM OF NETCO RACK INSERTS

Coupon Type	First Ten Years	After 10 Years with Acceptable Performance
General	2 coupons every 2 years	2 coupons every 4 years
Bend	1 coupon every 2 years	1 coupon every 4 years
Galvanic Couples		
304L Stainless	1 couple every 6 years	
Zircaloy	1 couple every 6 years	
Inconel 718	1 couple every 6 years	

Table 9.1-8

FREQUENCY FOR FULL INSERT INSPECTION
FOR LONG-TERM FULL RACK INSERT SURVEILLANCE PROGRAM OF NETCO RACK INSERTS

Inspection Type	Qty / Interval	Objective
In-Situ Inspection	2 inserts every 2 years	Visually Monitor for Signs of Degradation
Removal Inspection	1 insert every 10 years	Test for Wear Along Insert Length and Adequate Retention Force

Table 9.1-9

LONG-TERM SURVEILLANCE FULL INSERT REMOVAL INSPECTION CHARACTERIZATION FOR LONG-TERM FULL RACK INSERT SURVEILLANCE PROGRAM OF NETCO RACK INSERTS

Test	Pre-Characterization	Post-Characterization	Acceptance / Rejection Criteria
Visual (high resolution digital photo)	√	√	Evidence of visual indications
Thickness	√	√	Min. thickness: 0.005 inch less than nominal thickness Thickness Change: Any change of +0.010 inch / - 0.004 inch
Retention Force		√	Retention force less than 50 lbf.

9.2 WATER SYSTEMS

The auxiliary water systems for Quad Cities Station include:

A. Residual heat removal (RHR) service water subsystem,

B. Station service water system,

C. Reactor building closed cooling water (RBCCW) system,

D. Demineralized water makeup system,

E. Ultimate heat sink (discharge and intake bay),

F. Condensate storage facilities,

G. Turbine building closed cooling water (TBCCW) system, and

H. Standby coolant supply system.

9.2.1 Residual Heat Removal Service Water Subsystem

The residual heat removal system has three primary modes of operation that satisfy all objectives and bases. These modes are: low pressure coolant injection (LPCI), containment cooling, and reactor shutdown cooling. [9.2-1]

Residual heat removal service water is a subsystem of the RHR system and serves to limit torus water temperature through the RHR containment cooling mode or remove core decay heat through the reactor shutdown cooling mode. The RHR system also provides an auxiliary function during refueling to assist in removal of heat from the spent fuel pool as described in Section 9.1.3.2. This section covers RHR service water subsystem support for the RHR system in primary modes requiring heat removal. Torus water temperature limits are discussed in Sections 6.2.1.3.1 and 6.2.2. Additional RHR system information is found in Sections 5.4.7, 6.2.2, and 6.3.2.

9.2.1.1 Design Bases and Design Features

9.2.1.1.1 Design Bases

The design bases of the RHR service water subsystem are as follows:

A. To support the RHR system in limiting the pressure suppression pool water temperature as stated in Section 6.2.2.1; and [9.2-2]

B. To support the RHR shutdown cooling mode of operation in removing the reactor residual and decay heat as stated in Section 5.4.7.3.2; and [9.2-3]

C. To support the Control Room HVAC Train B in removing heat as stated in Section 6.4.2.2.

9.2.1.1.2 Design Features

The RHR service water system is designed to meet Class I seismic requirements and the piping conforms to USAS specifications. The tube side of the RHR heat exchangers conforms to the requirements of Section VIII of the ASME Boiler and Pressure Vessel Code as well as the code requirements of the State of Illinois and Tubular Exchanger Manufacturers Association (TEMA).

9.2.1.2 System Description

The RHR service water subsystem is an open cooling water system consisting of four RHR service water pumps, associated valves and piping, and the necessary controls and instrumentation for proper system operation. Schematic diagrams of the RHR service water subsystems for Units 1 and 2 are shown in FSAR Figure 9.2-1 and P&IDs M-37 and M-79 respectively. Only the RHR service water subsystem is described in this section. The RHR system is discussed in Section 5.4. [9.2-4]

As shown in FSAR Figure 9.2-1 the RHR service water subsystem is subdivided into two independent loops. Each loop provides cooling water flow to the respective loop of the RHR system and includes a supply header from the crib house, two RHR service water pumps, and associated valves and instrumentation. Each RHR service water pump is a two-stage tandem pump, with one motor driving both pump stages. Both first stage pumps of each loop take a suction from a common header leading from the crib house and discharge to the respective second stage pump suction. A line is tapped off each first stage pump discharge to supply cooling water to the respective RHR service water pump cubicle cooler. [9.2-5]

The second stage pumps for each subsystem discharge to a common header which supplies cooling water to the associated RHR heat exchanger for RHR system cooling.

The RHR service water pumps were sized to assure sufficient cooling for the RHR containment cooling mode of operation. Refer to Table 9.2-1 for RHR service water equipment details. The design requirements for the RHR service water pumps were reassessed as the result of adding additional flow demands on the subsystem after the original design. The RHR service water pump design capability (head versus flow) varies for the different RHR system modes of operation. The functional capability for the RHR service water pump is to provide a minimum pressure at the heat exchanger service water outlet 20 psi greater than the maximum RHR inlet pressure in the containment cooling mode. [9.2-6]

Valving is provided to permit reversal of the service water flow through the RHR heat exchanger thereby backwashing the heat exchanger tubes. [9.2-7]

When service water is flowing, the pressure on the tube (service water) side of the RHR heat exchangers, is maintained above the pressure on the shell side to prevent reactor water leakage into the service water and thereby into the discharge bay. The heat exchanger service water discharge line is provided with a throttleable motor-operated valve used to control subsystem pressure. Downstream of this valve, a common service water discharge header leads to the circulating water discharge flume. [9.2-8]

With the shell side of the RHR heat exchanger constantly pressurized by the emergency core cooling system (ECCS) keep fill system, leakage from the shell side to the tube side is

possible whenever the RHR service water pumps are shutdown. Such an event would be detected upon restart of an RHR service water pump by the service water process radiation monitor which is addressed in Section 9.2.2. The ECCS keep fill system is discussed in Section 6.3.2.1.4. [9.2-9]

The A subsystems for Unit 1 and Unit 2 can be connected by a normally isolated crosstie line. Similarly, the B subsystems can be connected by another normally isolated crosstie line. These lines can be used to supply RHR service water from Unit 1 to 2 and vice-versa. This capability to crosstie Unit 1 and Unit 2 has been taken credit for in the plant's fire protection safe shutdown analysis.

On April 3, 1974 during the first refueling outage for Unit 1, a leak was found in the 16-inch line from the Unit 1 RHR service water pumps to the 1A RHR heat exchanger. The pipe was repaired without loss of the shutdown cooling mode by switching to the B loop of RHR as documented in Special Report No. 13 for Quad Cities Station, "RHR Service Water System Special Report." [9.2-10]

This event recurred on November 21, 1981. A crosstie between the A loops of Unit 1 and Unit 2 was installed to allow the 2A and 2B RHR service water pumps to supply cooling water to either 1A or 2A RHR heat exchangers. In July 1982, an above-ground reroute of the Unit 1 A loop of RHR service water was completed. It is tied into an existing service water line in the RHR vault and the RCIC room. The underground portion is cut and capped and is not available. [9.2-11]

Since then, the B loop of RHR service water has developed similar leaks. A crosstie between the B RHR service water loops of Units 1 and 2 was installed to allow the 1C and 1D RHR service water pumps to supply either the 1B or 2B RHR heat exchangers. An above-ground reroute of the Unit 2 B loop of RHR service water was completed. The underground portion is cut and capped and is not available. [9.2-12]

An above-ground reroute of the Unit 1 B loop, and Unit 2 A loop, of RHR service water has been completed. The original underground piping for each loop, which remains intact and available for use if needed, is isolated by manual isolation valves.

A line originating at each RHR service water pump discharge header supplies cooling water to the respective RHR subsystem pump seal and motor coolers. The discharge from these coolers flows to the respective RHR heat exchanger discharge line. A second line is tapped off each RHR service water pump discharge header to supply cooling water to the control room refrigeration condensing unit. There is only one condensing unit, but any one of the four RHR service water subsystems (two from Unit 1 and two from Unit 2) can supply cooling water to it. [9.2-13]

The RHR service water pumps are located in watertight vaults in the turbine building condensate pump room. Each vault has one vault cooler for each pump in the vault. The cooler starts when its associated pump starts. The coolers are designed to maintain the vault at or below 120°F during pump operation. Cooling water for each cooler is supplied by its associated pump discharge, eliminating the need for an outside water source to the vault. Each vault contains a sump and pump to collect any floor and equipment leakage inside the vault and pump it through three discharge check valves (one inside the vault, remaining two outside) to the service water discharge line. Refer to P&IDs M-22 and M-69, for drawings of the vault sump pumps. Refer to Section 3.4 for a description of the RHR service water pump flood protection. [9.2-14]

Equipment is provided to inject a biocide solution and a corrosion inhibitor into the RHR service water pump suction header in the cribhouse to minimize marine growth and reduce piping corrosion in the RHR service water and diesel generator cooling water systems when they are in service.

9.2.1.3 Safety Evaluation

Residual heat removal service water equipment is designed in accordance with Class I seismic criteria to resist the response motion from a design basis earthquake. The tube side of the RHR heat exchanger is designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII. [9.2-15]

Residual heat removal service water flow to the RHR heat exchangers is not required immediately after a loss-of-coolant accident (LOCA) because heat rejection from the containment is not necessary during the time it takes to flood the reactor. Power for each set of RHR service water pumps normally comes from an auxiliary ac power bus. If the normal power source to this bus is not available, power is available from the standby diesel generator. [9.2-16]

The coolers and cooling water lines for each RHR service water pump vault are designed and constructed to seismic Class I standards. [9.2-17]

9.2.1.4 Testing and Inspection Requirements

A design flow functional test is performed for each RHR service water pump every 3 months during normal plant operation and after pump maintenance. The functional test verifies that the RHRSW pressure at the outlet of the RHR heat exchanger is equal to or greater than 199 psig with all system design flows, including 3500 gpm through the heat exchanger. All other system design flow paths are described in UFSAR Section 9.2.1.2. During this functional test, vibration data are recorded for each pump to enable plant personnel to monitor pump wear and maintain the pumps in proper operating condition. Pump and valve operability testing is performed once every 3 months, and a logic system functional test is performed each refueling outage. [9.2-18]

The RHR service water pump vault sump pump discharge check valves outside the vault are tested each operating cycle to verify integrity. [9.2-19]

Piping and heat exchanger intrusion by bivalves (such as Asiatic Clams and Zebra Mussels) has been identified as a potential hazard to the Quad Cities RHR service water and diesel generator cooling water systems. Quad Cities Station has implemented a program to trend flow blockage characteristics. This information is used to ensure flow blockage will not occur in safety-related systems using river water. The program includes: [9.2-20]

A. Periodic inspection of the intake bays;

B. Periodic flushing of infrequently used or stagnant lines in safety-related service water systems;

C. Annual water and substrate sampling;

D. Periodic testing, inspection and cleaning of safety-related heat exchangers;

E. Periodic inspection of high-flow and low-flow service water piping for corrosion, erosion, silting and biofouling;

F. A long-term program for ultrasonic test examination of cooling water lines associated with safety-related heat exchangers;

G. Corrosion coupons installed in DGCW and RHRSW piping.

This program has been applied to the RHR service water system.

9.2.1.5 System Instrumentation

As shown in P&IDs M-37 and M-79 control room instrumentation for each RHR service water loop includes flow indication to the associated RHR heat exchanger, pressure indication for heat exchanger outlet pressure, and position indication for the throttleable discharge valve of the RHR heat exchanger. [9.2-21]

Differential pressure between the tube side and shell side of the RHR heat exchanger is measured, and on low differential pressure an annunciator is actuated. Temperature of the service water to and from each RHR heat exchanger is recorded and high temperature is annunciated.

Each RHR service water pump vault watertight door has a limit switch which actuates an annunciator whenever the door is open. Each vault contains a level switch which actuates an annunciator on high vault water level. [9.2-22]

Each RHR service water pump is normally controlled by manual switches in the control room, but can also be operated at the breaker using a local control box.

Radiation monitoring of the RHR service water effluent is performed on the station service water common discharge line. This is described in Section 9.2.2.

9.2.2 Station Service Water System

9.2.2.1 Design Bases

The station service water system is a non-safety-related system. The design objective of the station service water system is to provide strained river water for cooling the reactor and turbine building closed cooling water systems, and other building services such as the recirculation pump adjustable speed drive (ASD) coolers, generator stator water coolers, turbine oil coolers, and generator hydrogen coolers. [9.2-23]

The system is available to cool the RBCCW system essential loads under all operating conditions. The cooling water requirement during the shutdown mode represents the most severe condition and is used as the design basis.

9.2.2.2 System Description

Flow diagrams of the station service water system for both units are shown in FSAR Figure 9.2-2 and P&IDs M-22 and M-69. The station service water system consists of a total of five service water pumps which supply service water needs for both units. Each pump is rated at 13,800 gal/min at 210 feet total developed head (TDH). All five pumps take suction from a pit in the crib house filled with river water and discharge into a common header. During normal plant operation, four pumps operate with the fifth in standby. Depending on seasonal temperature extremes or plant heat load requirements, the number of operating pumps may vary. The pumps discharge through three wire mesh strainers each having automatic self-cleaning capability. Provisions have been made for injection of biocide, silt dispersant and corrosion inhibiter solutions into the service water discharge header downstream of the strainers as shown on drawing M-22 and M-69. [9.2-24]

As shown in FSAR Figure 9.2-2, the station service water provides cooling water to the plant heat loads listed in Table 9.2-2, Station Service Water System Loads. [9.2-25]

Additionally, station service water provides a source of water to:

A. The standby coolant supply system (see Section 9.2.8);

B. The traveling screens for screenwash water;

C. Maintain the fire header pressurized;

D. Dilute the chemical additives to the circulating water, service water, and RHR service water systems; and

E. Supply the fire main in the event both diesel fire pumps fail.

The system is a once-through flow network. Each heat exchanger discharges into one of two standpipes on each unit which connect to the plant discharge flume. The largest of the two discharge standpipes is monitored for radioactive contamination by a radiation monitor which will alarm in the control room if high radiation is sensed. The second standpipe is not monitored for radiation since there is a very low probability that systems that discharge into it will be contaminated.

Station service water may be used to fill the condenser hotwell with river water via two normally closed isolation valves. This is termed standby coolant supply and is addressed in Section 9.2.8. [9.2-26]

Station service water keeps the station fire protection system header pressurized when the fire water system is not in use. The fire water header pressure will be maintained by the diesel driven fire pumps if the station service water pumps fail to do so. If the diesel driven fire pumps fail, the station service water system may be used to provide required fire water flow through a normally closed isolation valve. Refer to Section 9.5.1 for details of the fire protection system.

In the event of a failure of the service water pumps to maintain header pressure, motor-operated isolation valves are provided that may be closed to isolate nonessential loads (TBCCW heat exchangers, reactor recirculation pump, ASD coolers, main generator stator cooling water heat exchangers, and hydrogen coolers) from the service water system.

Station service water is tied to the High Pressure Coolant Injection (HPCI) room emergency cooler. This non-safety-related cooling water supply allows the HPCI room emergency cooler to remove heat from the HPCI room during normal/non-accident conditions. This cooling can be utilized during normal/non-accident conditions to ensure that the HPCI room does not exceed the requirements for a mild environment as described in Section 3.11 during a HPCI run of sufficient duration to meet the HPCI function described in Section 6.3.1.3. The service water tie-in is seismically designed. Two in-line check valves are provided to ensure that diesel generator cooling water is available during an accident or transient. Refer to Section 9.5.5 for a description of the diesel generator cooling water system. [9.2-27]

The station service water pumps are powered by 4-kV buses 13(23) and 14(24). The 1/2 service water pump can be powered by either Unit 1 or Unit 2. In the event of loss of power to any of these buses, the associated service water pumps that lose power will trip on undervoltage. If the loss of power to the 4-kV bus results in a reduced service water header pressure and the 4-kV bus 14 is available, the 1B service water pump would automatically start with proper control switch logic. Once power is restored to the bus, the service water pump fed from that bus may be manually restarted. [9.2-28]

In the event a service water pump trip causes service water pressure to decrease significantly, low service water header pressure is annunciated in the control room, and the standby pump can be started manually. If the 1B service water pump is aligned for autostart, and the service water header pressure decreases to the autostart bistable setpoint, the 1B service water pump will start automatically. There are no automatic start features designed into the 1/2, 1A, 2A, and 2B service water pumps. [9.2-29]

Service water is essential to normal plant operation. In the event auxiliary power is lost, power to the buses that power the service water pumps can be fed from the diesel generator bus. Sufficient flow would be provided by the pump to cool the necessary heat loads. [9.2-30]

9.2.2.3 Safety Evaluation

Assuming a condition where all offsite electrical power is lost simultaneously with a loss-of-coolant accident on one unit, the running of one service water pump is sufficient to satisfy the needs of both units. The loss of all offsite power will result in both reactors being scrammed. Since one unit is assumed to have experienced a LOCA, service water supply to that unit is not required. The only service water required to the nonaccident unit is that which is necessary to handle the heat load from the primary containment. The service water requirement to handle this load is less than 3000 gal/min. Hence, the capacity of one service water pump (13,800 gal/min at 210 feet TDH) is more than adequate. [9.2-31]

9.2.2.4 Testing and Inspection Requirements

The station service water system is normally in operation, and no functional tests are required. [9.2-32]

The service water effluent gross activity monitor is required to be operable, or a grab sample must be taken and analyzed every 12 hours. This radiation monitor is verified operable once per 24 hours. Specific surveillance requirements are listed in ODCM. [9.2-33]

9.2.2.5 System Instrumentation

Principal measurements such as service water header pressure, supply pressure, and pump motor amps are indicated in the control room. Local pressure and temperature gauges are provided for flow balancing and equipment cooling by manual valve adjustment, if desired. For that equipment which requires a controlled temperature, local automatic temperature controllers are provided to control service water flow through the equipment. As shown in FSAR Figure 9.2-2, temperature control valves are included for the following: [9.2-34]

A. The TBCCW heat exchanger service water discharge;

B. Turbine oil coolers common service water discharge;

C. Main generator hydrogen coolers common service water discharge; and

D. The RBCCW heat exchanger service water discharge.

Abnormal conditions, such as low service water pressure or a service water pump trip, are annunciated in the main control room. For the abnormal condition of the 1B service water pump automatically starting, the system status is identified by the combination of the low service water header pressure alarm clearing and the associated running light illuminating. These provide the operator with information to assess the abnormal conditions and initiate corrective actions.

An autostart bistable is provided to the 1B service water pump start circuit with its availability determined by the operator's control of the associated handswitch. Instrumentation is provided for the automatic backflush operation of the service water strainers on high differential pressure.

9.2.3 Reactor Building Closed Cooling Water System

Reactor auxiliary equipment is cooled by the RBCCW system. The RBCCW system is described in this section. [9.2-35]

9.2.3.1 Design Basis

The performance objective of the RBCCW system is to provide cooling water for equipment and systems in the reactor building and to minimize release of radioactive material from the reactor equipment to the service water. To achieve these objectives, the system has been designed using the following bases and is capable of removing the maximum heat load required: [9.2-36]

Design flow	5200 gal/min	2600 gal/min each pump
Heat Transfer Rate	27.64 X 10^6 Btu/hr	13.82 X 10^6 Btu/hr each heat exchanger

9.2.3.2 System Description

The RBCCW system is shown in UFSAR Figure 9.2-3 (with major loads) and P&IDs M-33 for Unit 1, and M-75 for Unit 2. [9.2-37]

The RBCCW system consists of pumps, heat exchangers, and necessary control and support equipment. The RBCCW system is a closed loop system with Unit 1 and Unit 2 each maintaining its own loop. Each loop has two dedicated pumps and heat exchangers with both pumps and heat exchangers in service for normal operations. A standby pump and heat exchanger located and controlled in Unit 1 can be connected to either loop. Provisions are made for lining up this spare equipment to either unit through appropriate valving. The number of pumps and the number of heat exchangers in service at any one time should be equal to ensure that heat exchanger flow does not exceed the design flow rate of the pump which would cause the pump to go into runout.

The RBCCW system heat exchangers are cooled by the station service water system as described in Section 9.2.2. Reactor building closed cooling water temperature is maintained by automatic temperature control valves that throttle the station service water flow through the RBCCW heat exchangers. The pressure of the RBCCW system is lower than that of the service water system. Maintaining this pressure differential

ensures that any heat exchanger leakage would be into RBCCW and not into service water, thereby preventing any passage of potentially radioactive process water to the river. A radiation monitor is located on the return header at the inlet to the RBCCW heat exchangers to detect the leakage of radioactive process water into the RBCCW system.

An expansion tank is located on floor elevation 647 feet 6 inches and connects to the RBCCW pump suction line. Its height above the RBCCW pumps ensures adequate net positive suction head (NPSH). Automatic makeup to the expansion tank is provided via an air-operated level control valve from the clean demineralized water makeup system. [9.2-38]

A chemical feeder is provided for batch addition of rust inhibiting chemicals to the system. [9.2-39]

There are no minimum-flow valves provided for the system. A flow path through various heat exchangers adequate to ensure 900 gal/min minimum flow should be provided prior to pump start. [9.2-40]

During normal operation, the RBCCW system provides cooling for the equipment listed in Table 9.2-3, RBCCW System Loads.

The portion of the RBCCW system penetrating the drywell wall can be isolated by remotely-operated isolation valves. The supply line to the drywell is provided with one motor-operated isolation valve outside containment and a check valve inside containment. The return line from the drywell is provided with a motor-operated isolation valve inside containment and another motor-operated isolation valve outside containment. All three of these motor-operated isolation valves are controlled by a common control switch. There are no automatic opening or closing features for these valves. [9.2-41]

A remotely-operated isolation valve is provided to isolate the portion of the RBCCW system that provides cooling water to the following loads:

A. Fuel pool cooling heat exchangers;

B. Reactor water cleanup system nonregenerative heat exchangers;

C. Reactor water cleanup pump seal and bearing coolers;

D. Reactor building equipment drain tank heat exchanger;

E. Containment pump back system air compressors and aftercoolers;

F. Radwaste floor drain filter holding pump cooler (Unit 1 only);

G. Radwaste collector filter holding pump cooler (Unit 1 only);

H. Hydrogen water chemistry autoclave subsystem sample cooler;

I. Reactor building process sample panel (Unit 1 only);

J. Primary containment particulate sampling heat exchanger (Unit 1 only); and

K. Primary containment oxygen analyzer moisture separator (Unit 1 only); and

L. Drywell Pneumatic Compressor Heat Exchanger (Unit 2 only).

There are no automatic opening or closing features for this valve.

9.2.3.3 Safety Evaluation

The RBCCW system is essential to plant operation. In the event of a long-term failure in the system, the affected unit would be shut down. [9.2-42]

In the event any of the dedicated unit RBCCW pumps lose power while they are running, they will restart when power is restored. This ensures that the RBCCW pumps will restart after an interruption in power when it is subsequently restored, thereby restoring RBCCW to the drywell cooling system. In this way an unnecessary ECCS actuation due to high drywell pressure is avoided. The spare RBCCW pump will trip either on overload or when undervoltage is sensed on the bus the pump is being powered. It must be restarted manually. [9.2-43]

It is undesirable to allow the RBCCW pumps which are fed from the 480V buses to automatically restart in the case of a loss of offsite power coincident with a LOCA or to continue to run in the case of a LOCA only. Circuitry has been provided to trip the RBCCW pumps on a core spray actuation signal. The unit RBCCW pumps will trip on:

A. Overload, or

B. High Drywell Pressure, or

C. Low-low Reactor Water Level.

If the operator desires to restart the affected pumps, they may be restarted manually:

A. After the high drywell pressure and low-low reactor water level have cleared, or

B. The key locked bypass switch is placed in the "Bypass" position.

This logic trips the RBCCW pumps on a LOCA initiation signal and provides a manual restart capability. This tripping logic prevents overloading the diesel generators during a LOCA/LOOP and improves the voltage regulation on the 480V ESS buses during LOCA with a degraded offsite voltage condition.

In the event of loss of instrument air pressure, the RBCCW temperature control valves fail open. This causes maximum station service water flow and thereby maximum cooling to the RBCCW system. [9.2-44]

In the event of an RBCCW system leak inside the drywell, the leak can be isolated by closing the containment isolation valves remotely from the control room. This requires operator action as there are no automatic isolation interlocks to these valves. This isolation feature meets the requirements of 10 CFR 50, Appendix A, Criterion 57. Reactor building closed cooling water isolation from the drywell would deprive cooling water to the reactor recirculation pump seals forcing a plant shutdown since the recirculation pumps must be tripped. [9.2-45]

9.2.3.4 Testing and Inspection Requirements

Since the system is operating at all times, there is no testing needed during normal operation to determine component operability. Reactor building closed cooling water system valves are verified operable after valve maintenance which could affect valve operability or each time the plant is in cold shutdown, but not more than once each 90-day period. Samples of the RBCCW system water are taken periodically. Rust inhibiting chemicals are added as necessary. [9.2-46]

9.2.3.5 System Instrumentation

Reactor building closed cooling water temperature is automatically controlled by local temperature controllers which regulate service water flow through the RBCCW heat exchangers. Instrumentation such as the RBCCW pump discharge header temperature and pressure are indicated in the main control room. Low RBCCW system pressure is detected by a pressure switch which monitors the discharge header pressure of the RBCCW pumps. Low pressure is annunciated in the main control room. High temperature at the RBCCW heat exchanger outlet is annunciated in the main control room. Local pressure and temperature gauges are provided for flow balancing and equipment cooling by manual valve adjustment, if desired. [9.2-47]

Instrumentation is provided in the main control room for the operator's information in assessing annunciated abnormal conditions and for initiating corrective measures. Temperature of the cooling water to the equipment located in the drywell is recorded in the control room along with cooling water outlet temperature from each drywell cooler. Low RBCCW flow from the reactor recirculation pumps is annunciated in the control room. Cooling water outlet temperatures from recirculation pump motor cooling coils, pump seals, and bearings are recorded and annunciated upon abnormally high temperature.

Water level in each RBCCW expansion tank is indicated locally. Water level is sensed by tank-mounted level switches. Abnormally high- and low-water level conditions are annunciated in the control room. Leakage into and out of the RBCCW system is detected by these high- and low-level conditions, respectively.

Radioactively contaminated leakage from equipment into the RBCCW system can be detected by the radiation monitor located at the inlet to the RBCCW heat exchangers. This monitor records and alarms in the control room. The outlet of each major component of the RBCCW system is also provided with a grab sample station which can be used to locate the source of a leak. [9.2-48]

9.2.4 Demineralized Water Makeup System

The demineralized water makeup system consists of all equipment required to transfer water from the wells onsite to the well water storage tank, and from this tank through the makeup demineralizers and into the condensate storage tanks. Well water also provides makeup to the domestic water system.

9.2.4.1 Design Basis

The design objective of the makeup water system is to provide reactor quality water of the desired quantity required for normal operation of the power plant. [9.2-49]

9.2.4.2 System Description

The demineralized water makeup system processes well water through a portable demineralized water makeup system consisting of anion, cation and mixed bed ion exchange resins. The flow diagram of the well water piping is shown in P&ID M-23. The system consists of storage tanks, pumps, and necessary control and support equipment to provide makeup water to the clean and contaminated condensate storage tanks. [9.2-50]

Two deep wells pump ground water to the 200,000-gallon well water storage tank. This tank is electrically heated for freeze protection. Two makeup demineralizer feed pumps draw water from the well water storage tank and discharge into a common header. Each pump has a minimum flow line designed to return flow to the well water storage tank through a restricting orifice. This prevents the pumps from overheating if the demineralizer system is isolated while the pumps continue to operate. From the pump common discharge header, well water is transported to the domestic water system pressure tank, the portable makeup demineralizer system, and the gland water tank. The system pumps are of adequate size to provide the maximum expected flow rate. The gland water tank supplies cool water to the gland seals of the diesel generator cooling water pumps and the circulating water pumps. Level in the gland water tank is maintained by an automatic level control valve.

The portable makeup demineralizer system processes the well water through two strong acid cation resin beds, three strong base anion resin beds and one mixed resin bed polisher demineralizer. The portable demineralizer pressure is controlled by a pressure reducing valve. The demineralizers are protected from overpressure by full-flow rupture disks. [9.2-51]

The discharge of the mixed bed ion exchanger is routed to either the contaminated condensate storage tank or the clean condensate storage tank. Condensate storage and transfer is addressed in Section 9.2.6. Once the portable demineralizer is depleted, it is replaced with another instead of being regenerated on site.

Operation of the makeup system is on demand at infrequent intervals to replenish demineralized water in the storage tanks. [9.2-52]

9.2.4.3 Safety Evaluation

The demineralized water makeup system is designed to provide reactor quality water for normal operation of the plant. [9.2-53]

9.2.4.4 Testing and Inspection Requirements

The makeup water system operates intermittently during operation of the plant and no testing of the system is required. [9.2-54]

9.2.4.5 System Instrumentation

The well water storage tank level is indicated and high and low level is annunciated in the main control room (P&ID M-23). A selector switch determines which well water pump will be the preferred pump for auto start signals generated by the tank level switches. The makeup demineralizer feed pumps are controlled from the main control room. Discharge header pressure is indicated in the main control room. Abnormally high and low levels in the gland water tank are annunciated in the main control room. Low gland seal water pressure to either the circulating water pumps or diesel generator cooling water pumps also annunciates an alarm in the control room. A locally-controlled level control valve maintains proper water level in the gland water tank. [9.2-55]

9.2.5 Ultimate Heat Sink

9.2.5.1 Design Bases

The design objective of the ultimate heat sink is to provide sufficient cooling water to the station to permit operation of the RHR service water and Diesel Generator Cooling Water (DGCW) pumps when the normal heat sink (the river) is unavailable. The use of RHR service water is discussed in Section 9.2.1. The use of DGCW is discussed in Section 9.5.5. [9.2-56]

9.2.5.2 System Description

The ultimate heat sink is provided to mitigate the consequences of the postulated failure of Lock and Dam No. 14 on the Mississippi River downstream of the plant, which would cause river level to drop. The ultimate heat sink is defined as the water that is captured inside the log boom, and it extends to the 574'9" weir gate located in the discharge canal. This captured volume is approximately 3 million gallons. A description of the river water supply and Lock and Dam failure scenario is provided in Section 2.4. Refer to Figure 2.4-2, Station Site Flow Diagram at the Mississippi for an elevation view of the following description. [9.2-57]

The station design is such that if Lock and Dam No. 14 were to fail, the water level would recede in the intake bay to the point where it would be separated from the river. As the water level recedes in the intake bay, circulating, service and fire diesel pumps would become inoperable, leaving only RHRSW and DGCW available to shutdown the units. Use of the ultimate heat sink to shutdown the reactors requires the operation of portable diesel pumps with a total capacity of 5100 gpm to reverse the normal flow of makeup water. Makeup water would be provided from the river through the discharge piping and return to the river across the log boom in the intake bay. Portable pumps of sufficient capacity are available from a leasing facility. Following a dam failure, approximately 2 days would be available to position these pumps

to take suction from the discharge flume and to discharge to the center bay (containing the RHRSW and DGCW suction piping) of the Cribhouse building. Since the station discharge piping is below elevation 561 feet in the river, the river water can flow backflow through these pipes to the discharge flume. The RHR service water and DGCW pumps are located on the turbine building basement floor, elevation 547 feet 0 inches. The suction pipes for these pumps start in the crib house with the top of the uppermost pipe being at elevation 556 feet 6 inches and run to the turbine room basement in a concrete encasement. This arrangement provides that the pumps will at all times be capable of obtaining water.

The water pumped by the RHRSW and DGCW pumps is passed through heat exchangers and discharged into the discharge flume upstream of a weir with a top elevation at elevation 574 feet 9 inches. The ice melting line connects the discharge flume upstream of the weir with the intake flume with a bottom elevation of 558 feet 0 inches. A gate is provided in this line for isolation.

In the unlikely event of a failure of Lock and Dam No. 14, it would be necessary to open the gate on the ice-melting line to permit the discharged water to return to the intake flume. This procedure would permit the water impounded in the intake and discharge flumes to be used as an evaporative heat sink. [9.2-58]

The RHRSW and DGCW pumps would then draw a suction from the intake structure via the normal suction line. The water discharged from the heat exchangers would flow to the discharge flume via the normal path. The water would then flow through the open ice-melting line back to the intake flume to be used again. A portion of the discharged water would be displaced by the makeup water provided from the portable diesel pumps. This displaced water would overflow the log boom and return to the river.

9.2.5.3 Safety Evaluation

As stated previously, it is assumed that the river level at the station would drop to elevation 561 feet 0 inches if Dam No. 14 were to fail. (See Figure 2.4-2, Station Site Flow Diagram at the Mississippi River). At this elevation, the suction line to the RHRSW and DGCW pumps would be submerged by 4 feet 6 inches of water. [9.2-59]

The failure of Lock and Dam No. 14 is not assumed to occur in combination with any other design basis event or operating transient. Both units are assumed to be operating at full power. Based on the failure scenario described in Section 2.4.4, at least 48 hours would be available to shutdown the units using the circulating water system and the main condenser before the connection to the river would be lost. The volume of water impounded in the ultimate heat sink combined with 5100 gpm of makeup water from the portable diesel-driven pumps would be sufficient to remove reactor decay heat and provide suppression pool cooling, maintaining both units in cold shutdown. [9.2-60]

Recirculation of the ultimate heat sink volume would result in elevated RHRSW and DGCW temperatures. The worst case scenario would be a dam failure during the summer months with a river temperature of 95°F and minimum evaporative cooling. Assuming a conservative ultimate heat sink volume of 2.15 million gallons of water, 5100 gpm of makeup from the portable pumps and 24 hours of shutdown time on the main condenser, this results in a maximum RHRSW and DGCW inlet temperature of 109°F. This would be sufficient for each unit to operate one RHR pump, one RHR heat exchanger, one RHRSW pump and one DGCW pump for a total flow of approximately 10,000 gpm for

cooling. Spent fuel pool cooling would be provided by the CCST and clean demineralized water system. It is assumed that drywell and control room coolers would be lost during this event and that operators would take compensatory actions per approved plant procedures to cope with these conditions. The ultimate heat sink analysis does not take credit for alternative supplies of water which could be available such as the spray canal volume. Without a loss of offsite power, either the well water system or the fish pumps could be used to make up spray canal or ultimate heat sink volume.

Under summer conditions, the maximum evaporation rate of the impounded water would be approximately 55 gal/min. Makeup requirements can be met using the well water system or portable pumping equipment. Portable pumps of approximately 2000 gal/min are available. Therefore, makeup capabilities far exceed the summer evaporation rate.

If the dam failed during extremely cold weather conditions, the water would be cooled down rapidly before it was drawn into the RHR service water pump suction. Therefore, the summer conditions are the controlling cases. [9.2-61]

Refer to Section 3.8 for the seismic evaluation of the crib house.

9.2.6 Condensate Storage Facilities

The condensate storage facilities include all equipment necessary to store both clean and contaminated demineralized water and to transfer the water throughout the plant for various uses.

9.2.6.1 Design Basis

The design objective of the condensate storage facilities is to provide a storage volume for clean and potentially contaminated water of suitable quality for use in the reactor and other systems throughout the plant. [9.2-62]

The system is designed to ensure a minimum of 90,000 gallons of water is available from each contaminated condensate storage tank (CCST) for use by HPCI and RCIC. This is accomplished by the design of the discharge lines from the tanks; all taps into the tank for nonemergency use are no lower on the tank than the 90,000 gallon level. The safe shutdown pumps also take a suction from the CCST 90,000 gallon reserve volume.

9.2.6.2 System Description

The condensate storage facilities consist of two 350,000-gallon capacity contaminated condensate storage tanks, one 100,000-gallon capacity clean condensate storage tank, four condensate makeup pumps, three condensate transfer pumps, and three clean demineralized water pumps with associated piping and valving to transfer condensate throughout the plant. [9.2-63]

The demineralized makeup water system discharge, discussed in Section 9.2.4, is routed to either the clean or contaminated condensate storage tanks. All three condensate storage tanks have internal electric heaters for freeze protection.

The clean condensate storage tank influent is sourced solely from the portable makeup demineralizers which precludes the possibility of radioactive contaminants from entering the tank. Water is drawn from this tank through any one of three clean demineralized water pumps which transfer the water to a distribution header for the following uses throughout both units:

A. Decontamination;

B. Floor washdown in areas containing radioactive drain systems;

C. Laboratory use;

D. Reactor building closed cooling water system makeup;

E. Turbine building closed cooling water system makeup;

F. Heating boiler makeup; and

G. Other purposes requiring uncontaminated demineralized water.

The two contaminated condensate storage tanks provide a source of condensate for use by the following systems of both units:

A. Main condenser hotwell,

B. Control rod drive hydraulic system,

C. Reactor core isolation cooling,

D. Safe shutdown pumps,

E. High-pressure coolant injection,

F. Core spray, and

G. Residual heat removal.

The condensate makeup pumps take a suction from the contaminated condensate storage tanks above the 90,000 gallon level and provide the driving force to transport makeup water to the main condenser hotwell whenever there is no condenser vacuum.

Three condensate transfer pumps take a suction from the contaminated condensate storage tanks above the 90,000 gallon level and provide the motive force to supply the following systems with condensate:

A. Fuel pool cooling and cleanup,

B. Reactor water cleanup,

C. Radwaste, and

D. Emergency core cooling system fill header alternate supply.

In the event the condensate transfer pumps are inoperable, a crosstie line can be aligned to connect the discharge of the Unit 1 condensate booster pump with the condensate transfer header.

The HPCI and RCIC systems normally take a suction from the contaminated condensate storage tanks. The level in the CCSTs is maintained at or above 12 feet which provides sufficient static head to ensure the discharge pipes of the HPCI and RCIC systems are maintained full of water. Therefore, when the CCSTs, filled to 12 feet or greater, are aligned to supply HPCI and RCIC the discharge piping is ensured filled. [9.2-64]

9.2.6.3 Safety Evaluation

The storage tanks and system piping are designated as non-safety-related equipment. [9.2-65]

Although the HPCI system is designated as Class I-critical equipment, use of the CCSTs as the initial source of water is desirable to maintain high quality water in the reactor. The HPCI suction from the (Class I) torus will automatically transfer in the event the CCSTs become unavailable. It is therefore justifiable to utilize the non-safety-related CCSTs as the primary source of water to HPCI. [9.2-66]

9.2.6.4 Testing and Inspection Requirements

Water quality in the clean and contaminated condensate storage tanks is periodically analyzed.

9.2.6.5 System Instrumentation

Each storage tank level is indicated in the control room and low level alarms alert the operator to excessive use of condensate or when normal makeup is required. High level alarms are provided for each tank to indicate the "filled" condition. Each storage tank is electrically heated and thermostatically controlled locally. [9.2-67]

The condensate makeup pumps, condensate transfer pumps, and clean demineralized water pumps are remotely operated from the control room. Each is provided with circuitry to annunciate a tripped condition in the control room. The condensate makeup pump can automatically start due to a low hotwell level.

Condensate transfer pump discharge header pressure, demineralized water pump discharge header pressure, and condensate makeup pump discharge header pressure are indicated in the control room. Low condensate transfer header pressure and low demineralized water header pressure signals actuate alarms in the control room.

9.2.7 Turbine Building Closed Cooling Water System

9.2.7.1 Design Bases

The purpose of the TBCCW system is to provides a means of heat rejection from systems located in the turbine building and crib house.

9.2.7.2 System Description

The TBCCW system is a closed loop system consisting of pumps, heat exchangers, an expansion tank, and necessary control and support equipment. Separate, independent systems are provided for Unit 1 and Unit 2. The TBCCW systems for Units 1 and 2 are shown in FSAR Figure 9.2-4 and P&IDs M-21 and M-68 respectively. [9.2-68]

The TBCCW system consists of two, 100% capacity pumps, each rated at a minimum of 1000 gal/min. The pumps provide the motive force to circulate the cooling water throughout the unit. A 2000-gallon expansion tank piped to the TBCCW pump suction line is located on the turbine building ventilation fan floor (elevation 626 feet 6 inches). Its elevation above the TBCCW pumps ensures adequate NPSH for the pumps. It also provides a surge volume for the system as the cooling water density varies. Expansion tank level is maintained by an automatic level control valve which supplies demineralized water to the tank as level decreases. An internal overflow for the tank is routed to the turbine building floor drain system.

The TBCCW pumps discharge to a common header which supplies cooling water to the various equipment listed in Table 9.2-4, TBCCW System Loads.

The EHC fluid coolers each have a temperature control valve on the cooling water inlet to the heat exchanger which automatically controls the cooling water flow in response to EHC fluid effluent temperature.

The sparging air compressor aftercoolers each have a temperature control valve on the cooling water inlet to the aftercooler which automatically controls the cooling water flow in response to cooling water effluent temperature.

All other loads have no automatic temperature control but flow through them may be manually throttled, if desired.

Return flow from the various loads enters a common header which is routed to one of two 100% capacity heat exchangers. The cooling water flows through the shell side of the heat exchanger and the effluent is routed to the TBCCW pump suction. Station service water provides the cooling medium on the tube side of the heat exchanger. An air-operated temperature control valve, common to both heat exchangers, throttles the service water in response to the temperature of the cooling water effluent. A chemical feeder is provided

at the suction to the pumps which provides a mechanism to add a corrosion inhibitor to the system. Refer to Section 9.2.2 for a description of the station service water system.

9.2.7.3 Safety Evaluation

The TBCCW system is essential for normal plant operation. In the event the system fails, all loads cooled by the TBCCW would be shutdown. As a result, the normal heat sink would be lost, thereby forcing closure of the MSIVs. This would result in a loss of condensate and feedwater makeup to the reactor and a loss of circulating water. The affected unit would be shutdown. The HPCI and RCIC systems can be used for reactor pressure control and cooldown as appropriate. [9.2-69]

The TBCCW expansion tank overflow and drain line are routed to the floor drain system to prevent potentially contaminated water from being discharged from the station without being monitored for radioactivity. [9.2-70]

9.2.7.4 Testing and Inspection Requirements

The TBCCW system operates continually and requires no operability checks. The cooling water is sampled periodically. A corrosion-inhibiting solution is added via the chemical feeder when required, as determined by the sample analysis. [9.2-71]

9.2.7.5 System Instrumentation

A level switch is provided to automatically open the demineralized water makeup valve to fill the TBCCW expansion tank. A second level switch actuates a high or low expansion tank level annunciator in the control room. Leakage into and out of the TBCCW system is detected by high and low level conditions, respectively. [9.2-72]

The TBCCW pumps are remotely controlled from the main control room. Discharge header pressure is indicated and low header pressure is annunciated in the control room.

Discharge header temperature is also indicated and high temperature is annunciated in the control room.

The TBCCW pumps are powered by normal ac power supplies (480-V motor control centers) and are protected by thermal overload trips. A trip of a TBCCW pump annunciates in the control room. There are no automatic start features for the standby pump.

Local temperature and pressure indicators are provided throughout the system to allow for flow balancing and determination of individual heat exchanger performance.

9.2.8 Standby Coolant Supply System

9.2.8.1 Design Bases

The purpose of the standby coolant supply system is to provide an inexhaustible supply of water to the condenser hotwell so that feedwater flow can be maintained to the reactor in the event it is needed for core flooding or containment flooding following a postulated LOCA. [9.2-73]

9.2.8.2 System Description

FSAR Figure 9.2-2 shows the standby coolant supply to the condenser hotwell. The standby coolant supply system consists of interconnecting piping and associated valving between the service water pump discharge header and the condenser hotwell. This connection to the service water system can supply approximately 15,000 gal/min of screened river water to the hotwell. Two normally closed, motor-operated gate valves in series isolate service water from the main condenser. Double valves are used in the interconnected piping which permit valve testing and minimizes river water leakage to the condenser. The volume between the valves is provided with a tell-tale drain and a flow sight glass. [9.2-74]

A normally open manually-operated butterfly valve is installed upstream of the two motor-operated valves to isolate the system when necessary. A cleanout port is provided between the butterfly valve and the standby coolant supply motor-operated valves to permit flushing of the line. [9.2-75]

In the event that reactor vessel or containment flooding is required, the standby coolant supply system would be actuated manually from the control room. Water can then be pumped from the hotwell using the condensate and condensate booster pumps (and reactor feedwater pumps if necessary) to the reactor vessel for core flooding. The containment vessel could be flooded up to the top of the core by continued operation of the system if desired. Gases in the drywell would be vented through the standby gas treatment system to the main chimney by remote manual operation from the control room.

The functioning of this system is dependent upon the availability of auxiliary power and is not considered in the sizing of the diesel generators. [9.2-76]

Refer to section 9.2.2 for a description of the station service water system.

9.2.8.3 Safety Evaluation

To maintain core cooling capability during any LOCA, it is necessary to supply large amounts of water to the reactor vessel. This can be done by either the core spray, HPCI or LPCI subsystems, or the feedwater system, depending upon the type and conditions of the accident. The feedwater system, in addition to the HPCI system, would help reduce reactor vessel pressure thereby permitting the LPCI and/or core spray system to make up inventory. [9.2-77]

Flooding of the entire containment vessel to a water level above the reactor core gives ultimate assurance that core cooling can be maintained. In addition, flooding provides the means to achieve post-accident recovery under any undefined conditions that might prevent filling the reactor vessel.

If flooding the containment was desired, approximately 3 minutes of condensate flow from the hotwell is available. The 3 minutes is based on normal operating conditions of the unit (rated power and feedwater flow rates). Makeup from condensate storage tanks would be available and could be used. The standby coolant supply connection provides an additional coolant supply originating from the service water system which would supply river water to the condenser hotwell. This enables a continuous flow through the condensate and feedwater system. Thus, standby coolant supply serves as a backup to other core cooling systems and enables faster containment flooding rates.

This additional coolant supply is provided in excess of those required to satisfy the reactor vessel reflooding and containment flooding design objectives.

9.2.8.4 Testing and Inspection Requirements

Most of the components of the standby coolant supply system are normally and continually in operation, thereby eliminating the need for periodic testing. These include the service water system, the reactor feedwater system, and the hotwell-condensate system. [9.2-78]

The valves in the system are motor operated and can be exercised periodically to demonstrate operability. [9.2-79]

9.2.8.5 System Instrumentation

Each of the standby coolant supply system motor-operated isolation valves is individually controlled from the main control room. Each valve is monitored for valve position and an annunciator is actuated in the control room if either valve is open. [9.2-80]

Table 9.2-1

RESIDUAL HEAT REMOVAL SERVICE WATER EQUIPMENT DESIGN PARAMETERS

RHR Service Water Pumps	
Number	4 per unit (one required to provide required cooling capacity)
Type	Horizonal - centrifugal
Power source	Normal auxiliary power or standby diesel
Capacity	3500 gal/min each**
Head	760 feet**
RHR Heat Exchangers	
Number	2 per unit
Heat load	105 x 10^6 Btu/hr each
Primary side flow (containment water)	10,700 gal/min
Secondary side flow (river water)	7,000 gal/min*
Design temperatures	
River water	95°F
Containment water	165°F
Primary (shell) design pressure	450 psi
Code (shell side)	ASME Section IIIC
Secondary (tube) design pressure	350 psi
Code (tube side)	ASME Section VIII

*Note: Heat exchanger design parameter is 7,000 gal/min; however, only 3,500 gal/min (one RHR service water pump) is needed during accident conditions. Shutdown cooling mode was sized for 7,000 gal/min; however, typical operation in this mode uses only one pump at reduced flow.

**Note: These parameters (3500 gpm at 760 ft) document the original manufacturer's specification of the size of the pumps chosen to perform the RHR Service Water function.

Table 9.2-2

STATION SERVICE WATER SYSTEM HEAT LOADS

Reactor building closed cooling water heat exchangers

Turbine building closed cooling water heat exchanger

Main turbine lube oil coolers

Reactor recirculation system adjustable speed drive coolers

Main generator stator water coolers

Main generator hydrogen coolers

Steam tunnel coolers

Unit 1/2 Safe shutdown makeup pump room cooler (draws off Unit 2 header only)

Service building heating, ventilation and air conditioning (HVAC)

Off-gas glycol chiller units

Control room HVAC air conditioning units

Heating system condensate return cooling

High Pressure Coolant Injection room emergency cooler

Lift station lift pump bearing oil coolers

Offgas building process sample coolers

Table 9.2-3

REACTOR BUILDING CLOSED COOLING WATER SYSTEM LOADS

Reactor recirculation pump seals and motors (2)

Fuel pool cooling heat exchangers (2)

Drywell coolers (7)

Reactor water cleanup system nonregenerative heat exchangers (multi shell) (2)

Drywell equipment drain sump heat exchanger (1)

Reactor building equipment drain tank heat exchanger (1)

Miscellaneous loads:

- Reactor water cleanup pump seal and bearing coolers
- Joy air compressor (containment pump back system) aftercooler and jacket cooling
- Drywell pneumatic air compressor heat exchanger
- Reactor building process sample panel
- Radwaste floor drain filter holding pump cooler (Unit 1 only)
- Radwaste collector filter holding pump cooler (Unit 1 only)
- Hydrogen water chemistry autoclave subsystem sample cooler
- Primary containment particulate sampling heat exchanger
- Primary containment oxygen analyzer moisture separator

Table 9.2-4

TURBINE BUILDING CLOSED COOLING WATER SYSTEM LOADS

Circulating water pump thrust bearing oil coolers

Service air compressors and aftercoolers

Sparging air compressor aftercoolers (Unit 1 only)

Control rod drive pump oil coolers and thrust bearings

Reactor feed pump oil coolers, seal coolers and seal cooling jackets

Condensate and condensate booster pump bearing coolers

Electro-hydraulic control (EHC) fluid coolers

Alterex coolers

Bus duct coolers

Turbine building process sampling coolers

Air surge compressor oil coolers and aftercoolers (Unit 2 only)

Instrument air compressors 1A, 1/2 – (Unit 1 only)

Instrument air compressors 1/2B, 2 – (Unit 2 only)

9.3 PROCESS AUXILIARIES

Section 9.3 addresses four process auxiliary systems. Section 9.3.1 addresses the compressed air systems, Section 9.3.2 addresses the process sampling system, Section 9.3.3 addresses the plant equipment and floor drain systems, and Section 9.3.5 addresses the standby liquid control (SBLC) system.

9.3.1 Compressed Air Systems

The compressed air systems at Quad Cities consist of the instrument air system, the service air system, the sparging air system, the drywell pneumatic system, the air surge system, the diesel generator air start system, the nitrogen containment atmosphere dilution (NCAD) system and the pumpback system. Section 9.3.1 addresses the instrument air system in Section 9.3.1.1, the service air system in Section 9.3.1.2, the sparging air system in Section 9.3.1.3, the drywell pneumatic system in Section 9.3.1.4, and the air surge system in Section 9.3.1.5. The diesel generator air start system is addressed in Section 9.5.6. Both the NCAD and the torus to drywell pumpback systems are discussed in Section 6.2. [9.3-1]

9.3.1.1 Instrument Air System

The major components of the system for each unit are located on floor elevation 595 ft, in the turbine building. Unit 1 and Unit 2 each have their own compressor trains, 1A and 2. In addition, there are two swing compressors, 1/2B and 1/2, which are both aligned to Units 1 and 2. A general layout showing the compressors and the instrument air system is shown in Figure 9.3-1. Instrument air compressor train layout for Unit 2 is shown on Figure 9.3-2.

The design objective of the station instrument air system is to ensure the availability of compressed air of suitable quality and pressure to sustain power plant operation. Loading pressure setpoints for the compressors are established to ensure sufficient air flow and pressure are available to meet the design requirements of priority air loads which are the scram valves, the control rod drive flow regulator, the minimum flow feedwater regulating valves and the main steam isolation valves (MSIV). Unloading pressure setpoints for the compressors are established to protect the piping system. The station instrument air system receives electrical power from various 480-V switchgear. Only the 1/2B and 1/2 instrument air compressor trains are connected to the emergency power system, buses 28 and 18 respectively. All four air compressors (1A, 2, 1/2B and 1/2) are cooled by Turbine Building Closed Cooling Water (TBCCW). Cooling water can also be supplied to compressors (1A and 2) from service water (SW) by rotating a spectacle flange between the TBCCW and SW piping. Service water is not expected to be used as a cooling medium for these two compressors due to the possibility of fouling the small cooling water passages in the blowoff cooler, intercooler, and aftercooler. Cooling water can also be supplied to the 1/2 and 1/2B compressors from well water and will empty into outgoing service water. The inlet connection procedure for the well water line is addressed in station procedures. The outlet will be connected to service water by rotating a spectacle flange. The instrument air system will be operating at all times during plant operation and, therefore no testing procedures are required. The system provides a pneumatic supply for air accumulators, valve actuators, controllers, transmitters, instrument racks, and control rod scram components. Although not safety-related, the instrument air system supplies numerous safety-related equipment, and is therefore a vital part of the station. All critical level measuring and other recorder-controller devices

(those for which a failure thereof would limit or jeopardize the safety of the plant) are operated from an electrical power source, not station air. High quality air is required to prevent clogging of precision air openings associated with the components. The instrument air system, unlike service air, is not operated cross connected between Units 1 and 2. There are crosstie points, but the valves at these locations are locked closed. This is to prevent the inadvertent shutdown of both units as a result of a low pressure condition on one unit. The compressor discharge piping is protected against overpressure by relief valves. [9.3-2]

The 1A, 1/2, 1/2B, and Unit 2 instrument air compressor trains are equipped with the following components: [9.3-3] [9.3-4] [9.3-5]

A. Compressor – atmospheric air from inside the turbine building is compressed at the rate of 575 ft^3/min nominal for Unit 1A, 1/2 and Unit 2. Approximately 97 scfm air flow is utilized for purging (regenerating) the off-line dryer chamber. For the 1/2B compressor, atmosphere air from inside the turbine building is compressed at the rate of 673 ft^3/min (+/- 4%). Of this 673 ft^3/min, 81.4 scfm is utilized for purging (regenerating) the off-line dryer chamber. All four instrument air compressors are water-cooled. Discharge pressure is maintained by a load-unload feature, which is controlled by a pressure switch sensing system air pressure.

B. Prefilters – two filters are installed to remove oil and dirt, which may contaminate the dryer. One filter is used during normal operations.

C. Dryer – the drying unit is a dual-chamber, automatic drying regeneration system. While one chamber is drying, the other is regenerating. A portion of the dryer exhaust is routed to the other chamber, flows through the bed collecting moisture, and is exhausted to the atmosphere at the rate of 97 scfm, nominal. For the 1/2B dryer, this rate is approximately 81.4 scfm.

D. Afterfilters – two filters, one normally used and one standby are provided to remove alumina dust larger than .07 microns.

E. Receiver – a 96 ft^3 receiver is provided for the 1A and the U2 instrument air compressor. A 194 ft^3 receiver is provided for the 1/2B instrument air compressor. The receivers contain the compressed air and prevent system pressure oscillations. From the receiver, piping headers extend throughout the plant to supply air-operated components. The 1/2 instrument air compressor does not have an air receiver and ties directly into the piping headers.

In addition to the equipment described above, the 1A and 2 instrument air compressor trains have two additional features:

A. Service air backup supply — an air-operated pressure regulating valve will open at an instrument air receiver pressure of approximately 88 psig to admit service air into the instrument air system at a point between the compressor and pre-filter. To prevent instrument air backflow into service air, a check valve has been provided upstream of each service air instrument air interconnection. [9.3-6]

B. Coalescing Filters — A coalescing filter is installed to further filter oil [9.3-7] contamination which may come from the service air system. [9.3-8]

The configuration of the 1A and 2 instrument air compressor trains has the service air supply connecting to the instrument air system upstream of the instrument air filters and dryers to help maintain instrument air quality. This service air backup improves the reliability of the instrument air system.

The reactor cannot be operated without the instrument air system, but failure of the system will not jeopardize the safe shutdown of the reactor. Loss of instrument air will cause the outboard main steam line isolation valves to close and scram the reactor. The resultant transient is identical to the single failure analysis given in Section 15.2.4. Also upon loss of instrument air, the low flow feedwater regulating valves will fail as is and the control rods will begin drifting in. The feedwater regulating valve is addressed in Section 10.4. The control rod drives are addressed in Section 4.6 [9.3-9]

An instrument air low pressure alarm is actuated by pressure switches on the instrument air receivers, except for the 1/2 compressor, which does not have an air receiver. The instrument air dryers actuate alarms to indicate the bypass valve is open, and when a dryer failure has occurred. For the 1/2, 1A, and 2 dryers, these alarms can be disabled via a manual cutout switch. The 1/2B, 1A and 2 compressors have alarm windows at the 912-1 annunciator panel to indicate either a feeder breaker trip or an air compressor trip. For the 1/2 compressor, the alarm for the feeder breaker trip and air compressor trip is combined at one annunciator window. [9.3-10]

9.3.1.2 Service Air System

The design objective of the station service air system is to ensure the availability of compressed air of suitable quality and pressure for the power plant operation. The station service air system receives electrical power from various 480-V switchgear. The service air system consists of three air compressor trains and four air receivers. The service air supply systems will be operating at all times during plant operation and, therefore, no testing procedures are required.

The service air system provides a regulated supply of compressed air throughout the power station as shown in P&IDs M-25 and M-72. Loading pressure setpoints for the compressors are established to ensure sufficient air supply (flow and pressure) to the service air loads including the instrument air backup. Unloading pressure setpoints for the compressors are established to protect the piping system. The system consists of air compressors, aftercoolers, oil separators, air receivers, regulators, valves, piping, controls, and instrumentation. A typical compressor configuration is shown in Figure 9.3-3. When the system is placed in operation, it will function automatically to supply compressed air to equipment and outlets within the reactor building, drywell, turbine building, radwaste building, crib house, heating boiler building, service building, lift station, and to certain outside installations. The Unit 1 and Unit 2 service air systems provide backup to each other through a common air header system. The service air system for each unit also provides a backup source of instrument air for the unit. [9.3-11]

The 1A, 1B, and the 2 service air compressor trains take suction from outside the turbine building through filter-silencers. The filters prevent dirt and dust from entering the compressor cylinder and valves. The air is compressed and discharged through aftercoolers (cooled by turbine building closed cooling water (TBCCW)), and oil separators, into the air receivers. The compressor discharge piping to the aftercoolers and associated components is protected against overpressure by relief valves set at approximately 125 psig. An overpressure in this piping could occur only if the valves between the aftercoolers and air receivers are closed. The service air flow from the air receivers is supplied to the station equipment and air drops through the service air headers. [9.3-12]

Four receivers supply service air to the plant; air receivers 1A and 1B for Unit 1, air receiver 2 for Unit 2 and air receiver 1/2 for both units. Due to the integrated nature of the service air system, all four air receivers effectively supply the entire plant since Unit 1, Unit 2, and the 1/2 service air headers are interconnected. [9.3-13]

Equipment loads fed by service air include the stator leak monitoring system, standby liquid control tank, breathing air stations, spare floor drain filter, floor drain demineralizers, maximum recycle spent resin tank, reactor water cleanup filter demineralizers, waste demineralizer, fuel pool filter demineralizers, floor drain filter, waste collector filter, and hopper control panels. As a personnel safeguard, the service air system includes carbon monoxide monitoring to alert the control room of possible breathing air problems. [9.3-14]

A service air low pressure alarm is actuated by pressure switches on the service air receivers in the turbine building. On low service air pressure, the standby service air compressor will autostart. A service air compressor discharge high temperature alarm is actuated by a temperature switch located in the compressor discharge line between the compressors and the aftercoolers. High temperatures will trip the compressor. These alarms are annunciated in the control room. [9.3-15]

9.3.1.3 Sparging Air System

The sparging air system supplies a low-pressure, high-volume supply of air for use in mixing radwaste tank contents and for purging the off-gas system of hydrogen, when required. [9.3-16]

The sparging air system consists of two air compressors, snubbers, aftercoolers, moisture separators, regulators, valves, piping, controls, and instrumentation. The major components are shown in Figure 9.3-4. The equipment is common to both units, and as such, has the 1/2 designation. The two units are designed to supply 1300 ft^3/min at 13 psig. [9.3-17]

The compressors take suction from inside the turbine building through filter-silencers. The filter-silencer prevents dirt and dust from entering the compressor. The air is discharged to the aftercooler which is cooled by TBCCW. A temperature switch in the discharge line trips the compressor on high temperature. The cooled, compressed air is routed through a moisture separator to remove excess moisture. The system also contains a pressure control feature, which prevents overpressurization of the system and snubbers which reduce noise levels and limit piping vibration. [9.3-18]

9.3.1.4 Drywell Pneumatic System

The drywell pneumatic system is provided to supply compressed nitrogen gas or air to pneumatically-operated equipment in the primary containment as shown in P&ID M-24. Each unit has a separate drywell pneumatic system which consists of a compressor, separator, heat exchanger, filters, dryer, receiver, pressure regulator, and associated piping, controls, and instrumentation as shown in P&ID M-24. The compressor takes suction from the drywell atmosphere. A receiver is supplied to stabilize pressure. This nitrogen or air is filtered and dried before it enters the header to the containment. The system is crosstied so compressed gas can also be supplied from the instrument air system when the primary containment is not inerted or from the nitrogen makeup system when the primary containment is inerted. [9.3-19]

The drywell pneumatic compressor operates at approximately 105 psig. The backup supply (from either instrument air or nitrogen) is initiated at approximately 82 psig. These setpoints are established to maintain a minimum pressure of approximately 82 psig to instrument loads in the drywell. [9.3-20]

The reactor cannot be operated without the drywell pneumatic system, but failure of the system will not jeopardize the safe shutdown of the reactor. Loss of the drywell pneumatic system requires the Target Rock valve (valve 1(2)-203-3A) to be made inoperable and causes the inboard main steam line isolation valves to close, scramming the reactor. The resultant transient is identical to the single failure analysis given in Section 15.2.4. [9.3-21]

9.3.1.5 Air Surge System

The air surge system supplies compressed air to remove resins from the condensate demineralizers and move them to radwaste. The air surge system consists of two air compressors, aftercoolers, oil coolers, air filters, a receiver tank, valves, piping, controls and instrumentation. The equipment is common to both units and as such has the 1/2 designation. The units are designed to supply 180 ft^3/min at 150 psig. The compressed air and the compressor oil coolers are cooled by TBCCW. The system also contains overpressure protection. [9.3-22]

9.3.2 Process Sampling System

The process sampling system consists of the high radiation sampling system and additional sampling panels located throughout the plant. The high radiation sampling system (HRSS) is addressed in Section 9.3.2.1 and the rest of the plant sampling panels are addressed in Section 9.3.2.2.

9.3.2.1 High Radiation Sampling System

License Amendments No. 212 and No. 206 for the Quad Cities Station, Units 1 and 2 respectively, approve the elimination of the requirement to have and maintain the Post Accident Sampling System (or HRSS). The following items were committed to as part of License Amendments No. 212 and No. 206.

- Quad Cities Station has developed contingency plans for obtaining and analyzing highly radioactive samples of reactor coolant, suppression pool, and containment atmosphere. The contingency plans will be contained in the Quad Cities Station chemistry procedures and implemented with the implementation of the license amendments. Establishment of contingency plans is considered a regulatory commitment.

- The capability for classifying fuel damage events at the Alert level threshold will be established at a level of core damage associated with radioactivity levels of 300 micro-curies per milliliter (ml) dose equivalent iodine. This capability will be described in emergency plans and emergency plan implementing procedures and implemented with the implementation of the license amendments. The capability for classifying fuel damage events is considered a regulatory commitment.

- Quad Cities Station has established the capability to monitor radioactive iodines that have been released offsite to the environs. This capability is described in emergency plans and emergency plan implementing procedures. The capability to monitor radioactive iodines is considered a regulatory commitment.

The following information contained in the UFSAR regarding the past regulatory requirements for post accident sampling is retained for historical purposes.

9.3.2.1.1 <u>Design Basis</u>

The HRSS utilizes a number of manual sampling techniques to enable reactor coolant sampling operations over a wide range of normal and post-accident plant conditions. [9.3-23]

The primary function of the containment air HRSS is to obtain and analyze via onsite or offsite laboratory, a grab sample of containment air. The activity released is assumed to be 100% of an equilibrium core noble gas inventory and 25% of the iodine diluted in the containment air volume. The containment air sampling (CAS) system is designed and arranged in the HRSS building to limit the integrated dose to the technician during sampling. [9.3-24]

The delivery system is designed to minimize iodine plateout in the supply lines. To that end, lines are sized for optimum fluid velocity of 10 ft/s, are heat traced to prevent condensation, have large radius bends, and are routed from containment to the sample station in the shortest possible distance.

The HRSS is capable of providing information relative to post-accident plant conditions to allow operator actions to be taken to mitigate and control the course of an accident. Liquid samples can be obtained during the following plant conditions: [9.3-25]

A. Post-accident with no coolant loss;

B. Post-accident, ECCS on with small LOCA;

C. Post-accident, ECCS on with large LOCA;

D. Normal power operation; and

E. Normal shutdown.

The sampling operation is designed to capture reactor coolant source samples and analyze them, via onsite or offsite laboratory, while maintaining the total dose per technician within the prescribed limits of General Design Criterion (GDC) 19 from 10 CFR 50, Appendix A. Liquid source terms are based on release of 100% of noble gases, 50% of iodine and 1% of particulates of an equilibrium core diluted in the volume of the reactor coolant only. Waste storage capacity is provided by a 250 gallon tank which will handle approximately one week of sampling operation (prior to pumping liquid waste back to the drywell). Wastes are returned either to the plant waste streams for treatment or the drywell sump. Safety features are incorporated for handling of the combustible gas mixtures potentially generated during a post-accident sampling operation.

The HRSS is classified as non-safety-related except where tie-ins are made to a safety-related system. In the latter case, the sample piping up to the first remotely operated isolation valve is classified as safety-related. The sampling system piping and supports are designed to ANSI B31.1. The system components are not designed to seismic Category I requirements but do consider seismic loads due to the potential of routing over safety-related systems. All HRSS piping in the reactor building is seismatically supported.

All components, with the exception of tubing and valves in the reactor building, are located in the HRSS building. The HRSS building temperature is maintained at approximately 75°F. Maintaining the HRSS building at approximately 75°F is based on general habitability of the HRSS building and is not associated with a specific system design or operating limit. No severe environmental conditions are imposed on the design of the system components. The heating, ventilation, and air conditioning (HVAC) equipment is located outdoors and is designed for -20 — 105°F, and considers snow and wind loads. [9.3-25a]

9.3.2.1.2 <u>Function</u>

The major functions of the HRSS are as follows:

A. Obtain a post-accident reactor coolant grab sample in a shielded container suitable for transport to an onsite or offsite laboratory for analysis; [9.3-26]

B. Provide for storing and handling of the disposed sample wastes;

C. Provide for reactor coolant sampling during normal plant operation; and

D. Obtain a grab sample of the containment atmosphere in a shielded container suitable for transport to an onsite or offsite laboratory for analysis. [9.3-27]

9.3.2.1.3 Process Description

The objectives of the HRSS are to accomplish the following operations both in normal and post-accident conditions: [9.3-28]

A. Transfer the sample fluid from the source to the sampling area;

B. Control the temperature and pressure of the sample;

C. Manual capture of liquid and gaseous samples for onsite or offsite analyses; and

D. Store, handle, and return to the plant waste generated by the sampling operations.

9.3.2.1.3.1 Sample Transfer

The sample is transferred from the source to the sampling panel through stainless steel tubing. Optimum sample velocities have been specified to minimize settling and plateout, and to keep radwaste lines from clogging. The sample points are as follows: The reactor pressure vessel, the residual heat removal system (RHR), the reactor water cleanup system (RWCU), which all belong to the reactor coolant sampling module; the demineralizer reactor coolant sampling module; and the emergency core cooling system (ECCS) fill pump sample which belongs to the radwaste module. [9.3-29]

The equipment parameters and data for each component are listed in Table 9.3-1. See P&ID M-1065 for a general layout of the HRSS. [9.3-30]

9.3.2.1.3.2 Temperature Control

Cooling of the sample fluid to 120°F or less has been provided for liquid sample lines having a post-accident temperature greater than 120°F. The cooling is accomplished by shell- and tube-type heat exchangers. There are two parallel banks of five coolers connected in series on the cooling water side.

The sample cooling water is provided by a chilled water system as shown in P&ID M-1059. This system includes two redundant air-cooled condensing units and direct expansion coils which are immersed in the two chilled water storage tanks. The chilled water is constantly recirculated and passed through the expansion coils by a set of recirculation pumps. A second set of pumps provide a chilled water supply to the sample cooling rack. The temperature of the chilled water is maintained at 60°F. Thermal storage capacity is provided in the tanks which will allow obtaining at least two high temperature samples even in the event of complete failure of the refrigeration equipment.

9.3.2.1.3.3 Liquid Sampling

Refer to Table 9.3-1 for information related to this material.

The sample extraction takes place in the liquid sampling panel (LSP). The LSP is a free-standing, self-supporting structure containing the necessary sample tubing, valves, and gauges within a totally enclosed panel. To avoid cross contamination between high purity and low purity sample fluids, the incoming sample lines are grouped into categories and are hydraulically separated within the panel. The LSP contains the following three distinct and hydraulically separate modules installed in a common frame. [9.3-31]

1. Reactor coolant sampling module — the reactor coolant sampling module can accept five (including 1 spare connection) different sources of primary reactor coolant entering (only one at a time) at a maximum of 120°F and 1600 operating (2300 design) psig. Design flow rates through the panel are: 1900 cc/min during purging, and 200 cc/min during sampling. The module has power operated valves to automatically stop either purge or sample flow in the event of excessive sample temperatures resulting from failure of the chilled water system. [9.3-32]

2. Demineralizer reactor coolant module — the demineralizer module can accept three (including 1 spare connection) different sources of reactor coolant from the reactor water cleanup demineralizers entering (only one at a time) through the sample coolers. Design flow rates are: 1900 cc/min during purging and flushing and 200 cc/min during sampling. The only type of sampling capability provided is an open depressurized grab sample for routine sampling.

3. Radwaste module — the radwaste module has the capacity to accept ten (including seven spare connections) different water sources entering at 120°F and 150 psig. Design flow rates are 1900 cc/min during recirculating mode and 200 cc/min during sampling.

The LSP has the following capabilities: [9.3-33]

A. For routine, nonaccident sampling, depressurized reactor coolant samples can be captured as an open grab sample.

B. For post-accident sampling, undiluted depressurized reactor coolant can be captured in a sealed bottle. The bottle is remotely lowered into a shielded cask. The cask is removed from the panel. The sealed bottle is then removed and transported to the counting facility, laboratory, or offsite for analysis.

C. For post-accident sampling, a diluted depressurized sample can be captured in a sealed bottle and lowered into a shielded cask. The cask is removed from the panel. The sealed bottle is then removed and transported to the counting facility laboratory, or offsite for analysis.

The reactor coolant sample is drawn from the existing sample point on the recirculation loop. Sampling of reactor coolant under post-accident conditions does not require the startup of any isolated auxiliary system. Approximately 4 to 10 hours after accident scenario initiation, RHR shutdown cooling can be placed in service and a reactor coolant sample can be obtained via the RHR HX ‘A’ and ‘B’ sample points. The containment isolation valves on the sample line can be remotely opened from the control room to allow the reactor coolant sample to flow to the HRSS.

The sample lines are 1/2-inch OD stainless steel tubing of all welded construction up to the sample panels, with one exception. For ease of replacement, compression fittings may be used for sample line isolation valve connections. The HRSS panel sample lines can be flushed with demineralized water, and the purge and flush volumes can be stored in the waste tank in the HRSS building before pumping the wastes to the drywell floor drain sump or to the reactor building equipment drain tank. The design minimizes the potential for leakage of samples. Should a rupture of the reactor coolant line occur within the HRSS building, the containment isolation valves can be remotely closed and the liquid contained in the HRSS building sump or waste tank.

9.3.2.1.3.4 Section Deleted

9.3.2.1.3.5 Containment Air Sampling Panel

The containment air HRSS consists of two distinct subsystems: A sample point selection and header system, and a post-accident grab sample panel called the containment air sampling panel (CASP). These systems are utilized in various combinations during post-accident conditions. The containment air HRSS is operated from the containment air sample (CAS) control panel which integrates the functions of the three subsystems. [9.3-34]

The panel is an enclosed cabinet with provisions for locating and connecting a container for collecting a sample. The panel encloses a network of valves, tubing (1/4-inch OD stainless steel), fittings, instruments, and quick-connect couplings arranged so that all sampling operations can be performed manually or by an automatic sequence programmer. [9.3-35]

The sample line is a 1/2-inch OD stainless steel tubing tied into existing sample points downstream of the containment isolation valves. To minimize plateout, the sample tubing is run with large radius bends, flow velocities are maintained at 10 ft/s and the tubing is heat traced to maintain it at 275°F. To minimize sample loss, welded tubing is used up to the panel.

No isolated auxiliary system is required to be operational for sampling the containment air. The containment isolation valves on the sample lines can be opened from the control room to allow a sample to be taken.

9.3.2.1.3.6 Waste Handling

The HRSS waste handling system is provided to handle both liquid and gaseous wastes resulting from the sampling operations. In addition to the spent sample itself, waste is generated in the purging of the sample lines in order to obtain a representative sample. At the conclusion of the sampling sequence, the lines are flushed to reduce the background level of activity. Approximately 10 gallons of fluid are generated per sample extraction.

The waste handling system consists of a 250-gallon stainless steel collection tank supplied with two horizontal centrifugal discharge pumps. Liquids enter the tank via a 2-inch drain header. The discharge of the tank is directed to the reactor building equipment drain tank during normal operation and may be directed into the drywell floor drain sump during the post-accident mode. [9.3-36]

During post-accident conditions, the incoming samples may contain large quantities of dissolved hydrogen which will accumulate in the waste tank. Additionally, the noble gases dissolved in the sample will also be stripped and will accumulate in the tank. To control the concentration of these gases, inerting and evacuation features are provided. Since the hydrogen concentration can be approximately 30% by volume, the tank is inerted with nitrogen prior to filling to preclude an explosive gas mixture. Since the tank's atmosphere is not monitored, a rupture disc is provided as backup in the event of detonation of a combustible mixture in the tank. For control of gaseous radionuclides, an evacuating compressor will vent the tank's contents back to the drywell.

During normal operation, the tank is vented to the HRSS building HVAC and operates on a nominal 1/4-inch H_2O negative pressure.

9.3.2.1.3.7 Control and Monitoring Panels

Two individual control panels for the operation of the LSP and CASP are located in the operating area of the HRSS building and shielded from the sample panels by a 3-foot thick concrete wall. Under post-accident conditions, most of the operations for sampling and monitoring are performed from the following panels to limit the radiation dose to the technician from the radioactive fluids in the sample panels. [9.3-37]

A. High radiation sampling system control panel — the HRSS control panel consists of three sections. Annunciator windows indicating various alarm conditions are located in the top section. The midsection contains a graphic layout displaying the liquid sample system flow paths, valves, pumps, and other equipment. All hand switches with indicating lights for operating valves, pumps, and HVAC equipment are located in the lower section of the control panel.

B. Containment air sampling panel control panel — the CASP control panel contains selector switches, timers, pilot lights, an annunciator system, pressure controller and gauge, and an electro-mechanical programmer. A mimic diagram of the CASP flow paths, valves and equipment is also provided on the panel. The technician uses this control panel to select, initiate, and control sample filling exercises.

9.3.2.1.3.8 Motor Control Center

The motor control center (MCC) is located in the operating area and provides a 480-V power supply to the HRSS and HVAC equipment and a 208/120-V power supply for controlling lighting, and heat tracing the sample tubing.

This MCC is powered from 480-V bus 15 (Unit 1) or bus 25 (Unit 2). In the event of offsite power failure, standby diesel power is available for the HRSS and the MCC can be energized for sampling under post-accident conditions.

9.3.2.1.4 High Radiation Sampling System Building Environmental Control

The Unit 1 and 2 HRSS building HVAC systems provide heating and cooling, filtered and unfiltered exhaust systems, and positive control of airflows. Conditioned air is supplied to the HRSS building to offset the environmental and internal loads seen by the building. In addition, air is exhausted from the sample panels to control internal leakage. The exhaust air may be passed through a combined high efficiency particulate air (HEPA) and activated carbon filter train. The Unit 1 and 2 HRSS building ventilation systems are shown in P&IDs M-1058, and M-1063. [9.3-38]

A single filter bypass fan is provided for routine operation to prevent the filters from loading. Control of airflows is provided to assure that the HRSS building is maintained at a negative pressure with respect to the environment. The exhaust air flow rate is maintained at 1000 ft^3/min while the intake air flow rate is maintained at an adjustable differential to assure infiltration into the HRSS building.

To control airborne contamination, the building ventilation is designed such that the air flows from the lesser to the higher contaminated zone, i.e., from the vestibule to the operating area to the maintenance aisle and finally to the pit where it is exhausted outside the building. For enhanced reliability, redundant exhaust fans are provided on

the filtered train. The exhaust is routed to the stations's 310-foot chimney and is tied into the ventilation duct in the base.

9.3.2.1.5 General Arrangement

The HRSS components for each unit are housed in a dedicated building which is located adjacent to each respective reactor building. A connecting trench is provided for extending the piping and electrical lines from the reactor building to the HRSS building.

The HRSS building is designed in accordance with the Uniform Building Code requirements for Zone I. The HRSS building for Unit 1 is located south of the reactor building and the HRSS building for Unit 2 is located north of the reactor building as shown in Figure 9.3-5. Each building is free standing and arranged into four separate areas as shown in Figure 9.3-6 and as described in the following. [9.3-39]

The HRSS building equipment layout is based on dividing the building area into the following four distinct radiation zones;

1. The vestibule area — where preparations are made for entry to the sampling areas. The building is entered through the vestibule area which contains a clothing change area and radiation monitoring equipment. The vestibule is separated from the operating area by a wall with a door.

2. The operating area — where all control and sampling manipulations at the panels are performed. The operating area contains the control panels for liquid and containment air sampling, the motor control center, the LSP and the CASP. The HVAC system control panel is located adjacent to the vestibule. An aisle in front of these panels is provided for manual operations such as valve alignment at the panels, calibration, and shielded cask cart movement.

3. The maintenance aisle — which serves as access to the rear of the sampling panels for maintenance purposes. The maintenance aisle behind the sampling panels is separated from the operating area by a combination of concrete shield walls and a shield door.

4. The pit area — which contains the waste tank and pumps, and serves as the pipe and valve gallery. The pit area houses the sample waste tank, the waste pumps, the sample coolers, the chilled water system, and the HRSS building sump. This area is adequately shielded in view of the very high radiation levels associated with post-accident sample wastes that are collected in the waste tank. A 5-foot wide, 3-foot deep concrete trench with 2-foot thick concrete removable covers connects the reactor building and the pit area. Piping carrying process samples, demineralized water, instrument air and other services, and electrical power and control cables are located in the trench.

The interior finishes of the HRSS building are sealed and painted to provide for easy decontamination of wall and floor surfaces. This will provide surfaces which will minimize the penetration of any spilled radioactive liquids into the concrete and allow ease of decontamination of areas.

The CASP grab sample module is located in the shielded area and a gas partition sampler is connected to the sample module. [9.3-40]

The CAS control panel is located in the operating space area. All of the CASP operations, with the exception of the operations mentioned above, are performed in this space.

Gas cylinders required for operation of the CASP are located adjacent to the HRSS building in an unlimited access low traffic area.

9.3.2.1.6 Radiation Shielding

The HRSS is designed to provide a technician with the capability to extract, and dispose of samples of reactor coolant and containment atmosphere during post-accident conditions with radiation exposures well below the criteria of General Design Criteria (GDC) 19 (10 CFR 50, Appendix A). [9.3-41]

9.3.2.1.6.1 Design Criteria

The following criteria was used in the design of the shielding for the HRSS building, the sample panels, and sampling methods:

A. The design objective is to limit whole body exposure within GDC 19 limits;

B. Building shielding is designed such that the dose rate is 15 mrem/hr in general occupancy areas and 100 mrem/hr in areas infrequently occupied except directly in front of the sample panels;

C. Reactor coolant source term is based on the release to the coolant of 100% of the noble gas radionuclides, 50% of the halogen radionuclides, and 1% of the particulate radionuclides in an equilibrium reactor core operating at 3016 MWt; and

D. Containment atmosphere source term is based on the release to the containment of 100% of the noble gas radionuclides and 25% of the halogen radionuclides in an equilibrium core operating at 3016 MWt.

9.3.2.1.6.2 Building and Equipment Shielding

The HRSS building is provided with 3-foot thick external walls and a 2-foot thick roof to limit the radiation dose inside the building due to the post-accident radiation sources within the reactor building. Within the HRSS building, concrete shield walls protect the technician in the operating area from radiation sources due to sample flow in tubing, panels, and waste collection tanks.

The LSP is provided with a front panel shield consisting of 7 inches of lead shot sandwiched between two 1/2-inch steel plates. Shield glass viewing ports are provided for observing the sample bottle needle area and the gauges. The integral steel base consists of 5 inches of lead shot sandwiched between two 1/2-inch steel plates.

The CASP has a front panel of 3-inch thick steel plate which provides adequate shielding from the volume of post-accident containment atmosphere present in the CASP hardware.

The sample tubing raceway in the maintenance aisle is provided with a 4-inch thick steel cover to reduce the dose contribution from this source. To prevent radiation streaming from the gaps around the LSP or CASP, these gaps are packed with lead wool.

9.3.2.1.7 Section Deleted

9.3.2.1.7.1 Section Deleted

9.3.2.1.7.2 Section Deleted [9.3-42] [9.3-43] [9.3-44]

9.3.2.2 Additional Sampling Panels

Although the main post accident sampling panel for the plant is the HRSS, several other sample panels also provide for normal plant process sampling capabilities. These are described below.

9.3.2.2.1 Turbine Building Sample Panel

The turbine building sample panel provides continuous monitoring of the following parameters for each unit. The effluent of all eight condensate demineralizers is monitored for conductivity. The condensate demineralizer effluent header is monitored for conductivity and dissolved oxygen. A high conductivity condition is annunciated by an alarm in the control room. The condensate pump discharge is monitored for conductivity and annunciates a high conductivity condition alarm in the control room. The reactor feedwater is monitored for conductivity and dissolved oxygen. The turbine building sample panel is configured so a grab sample can be taken from any stream being sampled. All continuously monitored parameters (conductivity and dissolved oxygen) are recorded in the chemistry office. The panel provides all necessary cooling and pressure control of the sample streams. [9.3-45]

9.3.2.2.2 Reactor Building Sample Panel

The reactor building sample panel provides continuous monitoring of the following parameters for each unit. The reactor water recirculation flow is monitored for conductivity. The reactor water cleanup filter demineralizer inlet is monitored for conductivity, dissolved oxygen and pH. A high conductivity condition is annunciated in the control room. The effluent of each of the reactor water cleanup filter demineralizers is monitored for conductivity and annunciates a high conductivity condition by an alarm in the main control room. The fuel pool filter demineralizer inlet and outlet are monitored for conductivity. The control rod drive water is monitored for conductivity and dissolved oxygen. The reactor building sample panel is configured so a grab sample can be taken from any stream being sampled. All continuously monitored parameters (conductivity, dissolved oxygen and pH) are recorded in the chemistry office. The panel provides all necessary cooling and pressure control of the sample streams. [9.3-46]

9.3.2.2.3 Radwaste Building Sample Panel

The radwaste building sample panel provides grab sample points for the following: [9.3-47]

A. Two waste sample tanks,

B. Two floor drain sample tanks,

C. Waste demineralizer outlet,

D. Floor drain filter outlet,

E. Floor drain collector pump discharge,

F. Chemical waste tank,

G. Waste collector filter outlet, and

H. Waste collector pump discharge.

A sample station is also supplied for obtaining a sample from the two laundry drain tanks. This panel is common to both units and does not contain continuous monitoring instruments or any cooling capability. A sample station is also provided for obtaining samples in the radwaste tank farm tank. This station provides grab samples for the following:

A. Chemical waste sample tank,

B. Laundry drain sample tank, and

C. River discharge tank.

9.3.3 Equipment and Floor Drainage System

The objective of the equipment and floor drainage system is to collect and control all waste liquids and ensure they are processed or disposed of properly. The system drain sumps also provide detection of leakage from other systems. The sumps are sampled periodically to assist in the determination of leakage sources. [9.3-48]

The equipment and floor drainage systems consist of equipment and floor drains in the drywell, reactor building, turbine building and radwaste building, and a laundry sump in the service building. Radioactive waste sumps associated with the drainage systems are used to accumulate and transfer the liquids collected from the reactor process systems. These liquids are processed according to their purity (conductivity levels), therefore, it is necessary to segregate the collective process as much as possible in order to provide a safe, efficient and economical method of treatment.

In general the collected liquids are divided as follows:

A. The equipment drains/sumps normally contain low conductivity waste. Process fluids collected in the equipment drain sumps are generally at elevated temperatures which, in some cases, require a cooler. Liquid into an equipment drain system typically comes from anticipated equipment leakage, such as pump seal leakoff, vents and drains from major pieces of equipment, and relief valve outlets, which are hard-piped directly to the drain system.

B. The floor drains/sumps normally contain liquid with a higher conductivity level than the equipment drains/sumps. Liquid flowing into the floor drain system typically comes from the floor drain hubs and reflects leakage from anticipated equipment leakage, such as vents and drains from major pieces of equipment and unanticipated sources which are not hard-piped into the drain system.

C. The service building laundry drain/sump normally contains liquid with higher conductivity levels. Liquids flowing into the laundry drain/sump typically comes from anticipated equipment leakage, such as laundry drain pump packing leakoff and laundry drain tank drains.

The various drain systems and sumps are addressed in the following subsection. The processing of the collected liquids is discussed in Section 11.2. The primary containment isolation system is covered in Section 7.3.

9.3.3.1 Drywell Equipment Drains and Sumps

Each unit has one drywell equipment drain sump (DWEDS) with two pumps located in the basement of the drywell, north side. A heat exchanger cooled by reactor building closed cooling water (RBCCW) provides temperature control of the DWEDS by automatically opening a heat exchanger recirculation valve on the discharge of the pump, and closing the discharge to radwaste valve when the high temperature setpoint is reached. Once the temperature of the water in the sump is reduced to an acceptable level, flow is automatically established to radwaste. High temperature setpoint for the automatic recirculation valve is adjustable in the control room. A high temperature alarm is also provided. [9.3-49]

The equipment drain sump can be used in combination with other leak detection equipment to determine the source of leakage in the drywell. Leakage into the equipment drain tank is considered identified leakage and is composed of the normal pump seal and valve packing leakage and does not represent a safety consideration as long as the leakage is small compared to the reactor coolant makeup capacity available.

Drywell equipment drain sump pump indication and controls are located in the main control room. Flow from the DWEDS is used to determine total primary system leakage for comparison to Technical Specification limits. Total flow can be determined by the flow integrator in the main control room or by measuring the duration to manually pump the sump. [9.3-50]

The drywell equipment drain liquid is pumped to the waste collector tank through a common line with the reactor building equipment drains. The primary containment isolation valves in the DWEDS discharge line are normally closed when not pumping the DWEDS. When the unit is in operating mode 1, 2 or 3, the DWEDS are pumped down periodically by manually opening the DWEDS containment isolation valves from the Main Control Room and manually starting the DWEDS pump(s) or one sump pump starts automatically on a sump high level signal with the second pump starting on a sump high-high level signal. A high-high level alarm is provided in the main control room. The pumps trip on sump low level or when the primary containment valves are closed. This line can be cross-connected with the floor drain system to pump to the floor drain collector tank. [9.3-51]

Drywell equipment drain sump containment isolation valves close when a Group 2 primary containment isolation signal is received and fail closed on a loss of instrument air. This not only isolates the drywell but also prevents pumping potentially contaminated liquid from the drywell. For this reason a seal-in circuit is included on these valves to keep the valves closed after the isolation signal is reset. [9.3-52]

9.3.3.2 Drywell Floor Drains and Sumps

Each unit has one drywell floor drain sump (DWFDS) with two pumps located in the basement of the drywell, south side. Flow into the DWFDS is considered unidentified leakage. Drywell floor drain sump pump controls are located in the main control room. [9.3-53]

Flow from the DWFDS is used to determine if unidentified leakage exceeds Technical Specification limits. Total flow can be determined by the flow integrator in the main control room or by measuring the duration to manually pump the sump.

The DWFDS can be pumped to the floor drain collector tank or the waste collector tank. The primary containment isolation valves in the DWFDS discharge line are normally closed when not pumping the DWFDS. When the unit is in operating mode 1, 2 or 3, the DWFDS are pumped down periodically by manually opening the DWFDS containment isolation valves from the Main Control Room and manually starting the DWFDS pump(s) or one sump pump starts automatically on a sump high level signal with the second pump starting on a sump high-high level signal. A high-high sump level alarm is provided in the main control room. The pumps trip on sump low level or primary containment valves not fully open. [9.3-54]

Drywell floor drain sump containment isolation valves close when a Group 2 primary containment isolation signal is received and fail closed on a loss of instrument air. As with the equipment drains, the signal not only isolates the drywell but also prevents pumping potentially contaminated liquid from the drywell. The same seal-in feature is used as with the equipment drains. [9.3-55]

9.3.3.3 Reactor Building Equipment Drains and Tanks

Each unit has one reactor building equipment drain tank (RBEDT) located in the reactor building basement:

A. Unit 1 RBEDT is located in the 1B core spray pump room.

B. Unit 2 RBEDT is located in the 2A core spray pump room.

The single pump on each tank starts automatically on a high tank level signal or high tank temperature signal and trips on low tank level signal or low tank temperature signal. [9.3-56]

A heat exchanger cooled by RBCCW provides temperature control of the RBEDT fluid by automatically opening a heat exchanger recirculation valve on the discharge of the pump, and closing the discharge valve to radwaste when the high temperature setpoint is reached. The temperature switch will also start the pump if it is not running. Once the temperature of the water in the tank is reduced to acceptable level, flow is rerouted to radwaste, unless the heat exchanger recirculation loop was started by the temperature switch, in which case the pump trips. The high temperature setpoint for the automatic recirculation valve is adjustable in the main control room. The discharge valve fails open on loss of air while the recirculation valve fails closed. The RBEDT pump is interlocked off when a Group 2 primary containment isolation signal is received. [9.3-57]

The reactor building equipment drain liquid is normally pumped to the waste collector tank through a common line with the drywell equipment drains. A run time meter is provided to monitor the flow to the collector tank. A high temperature alarm is provided in the main control room. [9.3-58]

9.3.3.4 Reactor Building Floor Drains and Sumps

Each unit has two reactor building floor drain (RBFD) sumps with one pump in each sump. Both sumps are located in the reactor building basement with RBFD Sump A being on the north side and RBFD Sump B on the south. [9.3-59]

The reactor building floor drain liquid is normally pumped to the floor drain collector tank through a common line with the drywell floor drains. A run time meter is provided to monitor the flow to the floor drain collector tank. In each sump, the pump will start on a high sump level signal and trip on a low sump level signal. The pumps will also trip when a Group 2 primary containment isolation signal is received. A high sump level alarm is provided in the main control room. [9.3-60]

9.3.3.5 Turbine Building Equipment Drains and Sumps

Each unit has one equipment drain sump with two pumps located in the condensate pump pits (547 ft 0 in. elevation). Sump pumps are started automatically by a float switch. One sump pump starts on sump high level signal and the second pump starts on sump high-high level signal. A high-high sump level alarm is provided in the main control room. Both pumps trip on sump low level. Run time indication is provided in the radwaste control room. Normally, the sump pump discharge is directed to the waste collector tank; however, flow can be directed to the floor drain collector tank. [9.3-61]

9.3.3.6 Turbine Building Floor Drains and Sumps

Each unit has one floor drain sump with two pumps located in the condensate pump pit. Sump pumps are started automatically by a float switch. One pump starts on a high sump level signal and the second pump starts on high-high sump level signal. A high-high sump level alarm is provided in the main control room. Both pumps trip on sump low level. Run time indication is provided in the radwaste control room. Normally, the sump pump discharge is directed to the floor drain collector tank; however, flow can be directed to the waste collector tank. [9.3-62]

9.3.3.7 Radwaste Equipment Drains and Sump

The radwaste equipment drain sump is located in the radwaste building basement near the west wall. The main inputs to the radwaste equipment sump are various radwaste tank drains and overflows. The sump has a pump controlled by a float switch which automatically starts the pump on a sump high level signal and stops the pump on a sump low level signal. Run time indication is provided in the radwaste control room. A high sump level alarm is provided in the radwaste control room. Normally, the sump pump discharge is directed to the waste collector tank; however, flow can be directed to the floor drain collector tank. [9.3-63]

9.3.3.8 Radwaste Floor Drains and Sumps

Two sumps, each with one pump, are located in the radwaste basement, near the west wall. These two sumps are tied together internally. Each pump is started automatically by a level float switch on a high sump level signal and trips on a low sump level signal. Run time indication is provided in the radwaste control room. A high sump level alarm is provided in the radwaste control room. Normally, the sump pump discharge is directed to the floor drain collector tank; however, flow can be directed to the waste collector tank. [9.3-64]

9.3.3.9 High-Pressure Coolant Injection Room Floor Drains and Sumps

Each unit has one sump and sump pump located in their respective HPCI rooms. Each sump pump is started automatically by a float switch on a high level signal and the pump trips on a low level signal. Run time indication is provided in the radwaste control room. Normal flow is directed to the reactor building floor drain sump; however, flow can also be directed to the floor drain collector tank. A high sump level alarm is provided in the main control room. [9.3-65]

9.3.3.10 Laundry Room Sump

The laundry room sump is located in the basement of the service building and contains a single pump. The pump is automatically controlled by a float switch which starts the pump on a high sump level signal and trips the pump on a low sump level signal. Run time indication is provided in the radwaste control room. A high sump level alarm is provided in the radwaste control room. The laundry room sump pump discharges to the laundry drain tanks. [9.3-66]

9.3.4 Chemical and Volume Control System

This section is not applicable to the Quad Cities Station.

9.3.5 Standby Liquid Control System

9.3.5.1 Design Bases

The standby liquid control (SBLC) system fulfills three performance objectives.

The first performance objective of the SBLC system is to provide the capability of bringing the reactor from full power to a cold, xenon-free shutdown condition, assuming that none of the withdrawn control rods can be inserted. This is accomplished by injecting a quantity of boron which produces a boron concentration of no less than 600 ppm in the reactor core. [9.3-67]

The quantity of liquid control is determined by the negative reactivity required to render and maintain the reactor subcritical with the control rods withdrawn to their full power position. Allowance for leakage and nonuniform mixing of the liquid poison injected into the reactor coolant has been provided.

To accomplish this objective, the SBLC system was originally designed to supply a minimum of 3470 gallons of 13.4%, or equivalent, sodium pentaborate solution. The liquid control solution injection rate is 40 gal/min (1 pump flowrate) through either train of redundant pumps and valves. [9.3-68]

The second performance objective of the SBLC system is to respond to anticipated transient without scram (ATWS) conditions specified in 10 CFR 50.62. An operational criterion imposed by 10 CFR 50.62 requires the system to deliver 86 gal/min of 13 weight percent (minimum) sodium pentaborate solution containing natural B-10 or equivalent. To meet this objective, Quad Cities Units 1 and 2 have modified the content of the SBLC tanks to utilize sodium pentaborate solution enriched to ≥ 45 atomic % B-10. At 14 wt % (minimum) solution, a system flow rate (using a single pump) of 40 gal/min of the ≥ 45 atomic % B-10 provides the reactivity control that is equivalent to 86 gal/min of a 13 wt % naturally enriched solution.

Based on the 14 wt % concentration, the minimum net volume available for injection is 3254 gallons. An additional volume is contained below the pump suction and is not available for injection. [9.3-69]

The third performance objective of the SBLC system is to maintain the pH of the suppression pool at a value greater than 7 in the event of a design basis LOCA. Following a DBA LOCA, the required volume of sodium pentaborate is injected into the reactor (and ultimately flushed to the suppression pool via ECCS flow) to maintain the suppression pool pH at a value greater than 7. This action ensures that the iodine deposited into the pool during a DBA LOCA does not re-evolve and become airborne as elemental iodine. This SBLC function is credited in the radiological assessments performed as part of Alternative Source Term (AST) – see UFSAR Section 15.6.5.5.

9.3.5.2 System Design

The equipment for the SBLC system is located in the reactor building and consists of an unpressurized tank for low temperature sodium pentaborate solution storage, a pair of positive displacement pumps, two explosive-actuated shear plug valves, the injection sparger inside the reactor vessel, and the necessary piping, valves and instrumentation. The SBLC system is shown on UFSAR Figure 9.3-7 and P&ID M-40 and M-82. Table 9.3-2 summarizes the principle design parameters. [9.3-70]

The liquid control tank is complete with a top cover, vent and drain. The pump suction line is arranged and constructed to minimize entry of particulate material which might settle on the tank bottom. A heater is provided to heat the water during initial mixing and to maintain temperature as required to prevent solution crystallization during normal operation. An air sparger is provided in the tank bottom to assist with mixing. The tank has a nominal capacity of 5000 gallons. The neutron absorber solution used is at least a 14% solution (by weight), with a minimum saturation temperature of 64^{o}F. The ambient temperature of the solution is maintained above the minimum saturation temperature as defined by Tech Specs by the immersion heater in the solution tank. Temperature and liquid level alarms for the system are annunciated in the control room. Heat tracing is also provided on all pipes normally filled with the solution to keep temperatures high enough to prevent the solution from crystallizing. [9.3-71]

The sodium pentaborate solution is delivered to the reactor by one or both of two 40-gal/min, 1602 psi, positive displacement stainless steel pumps. The pumps and piping are protected from overpressure by two relief valves which discharge back to the liquid control tank.

The explosive valves are double squib-actuated shear plug valves. A low current electrical monitoring system gives visible (pilot light) indication of circuit continuity through both firing squibs in each valve. [9.3-72]

The operator operates a five position key switch if it is determined that neutron absorber solution should be injected into the reactor. A turn from off to the first position (single pump position) in either direction starts one pump and opens one of the two parallel valves for use in terminating an anticipated transient without scram (ATWS) event (Figure 9.3-8). See Sections 7.8 and 15.8 for additional description of ATWS. Turning the switch to the second position on either side of off (two pump position) starts both pumps and opens both valves for use in alternate water injection for vessel level control. Use of the key switch minimizes the probability of an accidental injection of the neutron absorber solution. The admission valves for this system are of the explosive type to provide a high assurance of opening when actuated and to ensure that no boron will leak into the reactor when the system is being tested. [9.3-73]

A test tank and demineralized water supply are an integral part of the system to facilitate system testing and flushing. [9.3-74]

Should the SBLC system ever be used to shut down the reactor, the sodium pentaborate would be removed from the primary system by flushing for gross dilution and by operation of the reactor water cleanup system for final polishing. [9.3-75]

9.3.5.3 Design Evaluation

The reactivity requirements for the SBLC system are sufficient to shutdown the reactor from full power to a cold, xenon-free shutdown in the absence of any control rod motion. A margin of 25% additional boron is added to compensate for leakage and possible imperfect mixing of the chemical solution in the water. The shutdown requirement can be achieved with 600 ppm boron in the moderator. For the controlling case, with a normal reactor vessel level, a net quantity of 3254 gallons of solution above the pump suction at less than or equal to 110°F and having a 14 weight percent sodium pentaborate concentration is required. [9.3-76]

At an injection rate of 40 gal/min, the time required to inject sufficient boron to override the rate of reactivity insertion due to cooldown of the reactor following the xenon peak from full rated power is approximately 83 minutes. [9.3-77]

An evaluation was performed on the simultaneous operation of both SBLC pumps to determine if the required amount of solution could be delivered under all conditions. One concern addressed was the net positive suction head (NPSH) available as a function of temperature to ensure sufficient NPSH exists for the expected ATWS pump operation. Technical Specification requirements for minimum solution volume, based on existing solution temperature and concentration, ensure that adequate net positive suction head exists for two pump operation. An acceptable operating region has been defined to meet both the reactivity and NPSH requirements discussed above. SBLC storage tank level and temperature requirements are specified for sodium pentaborate concentrations in the range of 14 to 16.5%. [9.3-78]

Since the SBLC system is to be operable in the event of a loss of off-site power, it can be powered from the diesel generator. The SBLC system is required to be operable in operating modes 1, 2, and 3. At least one pump and an explosive actuated shear valve must be operable for the system to function. [9.3-79]

The SBLC system is designed to Class I for all process equipment and to Class II for nonprocess equipment such as the test tank. Additionally, the system has no active components in the drywell that could fail during an event so as to disable the system. [9.3-80]

9.3.5.4 Tests and Inspections

The system is tested periodically to verify the operability of all components. Several tests are used to verify component operability as outlined in the following paragraphs. [9.3-81]

Pump operability is verified periodically in accordance with the IST program using demineralized water and the test tank. After the pumps are isolated from the SBLC storage tank, each pump is run taking water from the test tank and returning it through a test flow meter back to the test tank. A valve downstream of the pumps is throttled to establish a given backpressure on the pumps. This test verifies pump flowrate at the necessary discharge pressure to ensure sufficient flow to the reactor vessel when needed. [9.3-82]

With the injection valves closed, each pump may be started locally and the solution pumped from the storage tank and returned to the tank. This demonstrates the ability of the solution to be removed from the tank and the operability of the pumps. By valving

out the SBLC supply and valving in the demineralized water supply, the system can be flushed to prevent any boron precipitation in the pumps and lines. [9.3-83]

The system can be tested for complete continuity during a shutdown when demineralized water can be pumped into the reactor vessel. At least once per 24 months, one of the subsystems, including an explosive valve, will be initiated, and it will be verified that a flow path from the pump to the reactor pressure vessel is available. The replacement charge for the explosive valve will be from the same manufactured batch as the one fired or from another batch that has been certified by having one of that batch successfully fired. Both loops will be tested in 48 months. This test verifies the flowpath to the reactor vessel and particularly the proper operation of the check valves in the drywell. [9.3-84]

The settings on the SBLC relief valves are checked in accordance with the Inservice Testing program. This test ensures that the setpoint is within the required range to prevent premature relief valve lifting which could cause return of the boron solution to the storage tank instead of the reactor vessel during injection.

A local leak rate test (LLRT) is performed on the containment isolation valves, two check valves located in series near the drywell penetration. [9.3-85]

Inservice Testing (IST) is performed on the pump discharge check valves to verify that they will fulfill their function. [9.3-86]

Boron concentration of the solution is periodically determined by chemical analysis. Tank level and solution temperature are checked at least once per day. [9.3-87]

Vibration data are taken on the system pumps periodically when flow tests are performed to support the inservice testing program. [9.3-88]

9.3.5.5 Instrumentation Requirements

9.3.5.5.1 Initiating Circuits and Control Logic

The SBLC system has no automatic start functions. The SBLC pumps and squib (explosive) valves are initiated manually from the control room via a five position keylock switch. The switch positions and their associated actions are: [9.3-89]

Position	Action
System 1 and 2	Initiates both pumps and fires both squib valves.
System 1	Initiates pump no. 1 and fires squib valve no. 1.
Off	Turns any running pump(s) off.
System 2	Initiates pump no. 2 and fires squib valve no. 2.
System 2 and 1	Initiates both pumps and fires both squib valves.

Each pump and its associated squib valve and control circuitry is powered from a separate 480-Vac motor control center. The alarms and instruments are powered from the 120 Vac instrument bus. A heater and automatic thermostat maintains the SBLC tank temperature. A local control switch may be placed in the ON position to bypass the thermostat and provide constant heating of the SBLC tank contents.

9.3.5.5.2 Bypasses and Interlocks

The SBLC system is interlocked with the reactor water cleanup (RWCU) system such that the RWCU isolates upon SBLC system initiation. The SBLC tank heater is interlocked with its tank level to turn the heater off when the tank level has dropped to a point near the top of the heater.

9.3.5.5.3 Operator Information

9.3.5.5.3.1 Control Room Indications

The following indications are provided in the control room:

Analog Information

A. Storage tank level,

B. Pump discharge header pressure, and

C. Explosive valves monitoring circuit current.

Indicating Lamps

A. Pump running status,

B. Squib valve continuity,

C. Position of injection line manual stop valve (in the drywell), and

D. Flow status.

Annunciators

A. The loss of continuity in either squib valve circuit,

B. Standby liquid storage tank high or low temperature,

C. Standby liquid suction lines high or low temperature, and

D. Standby liquid tank high and low level.

9.3.5.5.3.2 Local Indications

The following indications are provided locally:

A. Storage tank level,

B. Pump discharge header pressure, and

C. Storage tank temperature.

Table 9.3-1

HRSS EQUIPMENT PARAMETERS

Liquid Sample Panel	
Quantity	1 per reactor unit
Sample Inputs	
Reactor Coolant Module	5
Demineralizer Module	3
Radwaste Module	3
Design Pressure/Temperature	
Reactor Coolant Module	2300 psig/120°F
Demineralizer Module	1250 psig/120°F
Radwaste Module	150 psig/120°F
Materials	
Tubing	1/4-inch Type 304 SS
Shielding	
Panel	7-inch of 0.09-inch dia. lead shot
Base	5-inch of 0.09-inch dia. lead shot
Panel Walls	1/2-inch steel plates (2)
Dimensions	
Height	7 feet
Depth	4 feet
Width	8 feet
Ventilation	300 ft^3/min. through panel

Table 9.3-1 (continued)

HRSS EQUIPMENT PARAMETERS

2. <u>Containment Air Sample Panel</u>

Quantity	1 per reactor unit
Manufacturer	Sentry Equipment Corporation
Materials	
Tubing	1/4-inch Type 304 SS
Shielding Front Panel	3-inch thick steel plate
Dimensions	
Height	7 feet
Depth	2 feet
Width	3 feet
Ventilation	150 ft^3/min. through panel

Table 9.3-2

REACTOR CORE STANDBY LIQUID CONTROL SYSTEM
PRINCIPAL DESIGN PARAMETERS

<u>SYSTEM</u>	
Boron Concentration	600 ppm (see note 1)
Poison Injection Rate	40 gpm per pump
Poison Compound	$Na_2 B_{10} O_{16} – 10 H_2O$
Low Level Solution Volume @ 14%, including portion below pump suction level	3607 Gallons
Minimum Solution Concentration	14 wt %
Nominal Standby Liquid Control Tank Capacity	5000 Gallons
<u>PUMPS</u>	
Type of Pump	Triplex plunger
Number	2 (one required)
<u>Normal Operating Conditions (each pump)</u>	
Capacity	40 gpm
Total Developed Head	1602 psi
Suction Pressure	Atmospheric
Pumping Temperature	70°F
Type of Drive	Electric motor
<u>POWER SOURCES</u>	
Pumping and Control	Auxiliary or Diesel Generator

Notes:

1. The SBLC system is capable of injecting a minimum concentration of 600 ppm of enriched boron into the RPV under the controlling case described in UFSAR Section 9.3.5.3. The minimum concentration that can be injected into the RPV by SBLC when the tank is filled at these minimum conditions with a ≥ 45% B^{10} isotopic enrichment has the equivalent B^{10} concentration of 1398 ppm of natural boron material.

9.4 AIR CONDITIONING, HEATING, COOLING, AND VENTILATION SYSTEMS

The design objectives of the station heating, ventilation and air conditioning (HVAC) systems are to provide protection to plant personnel and equipment from extreme thermal environmental conditions and to provide personnel protection from airborne radioactive contaminants. To achieve these objectives the following design bases were used: [9.4-1]

A. The design of equipment and components complies with the requirements of the codes and standards that are applicable to each specific system such as:

   Underwriters Laboratory;

   National Bureau of Standards;

   American Society of Heating, Refrigerating and Air Conditioning Engineers.

B. A pressure differential is maintained at all times during plant operation between areas which are clean and normally accessible, and those areas designated as having the greatest contamination potential.

The reactor building ventilation system, the turbine building ventilation system, the radwaste building ventilation system, the off-gas filter building ventilation system, the off-gas recombiner rooms ventilation system, the maximum recycle radwaste building ventilation system and the maximum recycle radwaste solidification and handling buildings ventilation systems are independent from each other. Inlet air to these systems is filtered and then routed to areas of progressively greater radioactive contamination potential.

At a similar BWR-3 (Dresden Unit 2), the NRC reviewed the systems and components needed to perform safety functions as a part of the Systematic Evaluation Program (SEP) and documented the results in NUREG 0823. As part of this evaluation, in SEP Topic II-2.A, the NRC concluded that the extreme maximum and minimum temperatures for general plant design (i.e., HVAC systems) are appropriate in which the maximum temperature is equaled or exceeded 1% of the time and the minimum temperature is equaled or exceeded 99% of the time. The review of the HVAC systems was performed under SEP Topic IX-5 "Ventilation Systems."

9.4.1 Control Room Area HVAC System

The control room area HVAC system provides conditioned air for personnel comfort, safety, and equipment reliability. The operation of the system under normal conditions is discussed in this section. The operation of the system during an emergency is discussed in Section 6.4. [9.4-2]

9.4.1.1 Design Bases

The control room area HVAC system is designed to: [9.4-3]

A. Maintain the main control room within the general design temperature range of 70°F minimum and 80°F maximum while outside temperatures vary between –6°F and 93°F. This temperature range is loosely based on NUREG 0700 and ASHRAE 55-74. There are no specific habitability criteria applicable to operation of the control room HVAC system;

B. Provide adequate radiation protection to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of the General Design Criteria (GDC-19) or Standard Review Plan (SRP) 6.4 limits (refer to Section 6.4 and 15.6.5.5);

C. Provide protection from toxic gas release (refer to Section 6.4);

D. Provide protection from fire and smoke (refer to Section 9.5.1); and

E. Provide HVAC to the other rooms and areas within the control room area including the cable spreading room, auxiliary electric equipment room, computer room, the Train A HVAC equipment enclosure (during Train A operation), the Train B HVAC equipment enclosure (during Train B operation) and miscellaneous rooms.

9.4.1.2 System Description

The control room area HVAC system consists of two independent air handling units; one multizone unit (Train A) and one single zone unit (Train B). The multizone unit is the normal temperature control air distribution unit for the control room emergency zone, Train A HVAC equipment room, and the miscellaneous areas. The single zone unit serves the control room emergency zone when the multi-zone unit is not available. The single zone unit contains a supply fan, heating coil, cooling coil and a filter bank. The single zone unit is fully discussed in Section 6.4. The control room area ventilation system is shown in P&ID M-725.

Train B of the control room area HVAC system serves the control room emergency zone which consists of the control room, cable spreading room, auxiliary electric equipment room, old computer room, and the Train B HVAC equipment enclosure. The old computer room is an enclosed area located within the boundary of the auxiliary electric room and is part of the control room emergency zone. Under normal conditions, the Train A control room HVAC system serves the Train A HVAC equipment room, the control room, cable spreading room, auxiliary electric equipment room, old computer room and miscellaneous rooms 301, 302, 303, 304, 305, 306, and 308.

The control room area HVAC system for normal conditions includes the following equipment: [9.4-4]

A. Train A HVAC equipment including a filter, a 27,150 cfm nominal capacity inlet fan, steam coils, and chilled water coils.

B. Chilled water equipment including water chillers, compressors, condensers, pumps and an expansion tank; and

C. Isolation and flow control dampers.

The control room area HVAC equipment required for control room habitability under accident conditions is described in Section 6.4.

The Train A multizone air handling unit provides individual zone temperature control by blending air from the heating and cooling sections to satisfy individual room thermostats. The Train A multizone unit supplies conditioned air to five separate zones as follows:

Zone 1 — Control Room

Zone 2 — Train A HVAC equipment area

Zone 3 — Computer room

Zone 4 — Miscellaneous areas

Zone 5 — Auxiliary electric equipment room and cable spreading room

During cooling operation, the air is cooled and dehumidified by a chilled water cooling coil within the Train A air handling unit. During heating operation, air is passed over a steam coil within the Train A air handling unit. [9.4-5]

The system is sized to dissipate both the internal and external heat loads, within each space, to maintain habitability and equipment requirements. Return air from each zone is collected and routed back through a common duct system via a vane-axial return air fan.

During normal operation make-up air is provided to the control room area by outside air flow of 2000 cfm through the inlet damper, with the exhaust damper closed. The Train A air handling unit can be used to exhaust smoke from the control room area by opening the exhaust damper and fully opening the inlet damper. This automatic action will prevent the recirculation of smoke into any of the occupied areas while exhausting 100% of the return air outside the building. Further explanation of this smoke exhaust operation is provided in Section 6.4. [9.4-6]

9.4.1.3 Safety Evaluation

An evaluation of the control room area HVAC system during a design basis accident is addressed in Section 15.6.

9.4.1.4 Inspection and Testing Requirements

The control room area HVAC system is used continuously during normal plant operations. [9.4-7]

The control room air filter unit is periodically tested, as described in Section 6.5.1.

9.4.2 Spent Fuel Pool Area Ventilation System

The spent fuel pool area is served by the reactor building ventilation system (see Section 9.4.7).

9.4.3 Radwaste Area Ventilation Systems

This section describes the radwaste building ventilation systems.

The radwaste building is a common area for Unit 1 and Unit 2 and includes the following ventilation systems: [9.4-8]

A. The radwaste building ventilation system,

B. The radwaste control room ventilation system,

C. The maximum recycle radwaste building ventilation system, and

D. The maximum recycle radwaste solidification and handling building ventilation system.

9.4.3.1 Design Bases

The radwaste ventilation systems have been designed for the following conditions: [9.4-9]

Outside	Minimum –6°F Maximum +93°F
Occupied areas inside	Minimum 65°F Maximum 104°F
Other areas (cells and collector tank room)	Minimum50°F Maximum120°F

9.4.3.2 System Description

The radwaste building ventilation system has a nominal capacity of 35,000 cfm. The system includes stationary outside louvers, air filters, steam heating coils, three supply fans and four exhaust fans. The outside air is filtered, heated as necessary and distributed by supply air ducts and registers throughout the building. The air flow sequence starts from clean areas and moves progressively to areas of greater potential contamination. [9.4-10]

The radwaste building ventilation system exhausts air out of the building to the 310-foot chimney at a nominal flow rate of 40,000 cfm. The exhaust fans draw building air into the exhaust vents located throughout the building. Hood exhausts are provided for each solid waste filling station and separate exhausts are also provided for the drum filling hoppers and centrifuge. These exhausts are prefiltered locally in an accessible shielded location prior to being routed to the main exhaust duct. The building exhaust air is ducted through a set of prefilters and absolute filters to the exhaust fans and discharged to the 310-foot chimney.

The number of Radwaste supply and exhaust fans which are operated is based on outside air temperature, Radwaste building temperature requirements and Radwaste internal pressure requirements.

The radwaste area ventilation system is shown in P&IDs M-375, M-685, and M-688.

The absolute filters are high efficiency particulate air (HEPA) filters. The HEPA filters have a minimum certified efficiency of 99.9% on 0.3 micron particles by the Dioctyl-phthalate (DOP) smoke test. The prefilters have a minimum efficiency of 40% rated according to the National Bureau of Standards (NBS) atmospheric dust spot test. [9.4-11]

The radwaste control room ventilation system consists of controllable louvers, a pre-filter, a 6000 cfm nominal capacity supply fan, electric duct heaters and a cooling unit. The system is a recirculation system with about 600 cfm of outside makeup air supplied to make up for 400 cfm leakage and 200 cfm discharged out of the control room. [9.4-12]

The maximum recycle radwaste building ventilation system is supplied by a 2500 cfm nominal capacity air handling unit. The air is filtered by a prefilter and heated as necessary by electric duct heaters in the air handling unit. The air is discharged to air ducts throughout the building flowing from clean areas progressively to areas of greater potential contamination. The exhaust has a capacity of 6000 cfm and exhausts air from the maximum-recycle building to the 310-foot chimney. The system operates with 2 exhaust fans. Each fan is preceded by a prefilter and a HEPA filter to remove particulate from the air. The discharged air is used to temper the inlet air with an air-to-air heat recovery heat exchanger.

The maximum recycle radwaste solidification and handling building ventilation systems include two separate air handling units. The larger unit includes an outside air intake with fixed louvers, a prefilter, a nominal capacity 4000 cfm supply fan, electric duct heaters, duct work, dampers, an exhaust prefilter, a HEPA filter, and two 4000 cfm exhaust fans. One exhaust fan is required for normal operation with its discharge routed to the 310-foot chimney. [9.4-13]

The smaller unit includes an outside air intake with fixed louvers, an adjustable damper, a prefilter, a 2,400 cfm nominal capacity supply fan, an electric duct heater, an air conditioning unit, ductwork, dampers, and a 600 cfm nominal capacity exhaust fan. The primary function of this unit is to provide the control panel area and with 2400 cfm of conditioned air. Most of the exhaust air (1800 cfm) is recycled to the inlet filter. The remainder of the flow (600 cfm) flows through the storage tank area to the exhaust fan and is discharged through fixed louvers to the atmosphere.

9.4.4 Turbine Building Area Ventilation System

The turbine building area ventilation system includes the following systems: [9.4-14]

A. East turbine room ventilation,

B. West turbine room ventilation,

C. Turbine building exhaust,

D. Motor-Generator (M-G) sets ventilation (Abandoned),

E. Reactor feed pumps ventilation,

F. Safe shutdown pump room ventilation,

G. Battery room ventilation,

H. Computer uninterruptible power supply (UPS) and battery room ventilation, and

I. Computer room ventilation system.

The turbine building ventilation system is shown on FSAR Figure 9.4-1 and P&IDs M-372, M-374, and M-895.

9.4.4.1 Design Bases

The turbine building ventilation system has been designed for the following conditions: [9.4-15]

Outside	Minimum-6°F Maximum+93°F
Inside	Minimum+65°F Maximum+120°F

9.4.4.2 System Description

The east turbine room ventilation system for each unit has a nominal capacity of 75,000 ft^3/min. The system includes fixed louvers, air filters, steam coil, and two 100% capacity supply fans, one operating and one on standby. The operating supply fan draws in outside air and distributes it through duct work to air registers in various areas of the turbine building. [9.4-16]

The west turbine room ventilation system for each unit has a nominal capacity of 68,000 ft^3/min. The system includes fixed louvers, air filters, steam coils, and three 50% capacity supply fans, two operating and one on standby. Two operating supply fans draw outside air and distribute it through duct work and registers to various areas of the turbine building. The west turbine room outlet flows are combined with the east turbine room outlets and routed to the turbine building exhaust fans.

The turbine building exhaust system for each unit has a nominal capacity of 157,000 ft^3/min. The system exhausts air from the east and west turbine building ventilation systems. There are three 50% capacity turbine building exhaust fans, two operating and one on standby. Two operating exhaust fans draw turbine building air from the turbine cavity, feedwater heater, steam jet air ejector and moisture separator areas. The exhaust air has been ducted to these areas from other areas of lesser radioactive contamination potential. The turbine building exhaust air is then routed to the 310-foot chimney.

The recirculation pump M-G sets ventilation system removes heat generated by the M-G set equipment and control panel and has a nominal capacity of 65,000 ft^3/min. The system includes two air filters and two 100% capacity ventilation fans. Outside air is drawn through the filters by the operating fan and is ducted to the M-G set equipment and control panels. A return air duct is provided back to the inlet of the ventilation fans for temperature control. Temperature-controlled dampers are provided to allow the air to be recirculated or exhausted for operation with 100% outside air. [9.4-17]

The reactor feed pump motor ventilation system removes heat generated by the reactor feed pump motors and has a nominal capacity of 56,000 ft^3/min. It consists of an air filter and two 100% capacity ventilation fans. Outside air is drawn through the filters by the operating fan and is ducted to the three reactor feed pump motors, FW Regulating Valve Station and hydraulic actuators. A recirculation air duct, from the three reactor feed pump motors, is provided back to the inlet of the ventilation fans for temperature control. Temperature-controlled dampers are provided to allow the air to be recirculated or exhausted for operation with 100% outside air. One of the ventilation fans must be operating before a reactor feed pump motor can be started.

The Unit 1/2 safe shutdown pump room ventilation system has a nominal capacity of 8000 ft^3/min and operates when the room thermostat indicates that additional cooling is required. The system includes a room cooler with a 8000 ft^3/min fan, and an air filter. The turbine building ventilation system normally supplies 1500 ft^3/min of air to the safe shutdown pump room. Air is discharged from the safe shutdown pump room at 1500 ft^3/min to the turbine building exhaust system. [9.4-18]

The battery room ventilation system is designed to maintain a winter design temperature of approximately 70°F for a minimum outside air temperature of – 10°F, to maintain battery cell temperatures. The battery room also contains a continuously operating exhaust fan, which keeps the hydrogen buildup in the room below flammability limits.

The computer uninterruptible power supply (UPS) and battery room ventilation system includes two HVAC trains, one in operation and one in standby. Each train consists of a filter and a HVAC unit assembly. Each train is capable of cooling the room by itself. The operating HVAC train recirculates conditioned air in the computer UPS room and supplies conditioned air to the battery room. A small amount of outside air is introduced to the UPS room during HVAC unit operation to provide ventilation for the battery room. An exhaust fan then removes the air from the battery room to preclude hydrogen buildup in the room. [9.4-19]

The Unit 1/2 computer room ventilation system has a nominal capacity of 6000 ft^3/min. The ventilation system is designed to maintain the computer room temperature between 70° and 80°F. The system includes two HVAC trains, one in operation and one in standby. Each train consists of a damper, a filter, an electric heating unit, a 6000 ft^3/min nominal capacity supply fan, and an air conditioning unit. The operating HVAC train supplies conditioned air to the computer room. The exhaust air is recirculated to the operating HVAC train inlet. Outside air at 100 ft^3/min is supplied with the exhaust air to replace 100 ft^3/min exfiltration. [9.4-20]

9.4.5 Diesel Generator Room Ventilation System

Each diesel generator room (Unit 1, Unit 2, and the 1/2) has an independent ventilation system. These ventilation systems are shown on P&ID M-813. [9.4-21]

A. Diesel Generators 1 and 2 [9.4-22]

The Unit 1 and 2 diesel generator rooms have identical ventilation systems. The system components include a ventilation fan, inlet and exhaust ductwork, pneumatically controlled isolation and modulation dampers,

heat activated fire control dampers and a pneumatic damper control system consisting of air supply control valves and temperature control instrumentation.

During normal plant operation, when the diesel generator is in standby, ventilation for the diesel generator room is provided via a duct aligned with the Unit 1(2) east turbine building supply fan that delivers air into the room. This air is exhausted by normal leakage around and under the room doors.

Upon diesel generator start-up and exceeding 800 rpm, the diesel generator room ventilation fan starts and delivers air into the room. Once the fan is energized, the control circuitry de-energizes one air supply solenoid valve which causes the damper in the normal ventilation duct to close and another air supply solenoid valve energizes to cause the vent fan duct dampers to open. The ventilation fan takes suction from both an outside air supply duct and two turbine building atmosphere ducts. Dampers in these ducts are modulated by a temperature controller to maintain the air temperature inside the diesel generator room at 80°F. At 75°F or less, the air supply from the outside is isolated and suction is taken completely from the turbine building. At 85°F or greater, the air supply from the turbine building is isolated and suction is taken completely from the outside atmosphere.

Air supply to the damper actuators is provided via the instrument air system. If instrument air drops to 40 psi or less, a solenoid valve is actuated to isolate the instrument air system and align two nitrogen bottles for damper control. In the event of a complete loss of damper control air, the turbine building supply dampers fail closed and the ventilation fan duct dampers and outside air supply damper fail open to ensure a ventilation path.

The EDG HVAC subsystem provides room ventilation to the diesel room to provide sufficient cooling to limit the temperature of the room to below 140°F. The EDG HVAC subsystem has no requirement to maintain a minimum temperature in the EDG room during diesel operation. During EDG standby, the necessary lube oil and jacket water temperatures are maintained by the EDG immersion heaters to maintain fast start readiness at ambient room temperatures as low as 40°F.

In the event of a fire in the diesel generator room, the ventilation fan is tripped, all inlet and exhaust dampers are closed, and carbon dioxide is injected into the room. In addition, each duct is provided with heat activated fire dampers.

B. Diesel Generator 1/2

The 1/2 diesel generator room ventilation system is similar to the Unit 1 and 2 diesel generator room ventilation systems except for the following:

During normal plant operation, the 1/2 diesel generator room is not cooled by forced air since it is located outside of the reactor and turbine buildings with its walls exposed to the outside atmosphere. A fan supplies air to the 1/2 diesel generator room.

Suction for the ventilation fan is taken from the outside atmosphere only. The ventilation fan has an inlet vane which is modulated to keep the room air temperature above 75°F.

The ductwork for the 1/2 diesel generator room does not have heat activated fire dampers. However, fire detectors in the room trip the ventilation fan (if running) upon the detection of a fire in the room which also results in the closing of the inlet and exhaust dampers. The cables for this fire detector run

from the ground floor of the turbine building through the reactor building to the 1/2 diesel generator room. A fire outside the 1/2 diesel room could also cause the ventilation fan to trip. To ensure that the ventilation fan will be operable during a fire outside the 1/2 diesel generator room, a bypass switch has been provided in the ventilation fan circuitry to bypass the fire detector contacts. This bypass capability is an NRC commitment to 10CFR50 Appendix R, Safe Shutdown/Fire Protection.

9.4.6 Off-Gas Ventilation Systems

The off-gas ventilation systems provide conditioned air to the off-gas equipment areas. Each unit has a separate off-gas recombiner room ventilation system which supplies the unit's off-gas condenser and recombiner cubicles. Unit 1 and Unit 2 share the off-gas filter building and its ventilation system. [9.4-23]

The off-gas ventilation systems are shown on P&IDs M-563, M-555, and M-556.

9.4.6.1 Design Bases

The off-gas ventilation systems have been designed for the following conditions:

Outside	Minimum-6°F Maximum+93°F
Inside	Minimum+55°F Maximum+104°F

9.4.6.2 System Description

The off-gas recombiner area ventilation system for each unit consists of two trains, one in operation and one in standby. Each train consists of a damper, prefilter, a steam heating unit, a supply fan and an exhaust fan. The supply fan is capable of supplying approximately 15,000 cfm. Outside air is supplied through a fixed louver, filtered, heated as necessary and discharged to the upper level operating aisle. From there, air flows to the remaining areas of the building. The off-gas control panels are ventilated with a separate 200 ft^3/min exhaust blower. Each exhaust fan has a nominal capacity of 15,200 ft^3/min. The off-gas area ventilation system discharges to the 310-foot chimney. Additional heating is supplied by four steam-heated area heaters located in the building. [9.4-24]

The off-gas filter building ventilation system has two trains, each with a capacity of 5000 ft^3/min. Each train consists of a fixed louver, outside intake, a prefilter, an electric duct heater, dual cooling units, a supply fan, and dampers. Ductwork carries air to various areas of the building. Air going to the charcoal adsorber vaults and upper-level access area can receive additional heating from electric duct heaters. The exhaust air passes through two filters before entering the exhaust fan for discharge. Each exhaust fan has a nominal capacity of 5500 ft^3/min. One exhaust fan is normally required for operation. The off-gas filter building ventilation system discharges to the 310-foot chimney.

9.4.7 Reactor Building Ventilation System

The reactor building has three ventilation systems: [9.4-25]

1. Reactor building ventilation,

2. Drywell ventilation, and

3. Drywell and torus purge exhaust.

The reactor building ventilation system is shown on UFSAR Figure 9.4-3 and P&IDs M-371 and M-1530. The drywell ventilation system is shown on UFSAR Figure 9.4-3 and P&IDs M-373 and M-34. The drywell and torus purge exhaust system is shown on P&IDs M-371 and M-1530.

9.4.7.1 Design Bases

The ventilation systems for the reactor building have been designed for the following conditions: [9.4-26]

Outside	Minimum	-6°F
	Maximum	+93°F
Inside (reactor building)	Minimum	+65°F
	Maximum	+104°F
Inside (drywell)	Normal operation	135°F (Average)
	8 hrs after shutdown	105°F (Average)

9.4.7.2 System Description

The reactor building ventilation system for each unit has a nominal capacity of 95,000 ft^3/min. Each system consists of an air filter, steam heating unit, and three supply fans. Normally, each unit operates using two 50% capacity supply fans. The third fan is on standby. Outside air is drawn into the system by the supply fans. The air is filtered, temperature controlled, and discharged into the supply system ducts. The supply air ducts distribute the air through the building to the air registers. In addition to the normal damper arrangement for directing the air flow, this system uses two emergency shutoff dampers, installed in series, in the main supply duct upstream of all branch ducts. Also, two emergency shutoff dampers are installed in series in the main exhaust duct upstream of the exhaust fan air intake and downstream of any branch connections to the exhaust duct. The operating fans are tripped off line whenever these dampers close. This provides positive shutoff of outside air into the building in the event of an emergency. [9.4-27]

When the dampers close, exhaust air from the building is routed through the standby gas treatment system as described in Section 6.5.3.

The emergency shutoff dampers in the supply and exhaust ducts will close immediately in response to any of the following signals:

A. Process radiation monitoring system trip (indicating high radioactivity in the drywell, reactor building vent or the refuel floor), [9.4-28]

B. Primary containment isolation system trip (low reactor water level or high drywell pressure),

C. Operating switch on a control room panel (912-1),

D. Operating switch on a local panel (2251(2)-24X),

E. Auto start of standby gas treatment system, or

F. Low air pressure at one of the emergency shutoff damper actuators.

The reactor building ventilation system removes exhaust air from the reactor building and from the drywell and torus purge exhaust system. The nominal exhaust capacity is 104,500 ft^3/min. There are two 50% capacity reactor building exhaust fans operating for each unit with a third fan on standby. The exhaust fans draw building air into exhaust vents located throughout the building and discharge it through the reactor building vent stack. [9.4-29]

The normal reactor building ventilation system provides at least one free-volume change of air per hour in the reactor building. Air flows through ducts to the uncontaminated areas, through potentially contaminated areas, and then through the exhaust fans to the roof vent stack. Cooling and heating units in various rooms of the reactor building provide for personnel comfort and equipment protection. Air pressure in the reactor building is automatically controlled at a negative pressure (0.1 - 0.70 in. H_2O) by the exhaust fan dampers, to assure in-leakage of air so that exfiltration of airborne radioactive contamination is minimized. [9.4-30]

The normal ventilation exhaust duct for the fuel pool area is arranged to take suction through multiple inlets around the periphery of the pool above the water line. This duct connects to the normal reactor building ventilation exhaust system and is routed to the reactor building vent stack. The transit time for activity released in the reactor cavity or fuel pool to reach the normal ventilation exhaust point to the atmosphere is approximately five seconds.

The drywell is ventilated by a closed cooling ventilation system. Warm air inside the drywell is circulated through coolers and discharged into the drywell supply air ducts.

There are seven drywell coolers (water-cooled heat exchanger fan units) located inside the drywell and spaced around the perimeter at two different elevations. Each of the seven cooler fans has a nominal capacity of 34,000 ft^3/min. [9.4-31]

Cooling water is circulated through the coolers from the reactor building closed cooling water system. One ventilation fan is located in the air duct on the outlet side of each cooler. The fan draws warm air into the cooler, over the cooling coils and discharge it into the supply air duct. The air is released back into the drywell through locked-open dampers for maximum cooling. There is an additional fan located at elevation 617 feet which is part of the high velocity air distribution system. This fan takes suction from a drywell cooling supply riser and discharges into a new riser leading to a distribution

header at the upper elevations of the drywell. This fan and distribution header forces the hot air at the upper elevations downward to mix with cooler air at the lower elevations, thereby reducing air temperature stratification in the drywell. Power from the emergency diesel generators maintains the drywell cooling system in operation in the event of the loss of offsite ac power, except with core spray and RHR both operating (a LOCA signal present) to prevent overloading the diesel generators. The drywell cooling system is also tripped on LOCA initiation without loss of offsite power. This tripping logic improves the voltage regulation on the 480V ESS buses during a LOCA with a degraded offsite voltage condition. [9.4-32]

The drywell ventilation system cools the drywell atmosphere to approximately 135°F. By maintaining a drywell ambient air temperature less than 150°F during normal plant operation, the insulation on motors, isolation valves, operators and sensors, instrument cable, electrical cable, and sealants used at the penetrations, will have a sustained life without deterioration.

The seven drywell coolers were checked initially and are checked at each major outage for leakage under normal cooling water pressure. Operation of the fans for each of the coolers and the high velocity air distribution fan are also observed at this time. During normal reactor operation, the temperature indicators in the drywell will monitor the effectiveness of the coolers and high velocity air distribution system. [9.4-33]

The drywell and torus purge exhaust system is used for purging, deinerting, and ventilating the drywell and torus when the reactor is shutdown for maintenance or whenever primary containment access is required. The system consists of two prefilters, two absolute filters, and two exhaust fans. One fan and set of filters is normally in operation and the other fan and set of filters is on standby. Exhaust air is drawn through piping connected to the drywell and torus by the exhaust fan and discharged into the reactor building main exhaust duct. Inlet air from the reactor building atmosphere is drawn into the torus and drywell through isolatable vents. [9.4-34]

9.5 OTHER AUXILIARY SYSTEMS

The descriptions and evaluations of other auxiliary systems are included in this section. Other auxiliary systems include the fire protection systems, communication systems, lighting systems, and the diesel generator fuel oil storage and transfer, cooling water, starting air, lubrication, and combustion air intake and exhaust systems.

9.5.1 Fire Protection System

Quad Cities Administrative Procedures define the fire protection program by assigning responsibilities, defining the organization, and providing information and procedures pertinent to fire protection. These procedures provide the Administrative Technical Requirements (ATR) for fire protection and safe shutdown equipment and specify surveillance requirements for the applicable systems and equipment. [9.5-1]

The design of the fire protection system and safe shutdown methodology is contained in the Fire Protection Reports including the Updated Fire Hazards Analysis (UFHA) and Safe Shutdown Analysis Report (SSA).

9.5.2 Communication Systems

9.5.2.1 Design Objectives

The design objectives of the station communication systems are to provide effective and reliable communications between onsite personnel and to offsite locations during normal operations and during emergency conditions for assembly, fire alarm and other emergency purposes. [9.5-2]

9.5.2.2 Communication System Description and Analysis

The station communication system is comprised of the following two functional groups: [9.5-3]

1. Extraplant communications, and
2. Intraplant communications.

Each of these communications groups is described and analyzed in the following subsections.

9.5.2.2.1 Extraplant Communications

The extraplant communications group provides for offsite communications during normal and emergency conditions. [9.5-4]

The extraplant communications group is comprised of the following telephone subsystems as described in the Exelon Emergency Plan (E-Plan) and annex:

A. Dial phone,

B. Dedicated line circuits,

C. Emergency Notification System (ENS),

D. Health Physics Network (HPN),

E. Nuclear Accident Reporting System (NARS), and

F. Emergency Response Data System (ERDS).

9.5.2.2.2 Intraplant Communications

The intraplant communications group provides for onsite communications during normal and emergency conditions. [9.5-5]

The intraplant communications group consists of the following subsystems:

A. Intercom phone/loudspeaker public address (PA),

B. Radio communications,

C. Sound powered phone,

D. Dial telephone,

E. Assembly and fire alarm communication, and

F. Emergency telephone.

Each of these intraplant communications subsystems is described in further detail in the following paragraphs.

The intercom phone/loudspeaker PA subsystem allows voice communication to all offices and routinely occupied areas, as well as those areas vital to plant operation, the control room, and all buildings and central areas within the plant. The control room has the ability to override the PA subsystem. The intercom phone/loudspeaker PA subsystem is accessed from either the PA call stations or the station PBX phones and can be operated in either a page mode or party (multi-user) mode of communication.

Radio communication subsystems are used for communication within the plant area, the surrounding area, and for emergency backup to more distant locations. The intraplant radio communication subsystem utilizes a trunked radio system with dispatch consoles, desksets, and two-way hand-held radios. Computer controlled repeaters are utilized by the trunked system to provide intraplant communications. The hand-held radios have channel selectors which allow them to be operated in the "talk around" mode without use of the repeaters as well as the normal trunked mode. The repeater system equipment is located in the Service Building Penthouse. Each operator, Field Supervisor, and Shift Engineer on duty has access to a portable radio. These radios are battery powered. Dispatch Consoles for the radio communications subsystem are located in the control room, central alarm station, and secondary alarm station. Radio Control Stations are located in the TSC and WEC. Radio desksets are located on the U1 and U2 desks, and in the Technical Support Center (TSC), and Work Execution Center (WEC). A separate radio communication system has been installed to allow coordinated environmental monitoring and assessment during an emergency. This system consists of the necessary hardware to allow satellite communication between the TSC, Emergency Operations Facility (EOF) and mobile units in Exelon Nuclear vehicles. Commercial cell phones or other means are available as backup to the primary field team communication system.

The sound-powered phone subsystem is comprised of approximately 60 sound-powered phone jacks located throughout the two-unit plant with headsets available for use with these jacks. This system is normally used where signals generated by radios may cause problems such as spurious actuation of electric equipment, or where concentrated use of radio for high-detail communications by some personnel would preclude availability of the radio for a greater number of somewhat more mobile personnel having brief communication needs.

The dial telephone subsystem previously described in Section 9.5.2.2.1 also provides for onsite/intraplant communications.

The assembly and fire alarm communication subsystems are located at strategic points throughout the plant to warn personnel of a nuclear incident or other emergency conditions. Existing plant alarm systems are sufficiently audible to alert personnel in the event of a fire or need for assembly. These alarm communication systems consist of warning sirens and lights (in high-noise areas) and the PA subsystem. For further information on maintaining communications within the plant during a fire, refer to Volume 6, Section 7 of the FPPDP (Fire Protection Program Documentation Package) [1]. Refer to Section 9.5.1 for further description of the station fire protection system. [9.5-6]

The emergency telephone subsystem is comprised of emergency telephones which provide for the coordination of an orderly reactor shutdown in the event the control room becomes uninhabitable. The telephone handsets are stored inside glass-sealed red boxes which are located at strategic points within the plant. The battery-powered emergency telephone system can be operated in two modes: individual unit enabled (separate position) and multi-unit enabled (combined position). The system allows a communication link between vital areas in the reactor building, turbine building, and auxiliary electric rooms. [9.5-7]

The Damage Control ringdown phone provides an additional automatic emergency response telephone link that enables communication between the control room, TSC, and Operational Support Center (OSC). For the performance of emergency drills, the control room phone can be silenced and switched to the simulator.

9.5.2.3 Testing and Inspection Requirements

The plant assembly and fire alarm communication subsystem is tested periodically. [9.5-8]

The functional capability of the NARS, ENS, and HPN is demonstrated monthly, and all emergency communications subsystems shall be tested annually as described in the E-Plan[2].

The functional capability of the hand-held radios is demonstrated on a quarterly basis.

The functional capability of the PBX is not periodically demonstrated since station personnel frequently use the system and any failure would be immediately noticed and reported to the local phone company.

9.5.3 Lighting System

The objective of the station lighting system is to provide adequate lighting for the operation and control of equipment and the performance of maintenance. To achieve this objective, the station lighting is designed to provide adequate lighting for the normal and emergency operation of the plant. A standby lighting system is provided which utilizes both ac power from the diesel generators and dc power from self-contained lighting units and from station batteries. The self-contained lighting units are battery-powered, emergency light assemblies with single or multiple, attached or remote lamps. The self-contained batteries are charged automatically from electric lighting circuits to which they are connected. This standby lighting is necessary to provide adequate lighting in all areas essential to the safe operation of the plant during loss of normal ac power. [9.5-9]

The following table lists the minimum standby lighting requirements originally provided in the areas and maintained today:

Location	AC Power Source (footcandles)	DC Power Source (footcandles)
Safety-Related Equipment and Control Areas	3	Not specified
Standby ac Equipment Areas	3	3 (local)
Access Routes	2	Silhouette

In order to resolve Human Engineering Discrepancies per NUREG 0700 (see Section 7.5.4), control room lighting was modified. The lighting fixtures provide sufficient control room lighting during normal operations to produce a minimum of 20 ft-c of illumination on the control panels and 50 ft-c for seated operator stations. Many of the lighting fixtures are supplied with backup ac power to provide control room lighting in the event that offsite power is lost. The illumination levels provided by these fixtures are a minimum of 10 ft-c. The lighting feed circuits provide lighting power from Unit 1 for the Unit 1 lights and lighting power from Unit 2 for the Unit 2 lights. [9.5-10]

Light dimming circuits have been installed in the Unit 1 and 2 lighting circuits. The dimming circuits will allow the unit operators to reduce the control room lighting down to,

but not lower than, 20 ft-c. The dimmer controls are kept under the control of the unit operators at all times.

Certain self-contained lighting units were upgraded to 8 hours while additional 8-hour units were added to provide illumination of areas containing safe shutdown equipment and to access routes leading to these areas in order to meet the requirements of 10 CFR 50, Appendix R, Section III.J. See the Safe Shutdown Report in the Fire Protection Reports (FPR) for further information concerning illumination requirements for safe shutdown areas and access routes. [9.5-11]

Station procedures provide for periodic testing of the standby lighting to demonstrate its availability. Normal station maintenance provides adequate inspection of normal lighting equipment. [9.5-12]

9.5.4 Diesel Generator Fuel Oil Storage and Transfer System

A separate fuel oil storage and transfer system is provided for each diesel generator (DG). It includes a 15,000-gallon underground fuel oil storage tank and a 750-gallon fuel oil day tank which is refilled from the storage tank by the diesel fuel oil transfer pump. The instrument air system supplies air to a bubbler tube in each diesel fuel oil storage tank. A level sensor and a level switch connected to each bubbler tube provide tank level indication and a control room fuel oil storage tank low level alarm respectively. A diagram of the Unit 1, Unit 2, and the 1/2 DG fuel oil storage and transfer systems is shown on P&ID M-29. [9.5-13]

During applicable reactor operational modes, the Technical Specifications require a minimum of 10,000 gallons of fuel to be available for each DG. Based on the day tank nominal capacity of 750 gallons, the day tank capacity is adequate for over four hours of diesel operation at rated load. The normal amount of fuel oil in the day tank is 708 gallons, which corresponds to the high level diesel fuel oil transfer pump trip. Diesel generator run times for 10,000 gallons and for 708 gallons at various load levels have been calculated and are shown in Table 9.5.4-1. [9.5-14]

Fuel oil day tank level is sensed by a level switch, which initiates signals to automatically start or stop the fuel oil transfer pump. A separate level switch senses abnormally high or low day tank levels and annunciates an alarm in the main control room. Day tank overflow is routed to the fuel oil storage tank. Fuel from the fuel oil day tank is supplied through a strainer to the fuel priming pump and the engine-driven fuel pump. From the discharge of the fuel priming pump and engine-driven fuel pump, the fuel goes through a dual spin-on filter assembly and is delivered to the fuel racks. Any excess fuel is returned to the fuel oil day tank. The diesel fuel oil day tank can also be filled locally by pumping fuel oil through a hose connection or pouring fuel oil into a receiving funnel. [9.5-15]

The DG fuel oil storage and transfer system can also supply fuel oil for the diesel fire pumps. Either the Unit 1 or Unit 2 DG fuel oil transfer pump can be lined up as the pump which provides manual fill capability to the diesel fire pump day tanks. A diagram of diesel generator fuel oil piping is shown on UFSAR Figure 9.5-1. The normal method of filling the diesel fire pump day tanks is via an off-site fuel source at a fill station located outside the crib house. The crib house fill station is shown on P&ID M-29, Sheet 1. [9.5-16]

The normal and alternate power supplies for the DG fuel oil transfer pumps are as follows: [9.5-17]

Diesel Generator Designation	Normal 480-V Power Supply	Alternate 480-V Power Supply	Switching Method
DG 1	MCC 19-1	MCC 29-1	Manual
DG 2	MCC 29-1	MCC 19-1	Manual
DG 1/2	MCC 18-1A	MCC 28-1A	Automatic*

* Upon loss of power at the diesel generator auxiliary panel.

The alternate power supplies for Unit 1 and 2 were provided to satisfy 10 CFR 50, Appendix R requirements.

The 1/2 fuel oil transfer pump normally receives power from MCC 18-1A. The 1/2 fuel oil transfer pump will automatically transfer to MCC 28-1A on a loss of power to MCC 18-1A or when either a Unit 2 loss-of-coolant accident signal is received or the 1/2 diesel generator output breaker closes to Bus 23-1.

Operability of the DG fuel oil transfer pumps is verified during DG testing. Diesel fuel oil is regularly sampled and tested to verify quality in accordance with the Diesel Fuel Oil Testing Program. [9.5-18]

9.5.5 Diesel Generator Cooling Water System

A separate diesel generator (DG) cooling water system is provided for each diesel generator. Each DG cooling water system has a closed loop portion (also referred to as jacket water) and a separate open loop portion (also referred to as raw water or DG service water). The closed loop portion of the DG cooling water system circulates cooling water through the DG cooling water heat exchangers, lube oil cooler, and passages in the diesel's cylinder liners, cylinder heads, and turbocharger aftercoolers. Temperature of the diesel engine cooling water is maintained relatively constant by a three-way temperature regulating valve which controls diesel engine cooling water flow through the DG cooling water heat exchangers. The motive force for this cooling water is provided by two engine-driven centrifugal pumps. During standby periods, an immersion heater is automatically energized to maintain the engine at a sufficient temperature to facilitate rapid starts. Diagrams of the Unit 1, Unit 2, and 1/2 DG cooling water systems are shown on UFSAR Figure 9.5-2 and P&IDs M-22 and M-69. [9.5-19]

The open loop portion of the DG cooling water system provides cooling water to the DG heat exchangers. A separate DG cooling water pump is provided for each DG cooling water system. Each of the DG cooling water pumps is located in a separate residual heat removal (RHR) service water pump vault. The DG cooling water pumps take suction from the RHR service water inlet header and ultimately discharge into the service water discharge pipe. In addition to providing cooling water to their respective DG heat exchangers, the Unit 1 and Unit 2 DG cooling water pumps provide cooling water to the following emergency core cooling system (ECCS) room emergency coolers in their respective units: the north and south core spray equipment room emergency coolers and the north and south RHR heat exchanger room emergency coolers. The Unit 1 and Unit 2 DG cooling water pumps also provide a supply of cooling water to their respective unit's

high pressure coolant injection (HPCI) room emergency cooler. The service water system can also provide a non-safety-related alternate supply of cooling water to the HPCI room emergency coolers. The service water supply is also discussed in Section 9.2.2. Descriptions of the ECCS room coolers are provided in Section 6.3. [9.5-20]

The Unit 1 and Unit 2 DG cooling water pumps can each supply 1304 gal/min. Approximately 900 gal/min at 95°F is routed to each of the respective DG heat exchangers and approximately a total of 404 gal/min is routed to the respective ECCS room emergency coolers, including the HPCI room emergency cooler. The 900 gal/min at 95°F and 404 gal/min at 95°F are based on original design specification requirements. The 1/2 DG cooling water pump normally provides cooling water only to the 1/2 DG heat exchangers. If necessary, the 1/2 DG cooling water pump can, through crossties and associated valves, adequately cool the 1/2 DG and provide cooling water to either unit's ECCS emergency coolers. The DG cooling water pumps are protected from flooding as discussed in Section 3.4.

A vault cooler is supplied for each DG cooling water pump to prevent the pump motors from overheating. Each cooler maintains vault temperature at or below 120°F during operation of its respective pump. The vault cooler starts when its respective pump starts. Each vault cooler is supplied with cooling water from the respective pump's discharge line and the cooling water is returned to the pump's suction line. [9.5-21]

The normal and alternate power supplies for the DG cooling water pumps are as follows: [9.5-22]

Diesel Generator Designation	Normal 480-V Power Supply	Alternate 480-V Power Supply	Switching Method
DG 1	Switchgear 19	Switchgear 29, fuel pool cooling water breaker	Manual
DG 2	Switchgear 29	Switchgear 19, fuel pool cooling water breaker	Manual
DG ½	Switchgear 18	Switchgear 28	Automatic and manual

The alternate power supplies for Unit 1 and 2 were provided to satisfy 10 CFR 50, Appendix R requirements. Alignment of the Unit 1 DG cooling water pump or the Unit 2 DG cooling water pump to its alternate power supply will cause the associated fuel pool cooling water pump to be inoperable. The Unit 1 and Unit 2 DG cooling water pumps will not auto-start when aligned to their respective alternate power supplies.

The 1/2 diesel generator cooling water pump normally receives power from Bus 18. The 1/2 diesel generator cooling water pump will automatically transfer to Bus 28 on a loss of power to Bus 18 or when either a Unit 2 Loss of Coolant Accident (LOCA) signal is received or the 1/2 DG output breaker closes to Bus 23-1.

Indicating lights are provided in the main control room to show when the DG cooling water pumps are energized. [9.5-23]

Operability of the DG cooling water pumps is verified during diesel generator testing. The DG cooling water heat exchangers are periodically cleaned, inspected, and tested in accordance with a program developed in response to Generic Letter 89-13, as described in Section 9.2.1.4. [9.5-24]

9.5.6 Diesel Generator Starting Air System

The diesel generators (DG) are started by air-driven starting motors. A separate starting air system is provided for each DG. Each DG starting air system has two starting air compressors and two starting motors. Both starting motors are required to start the diesel engine. Each of the starting air compressors supplies compressed air to a separate pair of air receiver tanks. The air receiver tanks are required to start the diesel engines, but the starting air compressors are not. The outlet from each pair of receiver tanks flows through a check valve into a common starting air header. Starting air flows from the header through a moisture separator and pressure regulating valve to a three-way solenoid valve and an air-operated isolation valve. Diagrams of the Unit 1, 1/2, and 2 DG starting air systems are shown on UFSAR Figure 9.5-3 and P&IDs M-25 for Unit 1 and 1/2 DG, and M-72 for Unit 2 DG. [9.5-25]

During a diesel generator start, the three-way, 125-Vdc solenoid valve is energized, admitting air to engage the two starting motor pinions to the flywheel ring gear. When the pinions are engaged, the air-operated isolation valve opens to supply air to the starting motors.

If, during a start attempt, either of the pinions fail to engage the flywheel, operating air may be blocked from the air-operated isolation valve. In this condition, the air operated isolation valve does not open and it will prevent the air start motors from spinning. An engine re-crank function will sense this condition by sensing air pressure at the outlet of the air isolation valve and will automatically cycle the three way solenoid operated valve allowing the pinions to fully retract and attempt to reengage the flywheel. This cycling will continue until the air operated isolation valve opens and the engine starts or failed start timer times out. [9.5-25a]

The DG starting air compressors are capable of recharging their respective air receiver tanks from minimum operating pressure in 30 minutes. The compressors maintain pressure in the air receiver tanks between 230 psig and 250 psig. The DG starting air system will crank the engine for 13.5 to 16.5 seconds or until the engine starts, whichever occurs first. With one pair of air receiver tanks at a pressure of 230 psig, there is sufficient air in the tanks to allow three successive starts without recharging the air receivers. The starting air systems are capable of starting their respective diesel generators with a minimum air receiver tank pressure of 175 psig. [9.5-26]

Power for the Unit 1 DG starting air compressors is supplied by 480-V MCC 19-2. Power for the Unit 2 DG starting air compressors is supplied by 480-V MCC 29-2. Power for the 1/2 A DG starting air compressor is supplied by 480-V MCC 28-1A and power for the 1/2 B DG starting air compressor is supplied by 480-V MCC 18-1A. [9.5-27]

Low starting air pressure initiates a diesel generator trouble alarm in the main control room. During a diesel engine start, if the engine does not reach 200 rpm within 15 seconds, a diesel generator fail-to-start alarm will annunciate in the main control room. After a diesel engine start failure, the lockout relay must be reset at the engine panel prior to making another start attempt. [9.5-28]

Operability of the diesel generator starting air system is verified during diesel generator testing. [9.5-29]

9.5.7 Diesel Generator Lubrication System

A separate lubrication system is provided for each diesel generator (DG). During operation, the diesel engine drives three oil pumps. The engine-driven oil pumps are the scavenging pump, the main lube oil pump, and the piston cooling pump. The DG lubrication system has two electric-driven oil pumps, which are normally run during diesel engine operation and during standby. The electric-driven oil pumps are the lube oil

circulating pump and the turbocharger lube oil circulating pump. A heater in the DG cooling water system keeps the lubricating oil warm during standby. The configurations of the DG lubrication systems are shown on P&ID M-943. [9.5-30]

The scavenging pump draws lubricating oil from the engine oil sump through the scavenging pump strainer and pumps the oil through the lube oil filter and lube oil cooler to the lube oil strainer. A portion of the flow is diverted to the camshaft counterweight housing.

The main lube oil pump delivers lubricating oil from the lube oil strainer to the internal main lube oil manifold for lubrication of the diesel engine's internal parts. A portion of the flow through the lubricating oil manifold is filtered and supplied to the turbocharger bearings.

The piston cooling pump supplies lubricating oil from the lube oil strainer to the piston-cooling oil header to cool the diesel engine's pistons.

The lube oil circulating pump draws lubricating oil from the diesel engine oil sump and delivers the oil through a relief valve, lube oil filter, and lube oil cooler to the diesel engine camshaft counterweight housing and the main lube oil manifold. [9.5-31]

The turbocharger lube oil circulating pump draws lubricating oil from the diesel engine sump and delivers the oil through the auxiliary turbocharger lube oil filter to the turbocharger bearings. The turbocharger lube oil circulating pump provides a pre-lube function.

Power for the Unit 1 lube oil circulating and turbocharger lube oil circulating pumps is supplied by 480-V MCC 15-2. Power for the 1/2 lube oil circulating and turbocharger lube oil circulating pumps is supplied by 480-V MCC 18-3. Power for the Unit 2 lube oil circulating and turbocharger lube oil circulating pumps is supplied by 480-V MCC 25-2. [9.5-32]

Low lubricating oil temperature, low lube oil circulating pump pressure, and/or low turbocharger lube oil circulating pump pressure initiate a diesel generator trouble alarm in the main control room. [9.5-33]

Operability of the DG lubrication system is verified during diesel generator testing. [9.5-34]

9.5.8 Diesel Generator Combustion Air Intake and Exhaust System

A separate diesel generator (DG) combustion air intake and exhaust system is provided for each DG. To support combustion of the diesel fuel oil, outside air is drawn through a filter to the turbocharger. The diesel engine exhaust gases are used to drive the turbocharger turbine and are then directed to the exhaust silencer, on the roof above the DG room. Diagrams of the Unit 1, Unit 1/2 and Unit 2 DG combustion air intake and exhaust systems are shown on P&ID M-943. [9.5-35]

Operability of the DG combustion air intake and exhaust system is verified during DG testing. [9.5-36]

9.5.9 References

1. Fire Protection Program Documentation Package (FPPDP).
2. Exelon Nuclear Standardized Radiological Emergency Plan (E-Plan).

Table 9.5.4-1

DIESEL GENERATOR FUEL CONSUMPTION AND RUN TIMES

Load	Consumption Rate (gal/hr)	10,000 Gallons Run Time (hours)	708 Gallons Run Time (hours)
50% (design)	103	97.1	6.9
100% (design)	184	54.3	3.8

9.6 CONTROL OF HEAVY LOADS

9.6.1 Introduction/Licensing Background

In July of 1980, the NRC issued NUREG-0612 entitled "Control of Heavy Loads at Nuclear Power Plants". All Nuclear Power Stations (NPS) were required to respond to NRC concerns for Phase I (NUREG-0612, Section 5.1.1) and Phase II (all other Sections) [1] . ComEd engaged in a series of submittals/correspondence with the NRC for NUREG-0612 Phases I and II.

The NRC accepted Quad Cities Station's Phase I Commitments to NUREG-0612 on June 27, 1983 per Technical Evaluation Report C5506-386/387, June 1, 1983, as developed by the Franklin Research Center [2].

On June 28, 1985, the NRC suspended all reviews of NUREG-0612, Phase II submittals under Generic Letter 85-11 [3].

On April 11, 1996, the NRC issued Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment" [4]. All NPS were required to respond. ComEd responded May 13, 1996 by stating that activities were within the current licensing basis [5]. The NRC accepted ComEd's response for this Licensing Action on May 20, 1998 [6].

9.6.2 Safety Basis

See UFSAR Section 9.6.4.1 and Reference 2 for a description of license commitments to Phase I of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants."

The Reactor Building Overhead Crane (RBOHC) main hoist has a 125 ton capacity and is designated as a single-failure-proof crane for 110-ton loads. The RBOHC auxiliary hoist has a 9 ton capacity. Refer to UFSAR Sections 9.1.4.1, 9.1.4.2.2, 9.1.4.3.2, and 9.1.4.4.2 for a description of the RBOHC.

The Turbine Building Overhead Cranes (TBOHC) are not single-failure-proof. These cranes are identified by area of coverage. Considering the size of loads, limited frequency of handling, and use of specific load handling procedures, the control of heavy loads as described in Reference 2 meet the intent of NUREG-0612.

The movements of heavy loads are controlled by station procedures within the license basis.

9.6.3 Scope of Heavy Load Handling Systems

The following heavy load handling systems were evaluated and found acceptable to the NRC during the NUREG-0612 Phase I submittal process [2]:

1. Unit 1 & 2 Reactor Building overhead crane
2. Second floor jib crane (Reactor Building)
3. Unit 1 drywell first level monorail

4. Unit 2 drywell first level monorail
5. New fuel inspection stand jib crane
6. CRD repair floor jib crane
7. Unit 1 & 2 reactor service platform jib crane
8. Unit 1 Turbine Building overhead crane
9. Unit 2 Turbine Building overhead crane

9.6.4 Control of Heavy Loads Program

The Control of Heavy Loads Program consists of the following:

1. Station commitments in response to NUREG-0612 Phase I elements.
2. A single-failure-proof crane for reactor pressure vessel (RPV) head and spent fuel cask lifts.

9.6.4.1 Station Commitments in Response to NUREG-0612 Phase I Elements

Refer to UFSAR Section 9.6.1 for a description of NUREG-0612. Refer to Reference 2 for the NRC's approval of station commitments in response to the following NUREG-0612 Phase I elements:

1. Safe load paths

   Safe load paths are required as a means to minimize the potential for a dropped heavy load to impact irradiated fuel in the vessel, safe shutdown equipment, or the spent fuel pool. Station and corporate procedures provide direction when deviation from approved paths becomes necessary.

   Procedures define specific RBOHC safe load paths for the drywell head, reactor head, steam dryer, steam separator, and spent fuel cask due to their vicinity to the reactor vessel, near spent fuel in the spent fuel pool or in other areas where a load drop may damage safe shutdown systems. For other miscellaneous heavy loads carried by the RBOHC, the safe load paths are specified as the shortest route, without traveling over spent fuel in the pools or the reactor cavity, and the lowest practical height from the lift point to the laydown area. This approach is deemed appropriate considering the reactor building refuel floor has been designed for a live load of 1000 psf. Procedures dictate that loads be directed along approved paths by a signalman rather than by physically marking the paths on the refuel floor. The RBOHC auxiliary hoist has a 9 ton capacity. The reactor vessel and spent fuel pool areas are restricted areas for the auxiliary hoist, and lifts are limited to 7 feet in other areas to ensure that no damage will occur to equipment located below the refueling floor.

   The safe load paths for the second floor jib crane, drywell first level monorails, new fuel inspection stand jib crane, CRD repair floor jib crane, and the Units 1 and 2 reactor services platform jib crane are defined by the physical location and the limited area of coverage.

2. Load handling procedures

   Site and corporate procedures form the basis for commitment compliance under which all heavy load handling is conducted.

3. Crane operator qualification, training, and conduct

   The Station complies with ANSI B30.2-1976 with respect to operator training, qualification, and conduct.

4. Special lifting devices
   Special lifting devices are designed according to industrial standards using good engineering practices. The reactor head strongback and the steam dryer/separator strongback comply with ANSI N14.6-1978, Section 3.2.1 with stress design factors of 3 for minimum yield strength and 5 for ultimate strength. Further, welding and coating comply with ANSI N14.6-1978.

   The Station procedures complies with ANSI N14.6-1978 Section 5, “Acceptance Testing, Maintenance, and Assurance of Continued Compliance” with some exceptions. It is not practical nor is it warranted to perform periodic load testing to 150% of the maximum load of the special lifting devices.

   Should an incident occur in which a special lifting device is overloaded, damaged, or distorted, an engineering assessment will be performed. This assessment will address ANSI N14.6 and will include consideration of the load test up to the original procurement load test value or 150%, whichever is less. This assessment of potential damage to a special lifting device and determination of the need for an overload test is consistent with the intent of the ANSI standard.

   The NRC concluded in Reference 2 that the stress design factors, welding processes, and coatings are consistent with the intent of ANSI N14.6-1978 for the RPV head strongback. Further, all special lifting devices in use have been load tested to weights substantially in excess of the maximum load currently lifted and therefore meet the intent of ANSI N14.6-1978 guidelines for load testing. Also, in lieu of periodic load tests, an annual (or prior-to-use, depending on frequency of use) series of inspections in accordance with ANSI N14.6-1978 Section 5.3.1(2) may be performed. This testing includes visual inspection, dimensional testing, and nondestructive testing of the major load-carrying welds and critical areas.

5. Lifting devices (not specially designed)

   The slings and other rigging devices used for lifting comply with ANSI B-30.9-1971.

   The Unit 1 Turbine Building Crane Auxiliary hoist has a vertical hoist speed in excess of 90 feet per minute (fpm) which corresponds to an increased dynamic affect. Due to this increased dynamic affect, slings are to be rated at twice the static weight of the lifted load when using this device.

6. Crane inspection, testing & maintenance

   Procedures for the testing, inspection, and maintenance of overhead cranes comply with ANSI B30.2.0-1976.

7. Crane design

   Refer to UFSAR Section 9.1.4.3.2 and Reference 2 for Reactor Building Overhead Crane (RBOHC) design criteria.

   The Turbine Building Overhead Cranes (TBOHC) substantially satisfy compliance with CMAA-70.

9.6.5 References

1. D. G. Eisenhut (NRC), Letter to All Licensees. Subject: Control of Heavy Loads, December 22, 1980.

2. D. B. Vassallo (NRC), Letter to D. L. Farrar (Licensee). Subject: Control of Heavy Loads – Phase I, Re: Quad Cities Nuclear Power Station, Units 1 and 2, June 27, 1983 w/ attachment TER-C5506-386/387, developed by the Franklin Research Center, June 1, 1983.

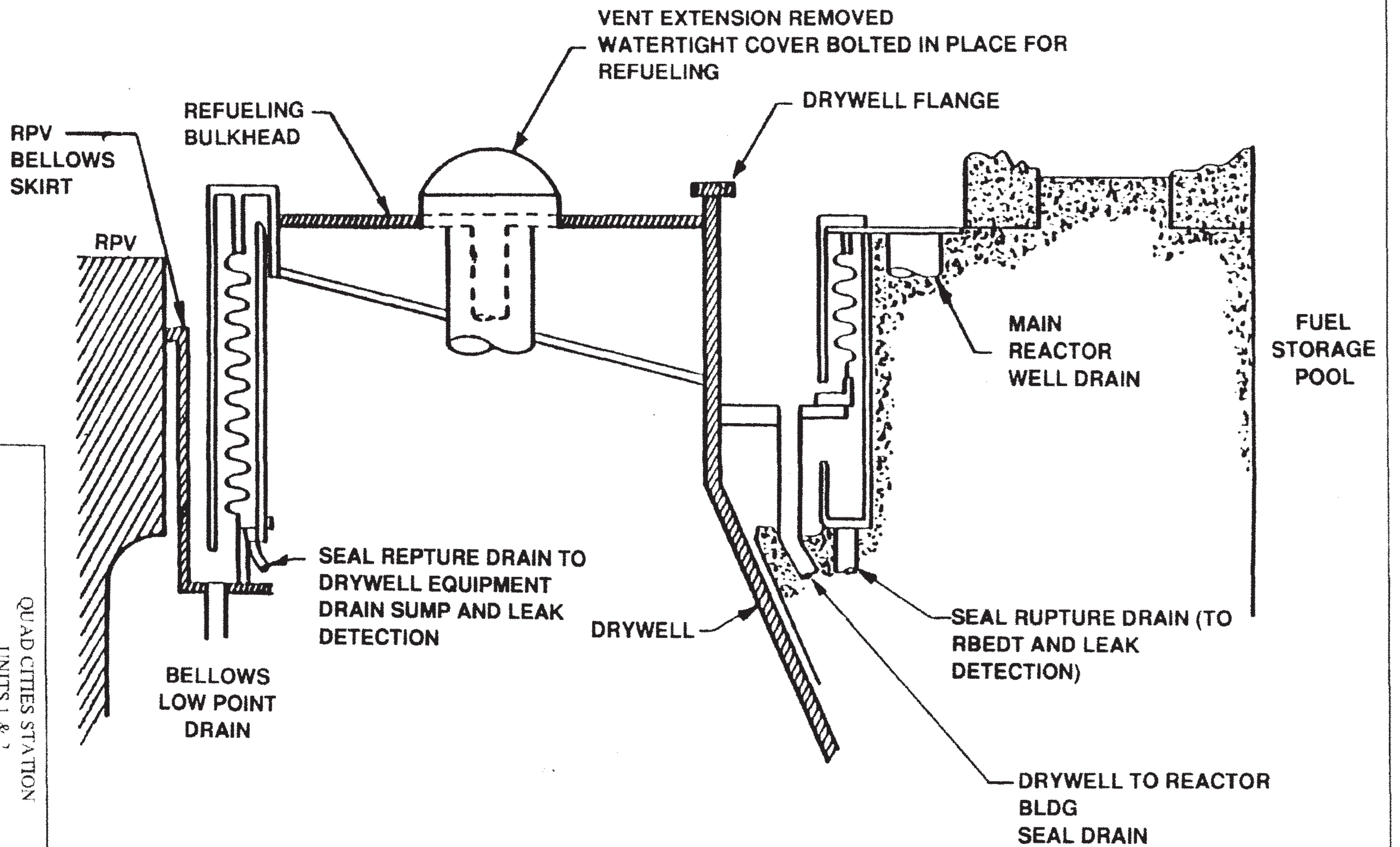
3. H. L. Thompson, Jr. (NRC), Letter to All Licensees. Subject: Completion of Phase II of "Control of Heavy Loads at Nuclear Power Plants" NUREG-0612 (Generic Letter 85-11), June 28, 1985.

4. D. M. Crutchfield (NRC), Letter to all Licensees. Subject: NRC Bulletin 96-02 "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment", April 11, 1996.

5. J. B. Hosmer (Licensee), Letter to the NRC. Subject: Response to NRC Bulletin 96-02 "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment", May 13, 1996.

6. R. M. Pulsifer (NRC), Letter to O. D. Kingsley (Licensee). Subject: Completion of Licensing Action for NRC Bulletin 96-02, May 20, 1998.

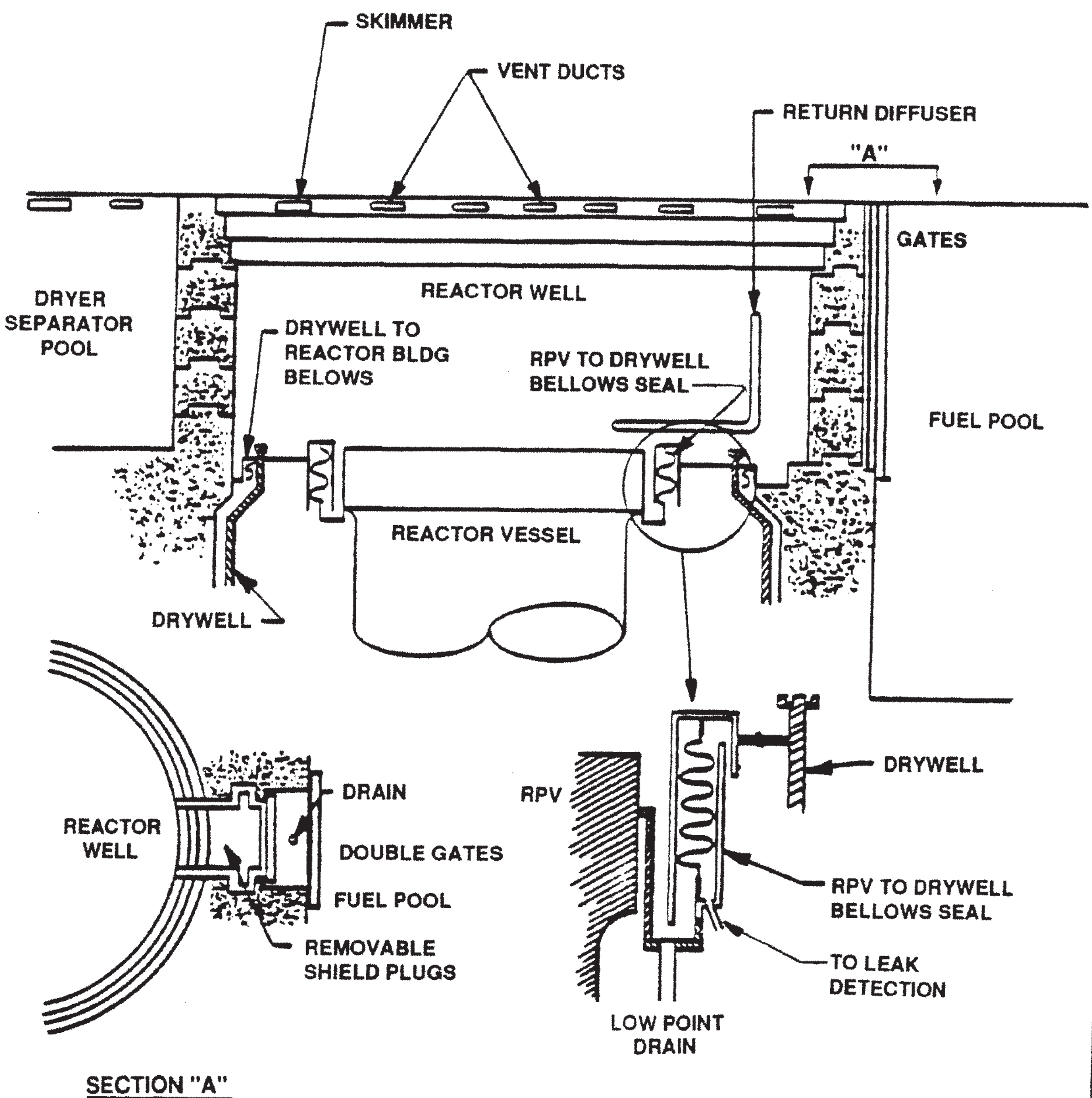
7. ComEd (Licensee), Letter to the NRC. Subject: 1981 Response to NUREG-0612 "Control of Heavy Loads at Nuclear Power Plants", June 22, 1981.



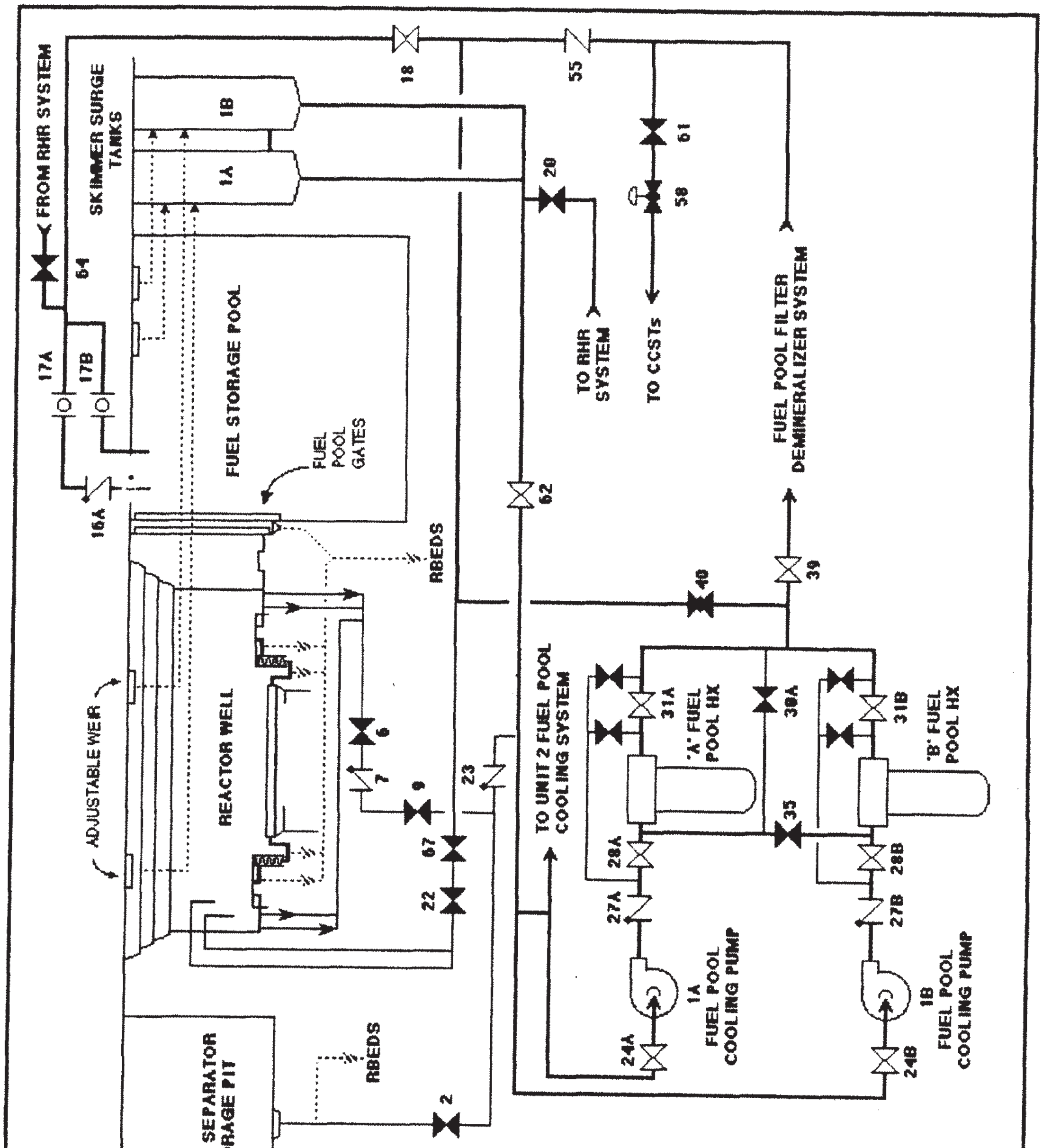
QUAD CITIES STATION
UNITS 1 & 2

REFUELING BULKHEAD AND ASSOCIATED
BELLOWS (DETAILS)

FIGURE 9.1-1



QUAD CITIES STATION UNITS 1 & 2
REFUELING BULKHEAD AND BELLOWS
FIGURE 9.1-2

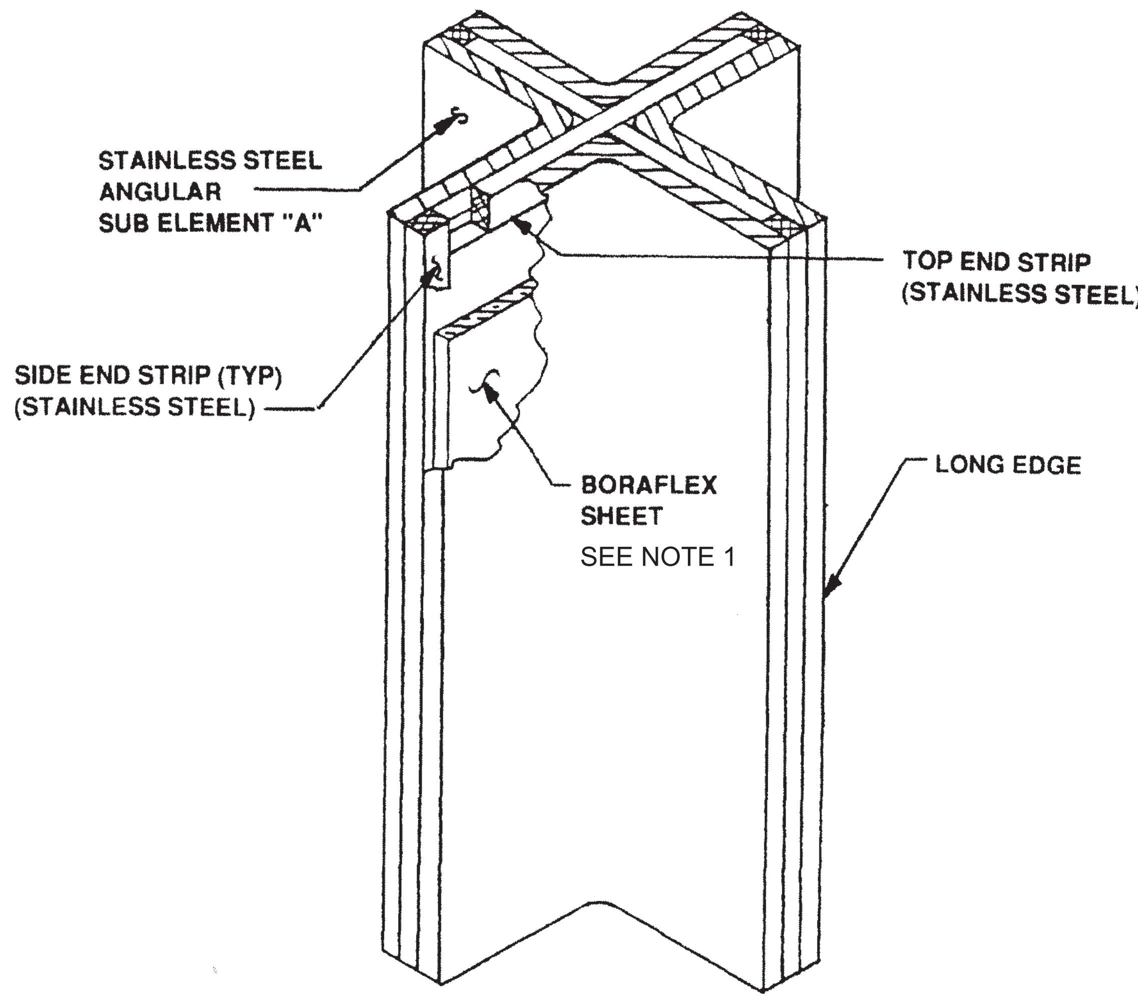


QUAD CITIES STATION UNIT 1

DIAGRAM OF FUEL POOL COOLING PIPING

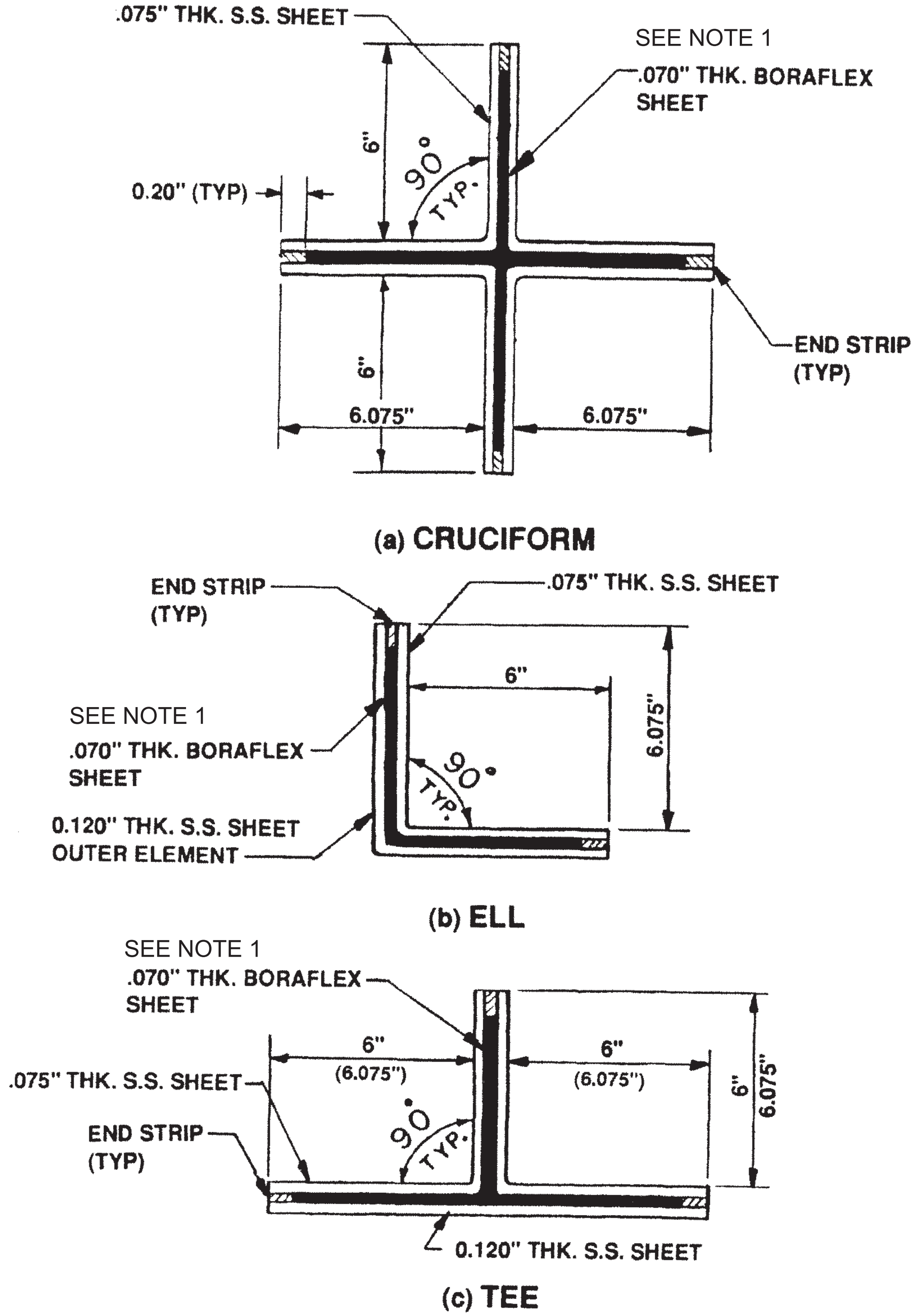
FIGURE 9.1-3

REV. 3, DECEMBER 1995



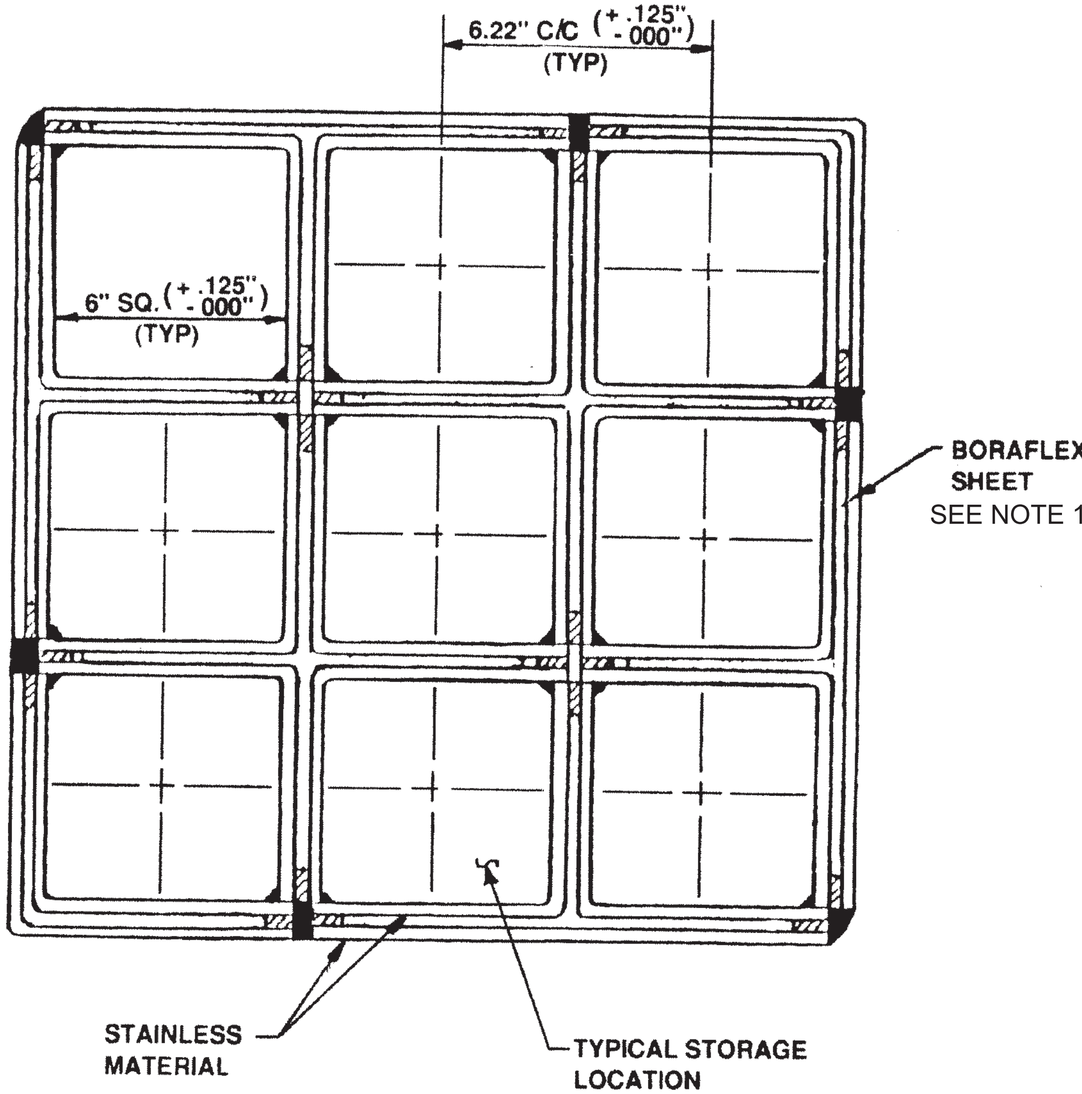
NOTE 1: BORAFLEX SHEETS ARE ABANDONED IN PL ACE. NETCO SPENT FUEL POOL RACK INSERTS REPLACE NEUTRON ABSORBING FUNCTION OF THE BORAFLEX SHEETS. (EC 389362)

QUAD CITIES STATION UNITS 1 & 2
HIGH DENSITY FUEL RACK CRUCIFORM ELEMENT ISOMETRIC
FIGURE 9.1-7



NOTE 1: BORAFLEX SHEETS ARE ABANDONED IN PLACE. NETCO SPENT FUEL POOL RACK INSERTS REPLACE NEUTRON ABSORBING FUNCTION OF THE BORAFLEX SHEETS. (EC 389362)

QUAD CITIES STATION UNITS 1 & 2
HIGH DENSITY FUEL RACK CRUCIFORM ELEMENT CROSS SECTION
FIGURE 9.1-8

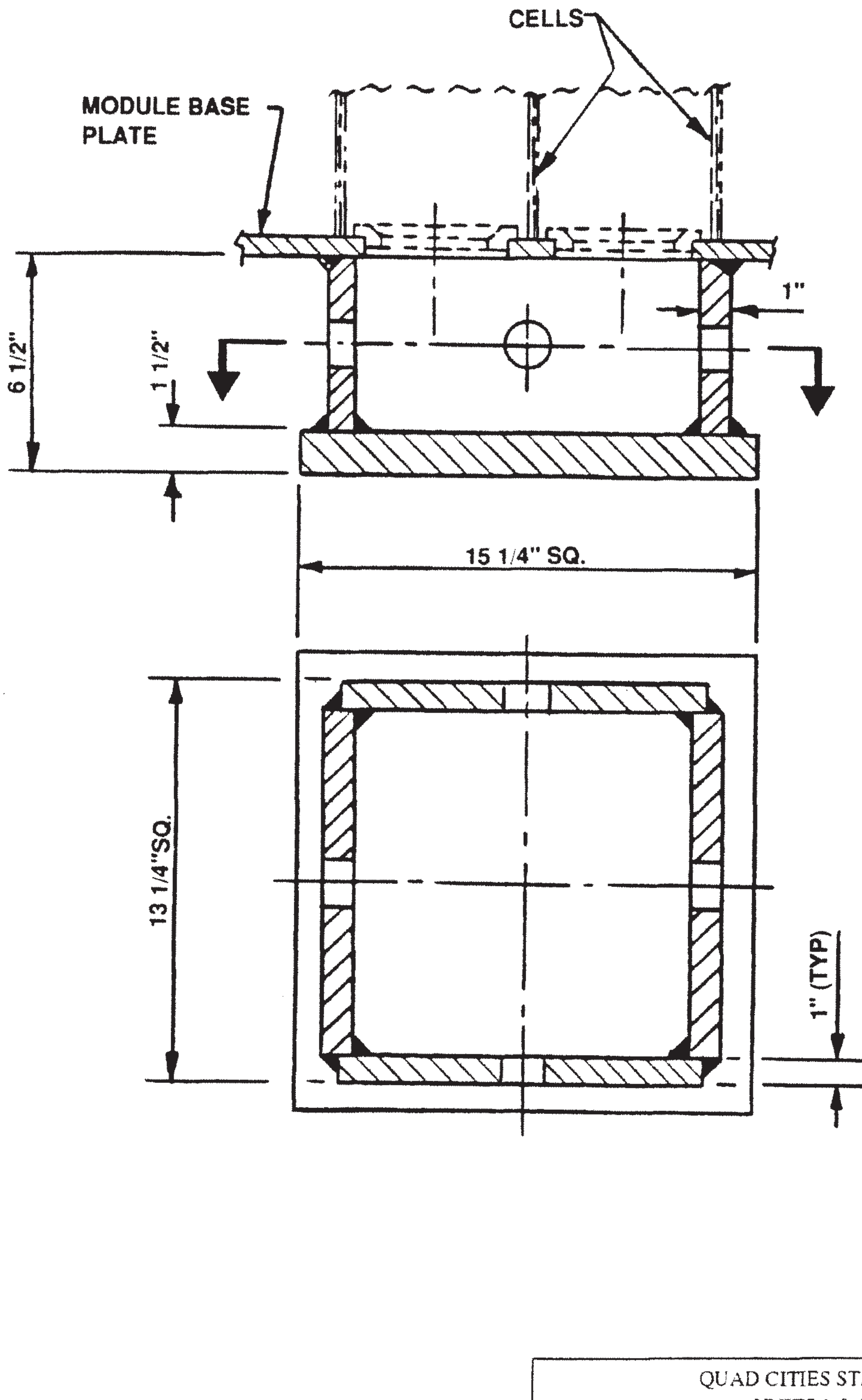


NOTE 1: BORAFLEX SHEETS ARE ABANDONED IN PLACE. NETCO SPENT FUEL POOL RACK INSERTS REPLACE NEUTRON ABSORBING FUNCTION OF THE BORAFLEX SHEETS. (EC 389362)

QUAD CITIES STATION
UNITS 1 & 2

HIGH DENSITY FUEL RACK
ARRAY OF CELLS (3 x 3)

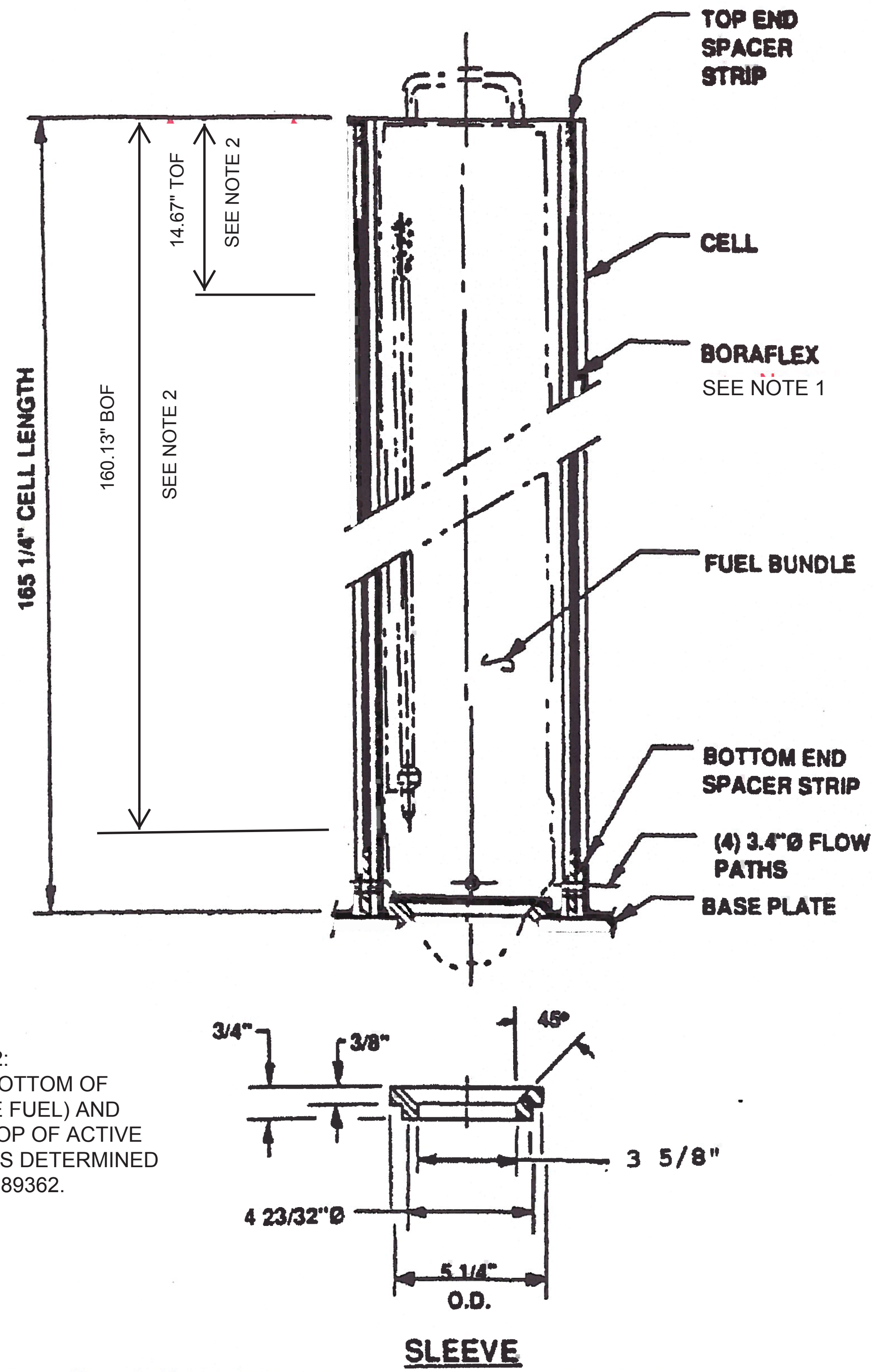
FIGURE 9.1-9



QUAD CITIES STATION
UNITS 1 & 2

HIGH DENSITY FUEL RACK SUPPORT

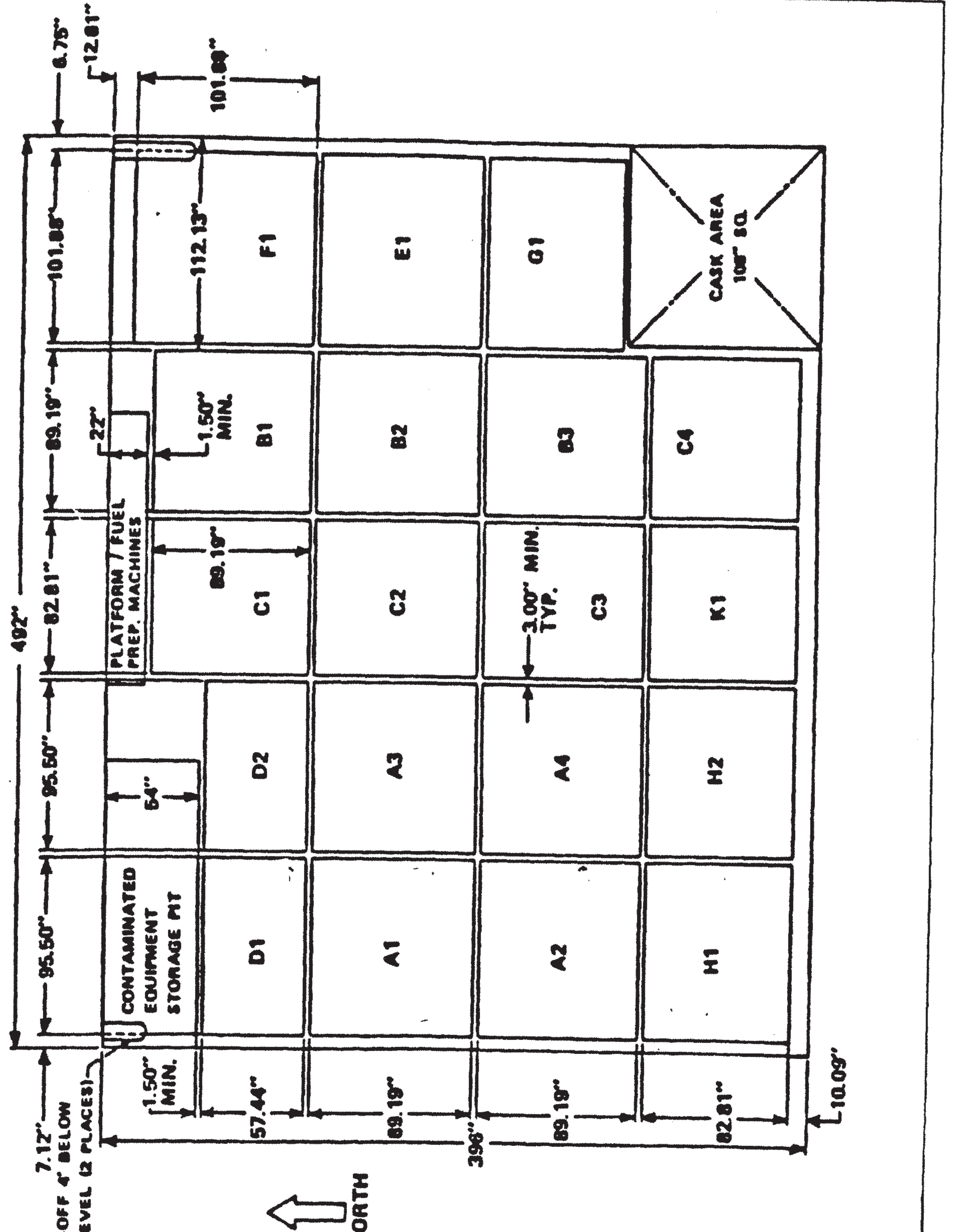
FIGURE 9.1-10



NOTE 2:
BOF (BOTTOM OF ACTIVE FUEL) AND TOF (TOP OF ACTIVE FUEL) IS DETERMINED IN EC 389362.

NOTE 1: BORAFLEX SHEETS ARE ABANDONED IN PLACE. NETCO SPENT FUEL POOL RACK INSTERTS REPLACE NEUTRON ABSORBING FUNCTION OF THE BORAFLEX SHEETS. (EC 38962)

QUAD CITIES STATION
UNITS 1 & 2
HIGH DENSITY FUEL RACK
TYPICAL CELL ELEVATION
FIGURE 9.1-11

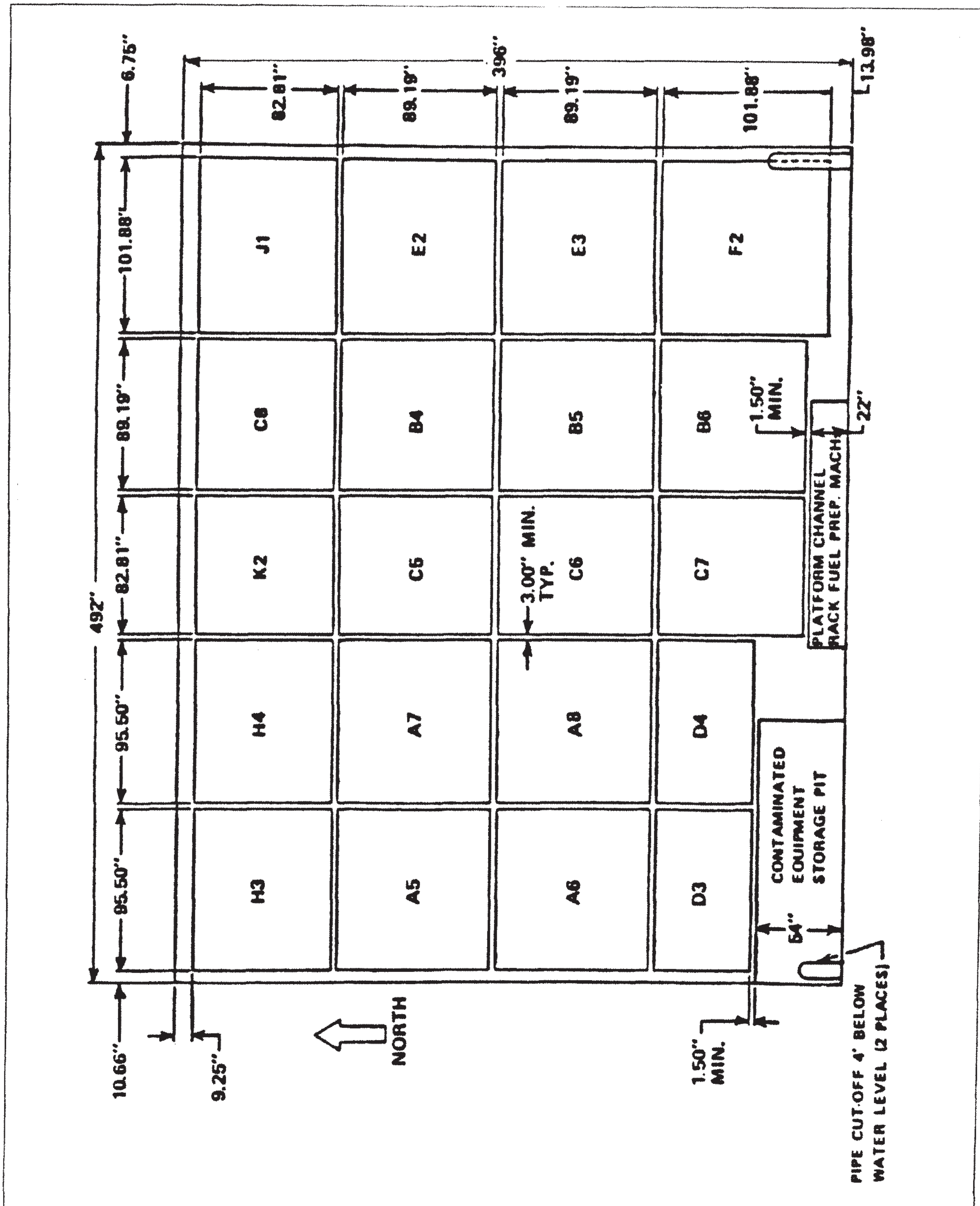


QUAD CITIES STATION
UNITS 1 & 2

GENERAL ARRANGEMENT OF HIGH DENSITY FUEL RACK MODULES QUAD CITIES UNIT 1 (3657 CELLS)

FIGURE 9.1-12

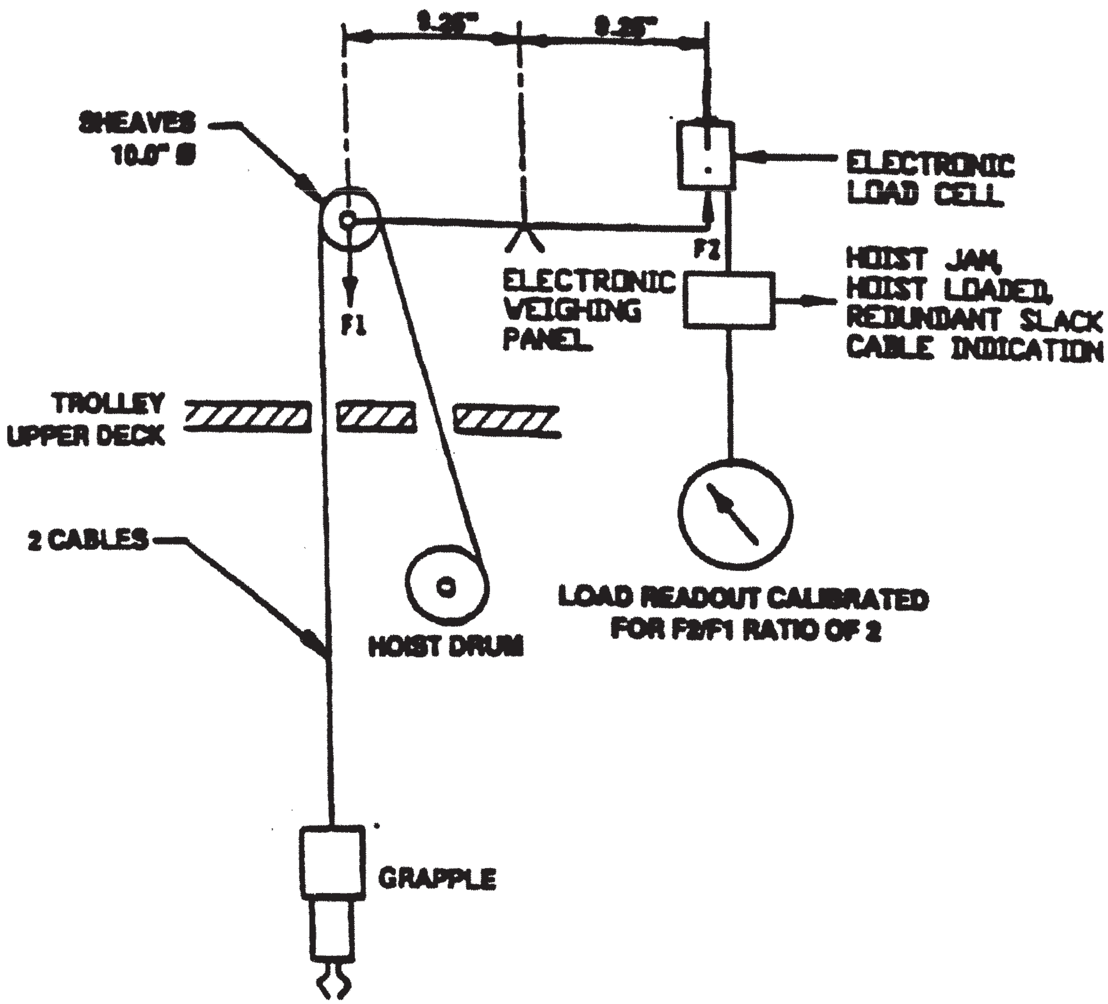
REVISION 4, APRIL 1997



QUAD CITIES STATION
UNITS 1 & 2

GENERAL ARRANGEMENT OF HIGH DENSITY FUEL RACK MODULES QUAD CITIES UNIT 2 (3897 CELLS)

FIGURE 9.1-13

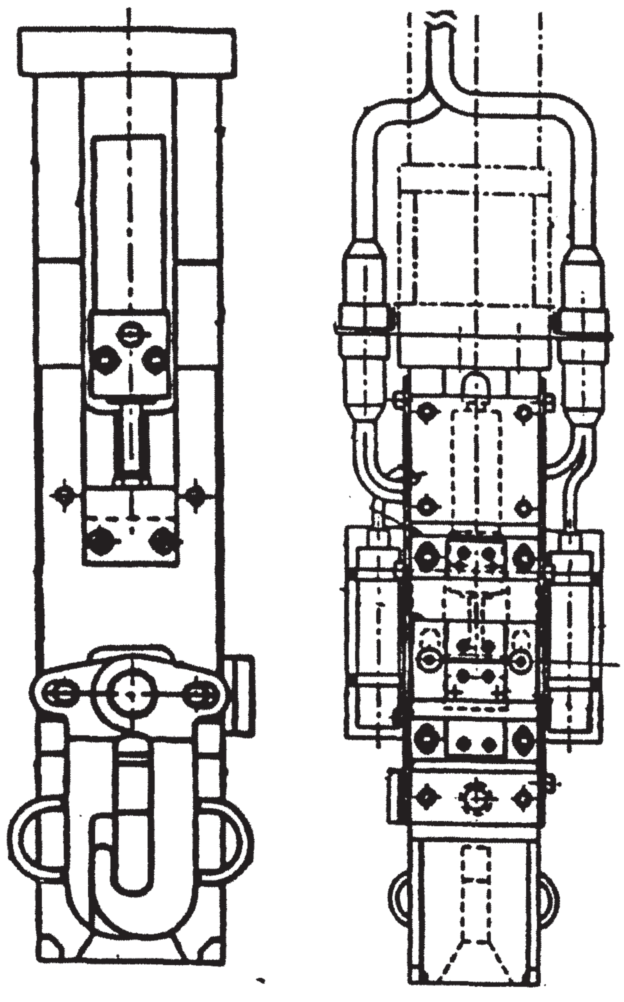


QUAD CITIES STATION
UNITS 1 & 2

REFUEL BRIDGE MAIN HOIST
LOAD WEIGHING ARRANGEMENT

FIGURE 9.1-14

REV. 3, DECEMBER 1995

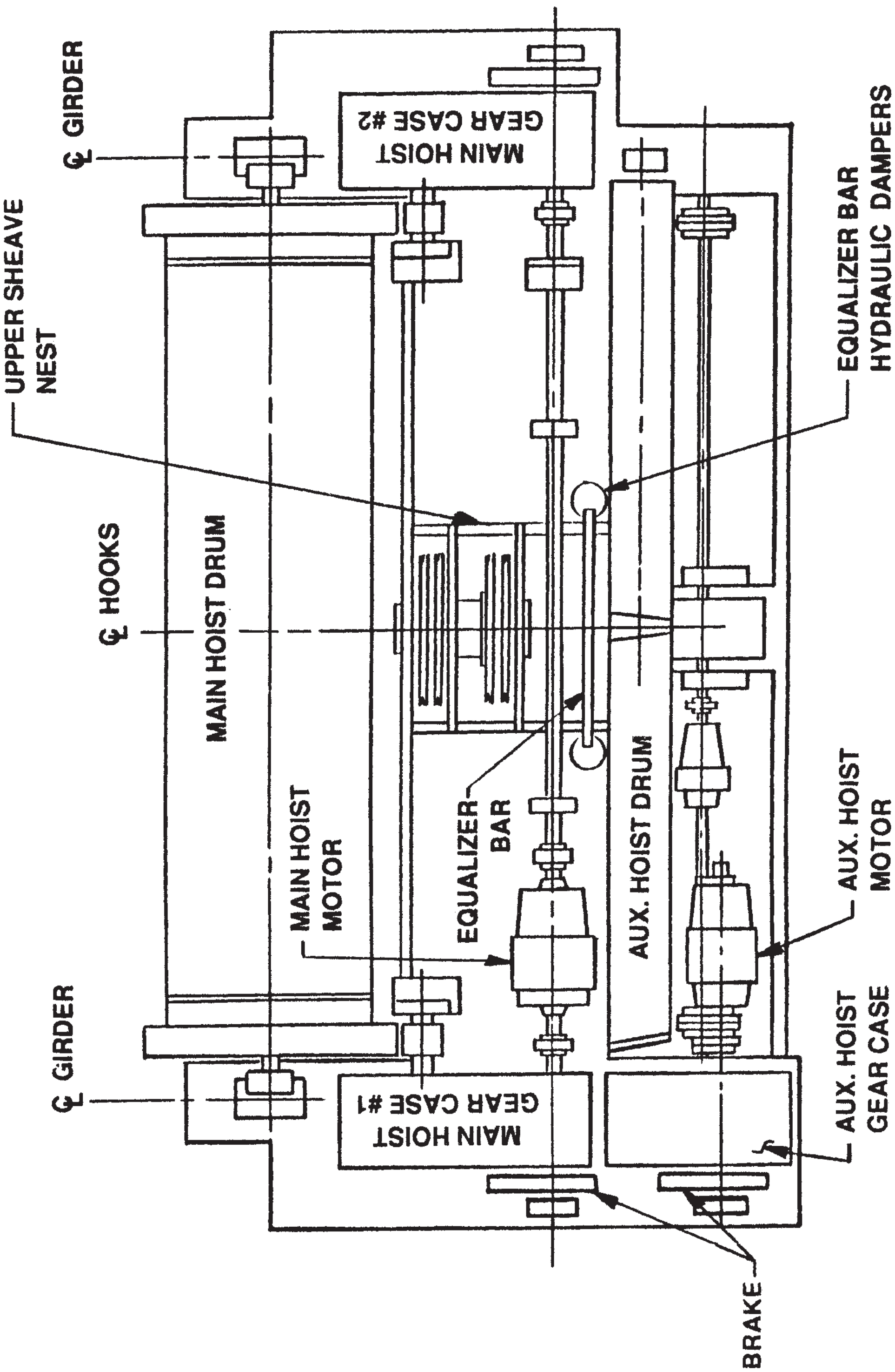


QUAD CITIES STATION
UNITS 1 & 2

REFUEL BRIDGE MAIN HOIST GRAPPLE HEAD

FIGURE 9.1-15

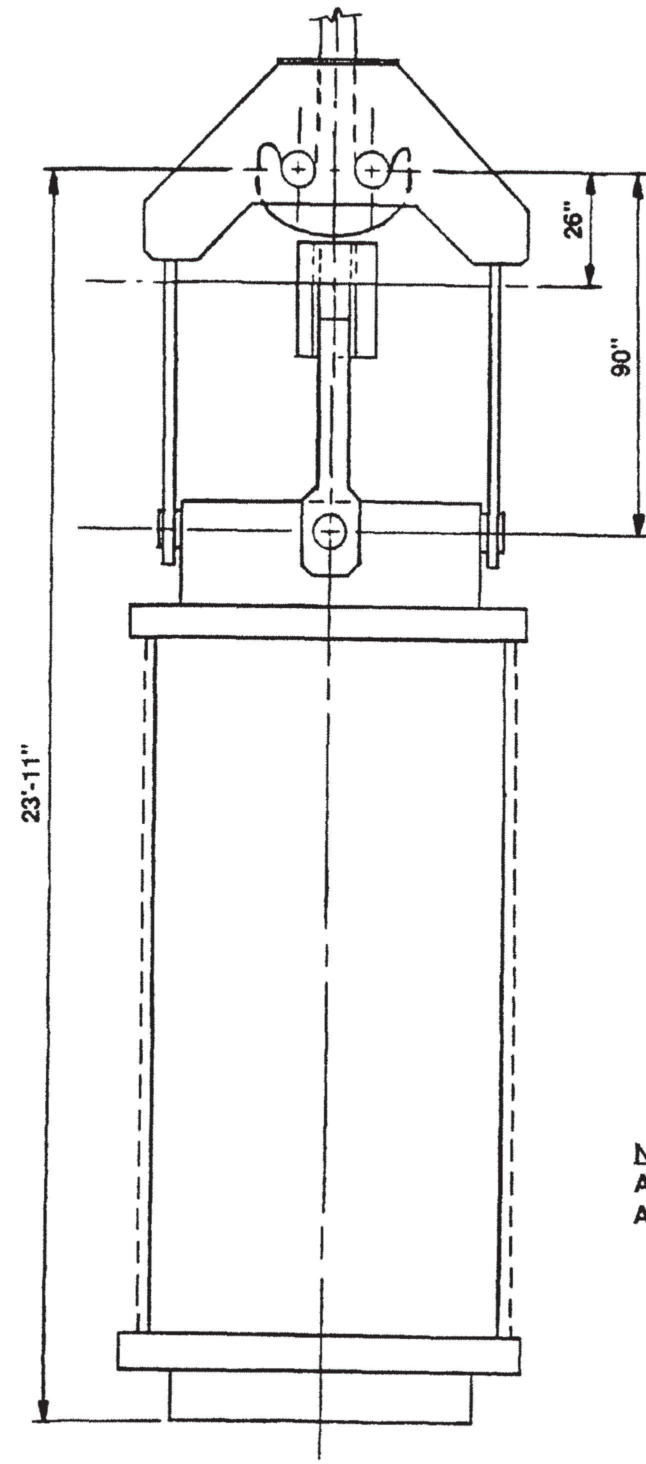
REV. 3, DECEMBER 1995



QUAD CITIES STATION
UNITS 1 & 2

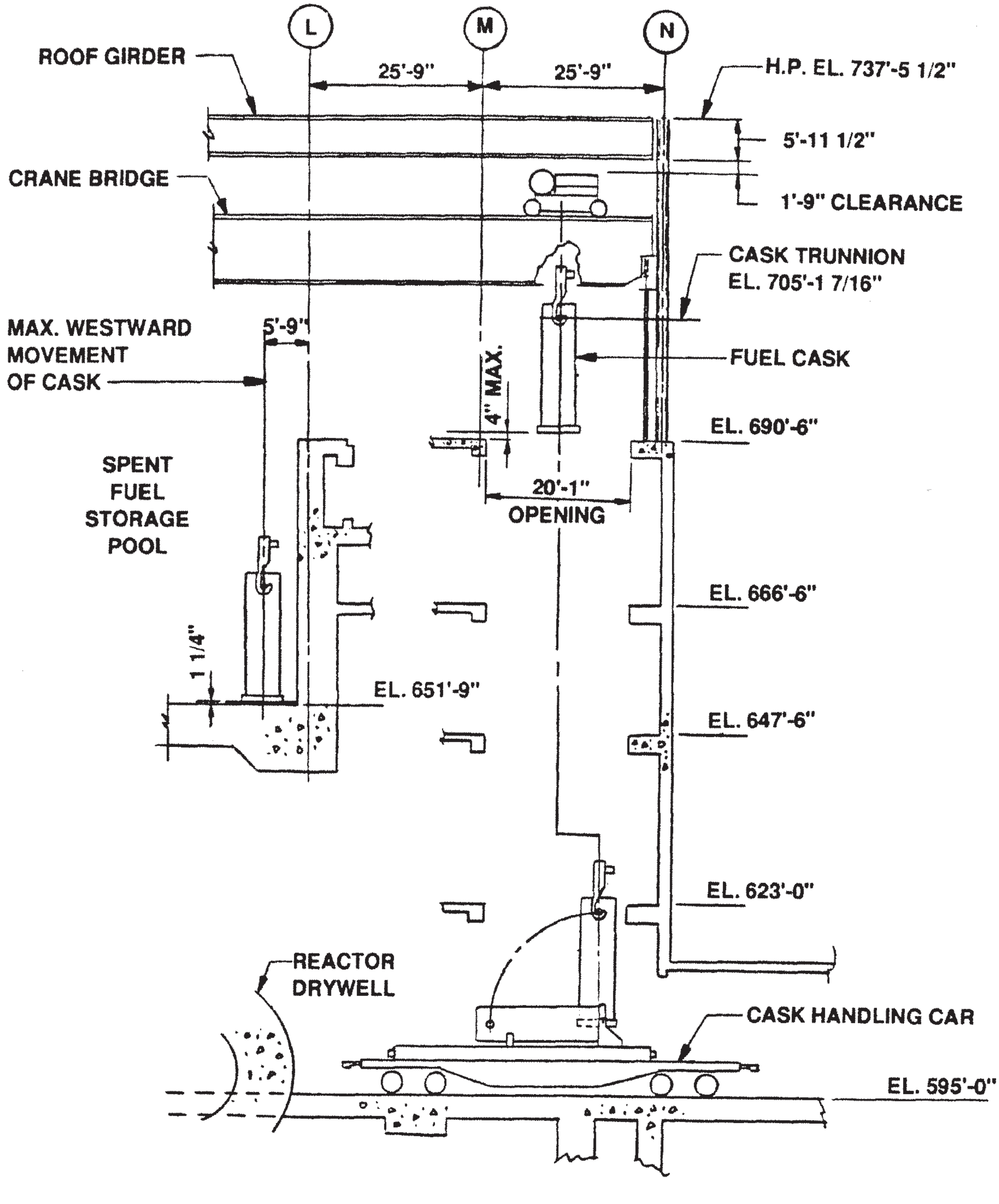
PLAN VIEW OF REACTOR BUILDING OVERHEAD CRANE TROLLEY WITH DUAL LOAD PATH MAIN HOIST

FIGURE 9.1–16
REVISION 11, OCTOBER 2011



NOTE:
ALL DIMENSIONS
ARE APPROXIMATE

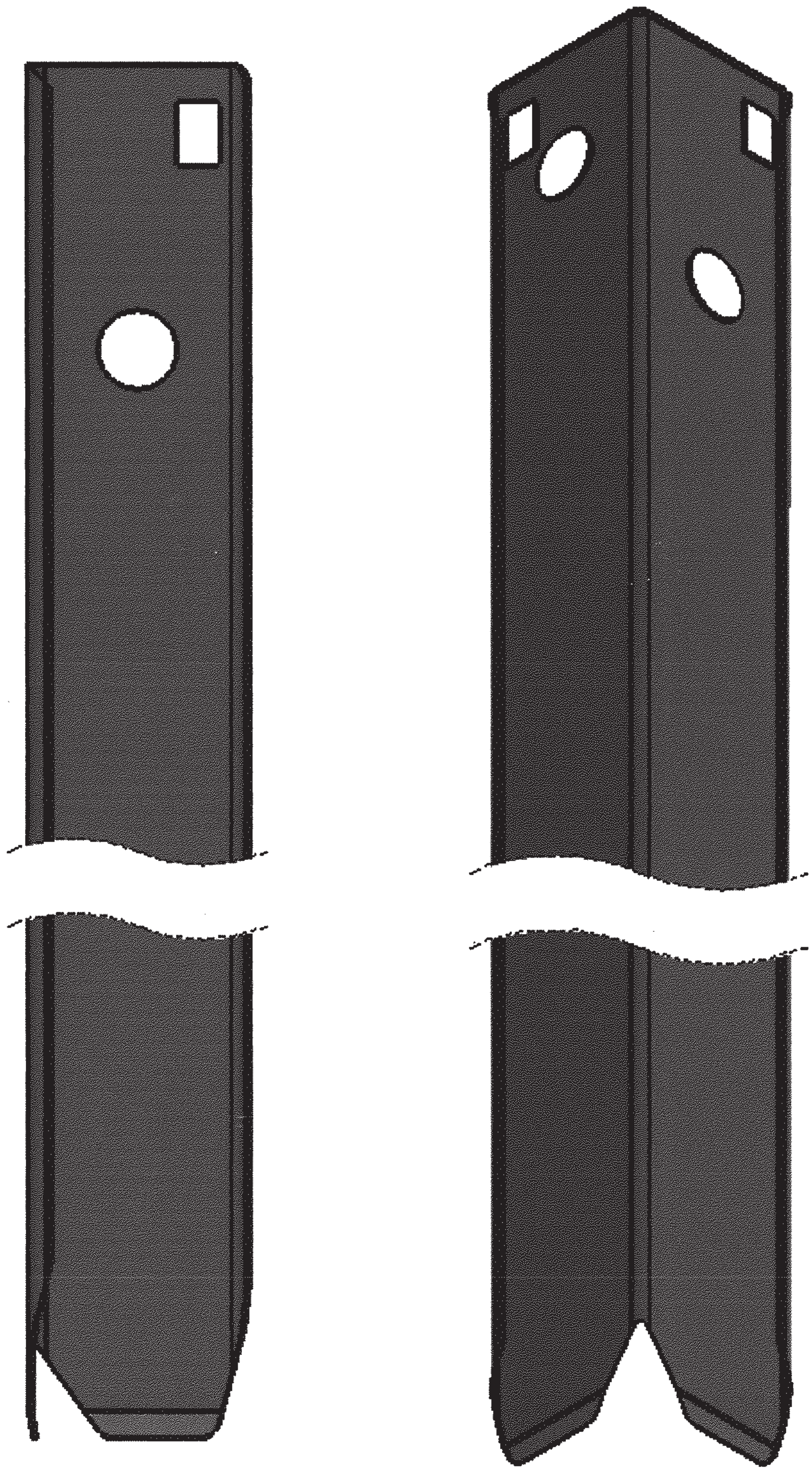
QUAD CITIES STATION UNITS 1 & 2
FUEL CASK REDUNDANT LIFT RIG WITH REDUNDENT HOOK
FIGURE 9.1-17



QUAD CITIES STATION
UNITS 1 & 2

NLI 10/24 FUEL CASK LOADING SECTION

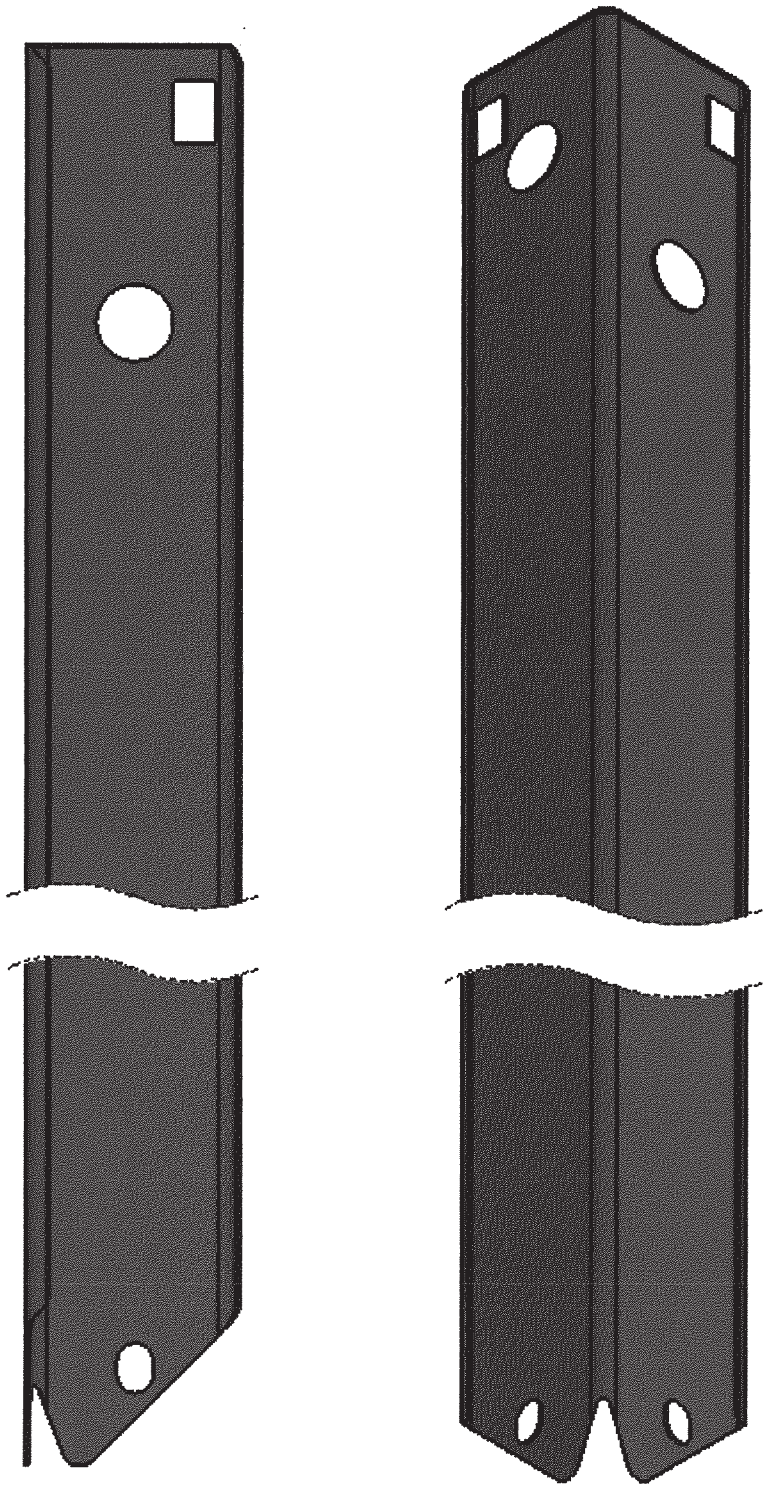
FIGURE 9.1-18



QUAD CITIES STATION
UNITS 1 & 2

NETCO SPENT FUEL POOL RACK INSERT – STYLE 1

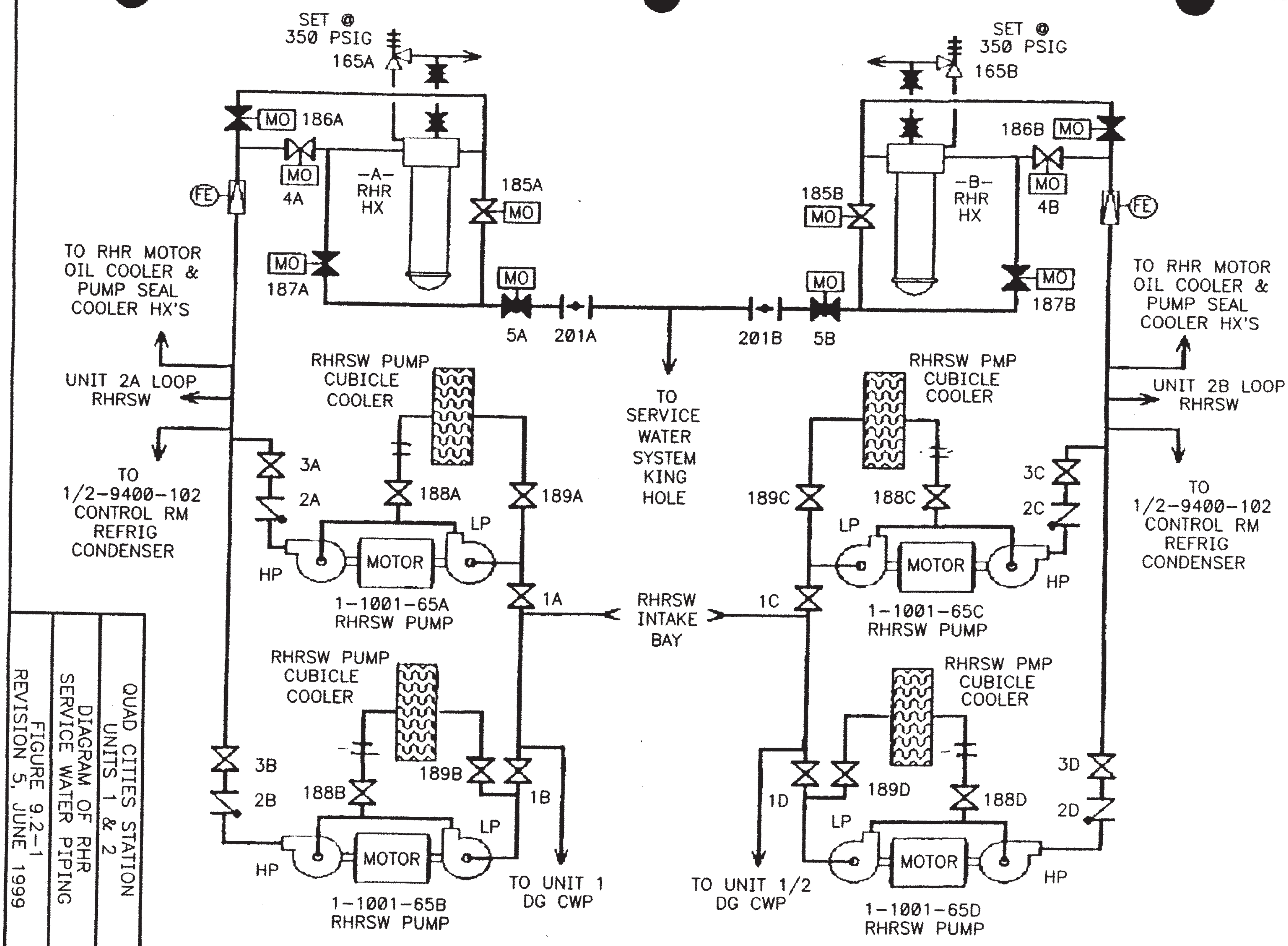
FIGURE 9.1-19



QUAD CITIES STATION
UNITS 1 & 2

NETCO SPENT FUEL POOL RACK INSERT – STYLE 2

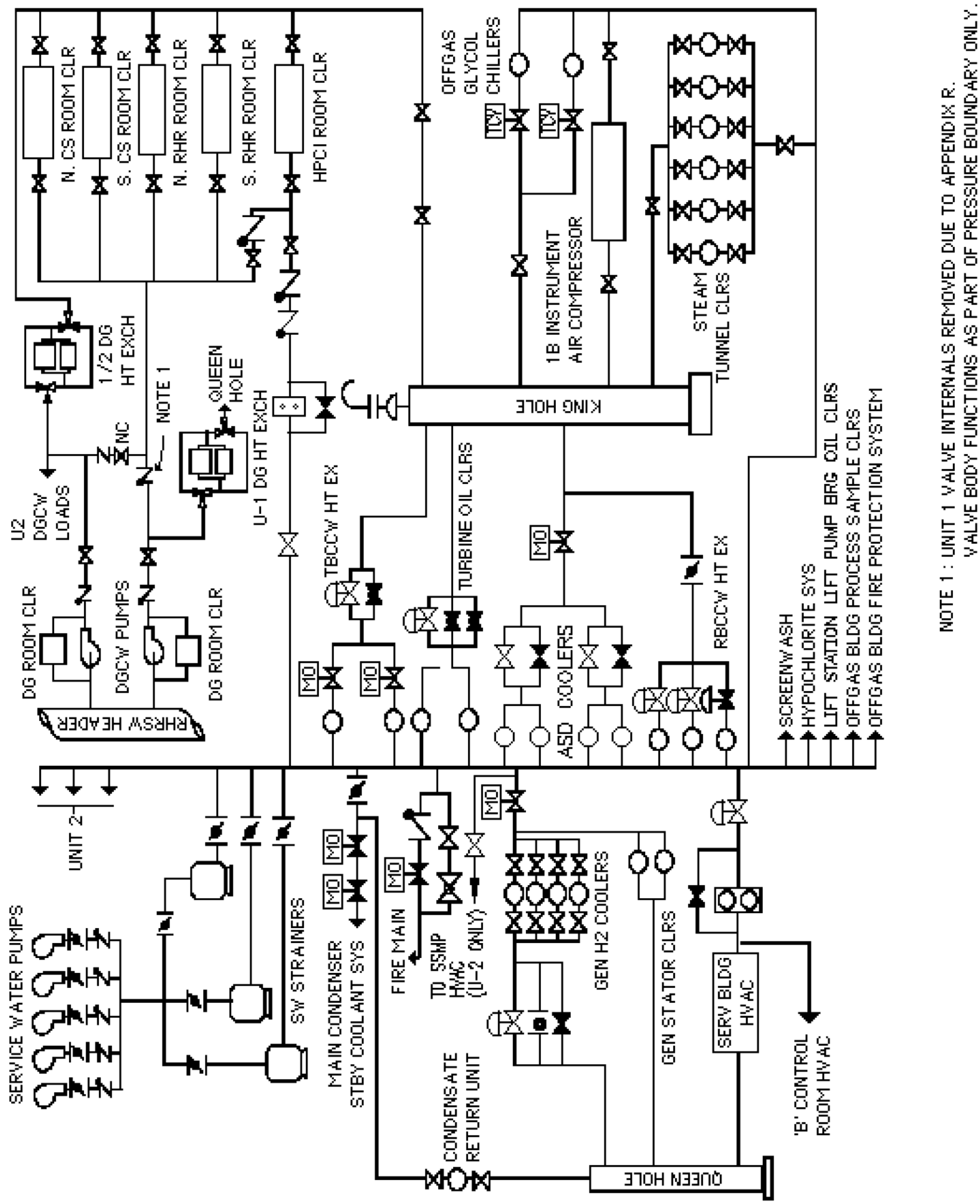
FIGURE 9.1-20



QUAD CITIES STATION
UNITS 1 & 2

DIAGRAM OF RHR
SERVICE WATER PIPING

FIGURE 9.2-1
REVISION 5, JUNE 1999

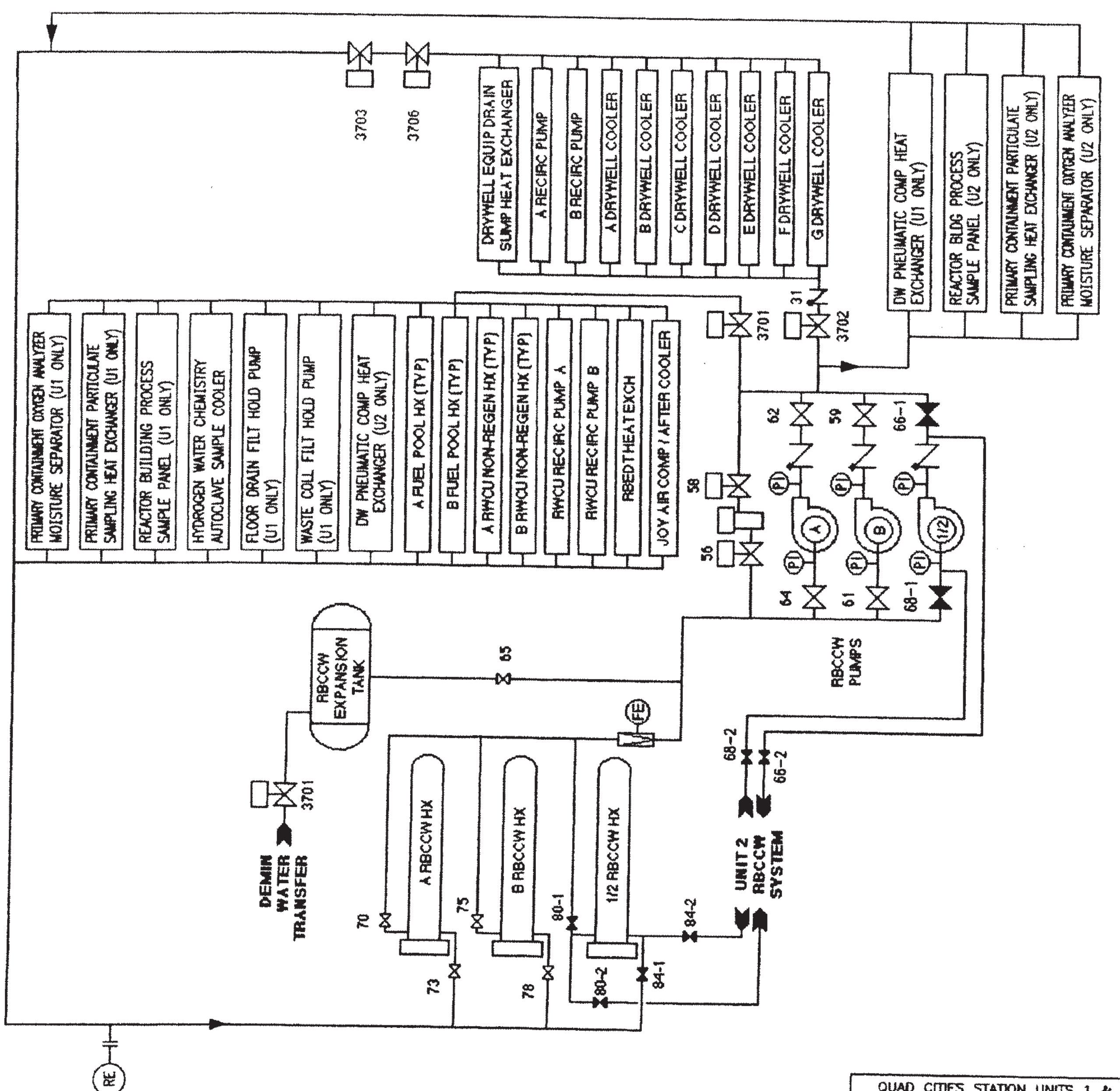


QUAD CITIES STATION UNITS 1 & 2

DIAGRAM OF
SERVICE WATER PIPING

FIGURE 9.2–2

REVISION 11, OCTOBER 2011

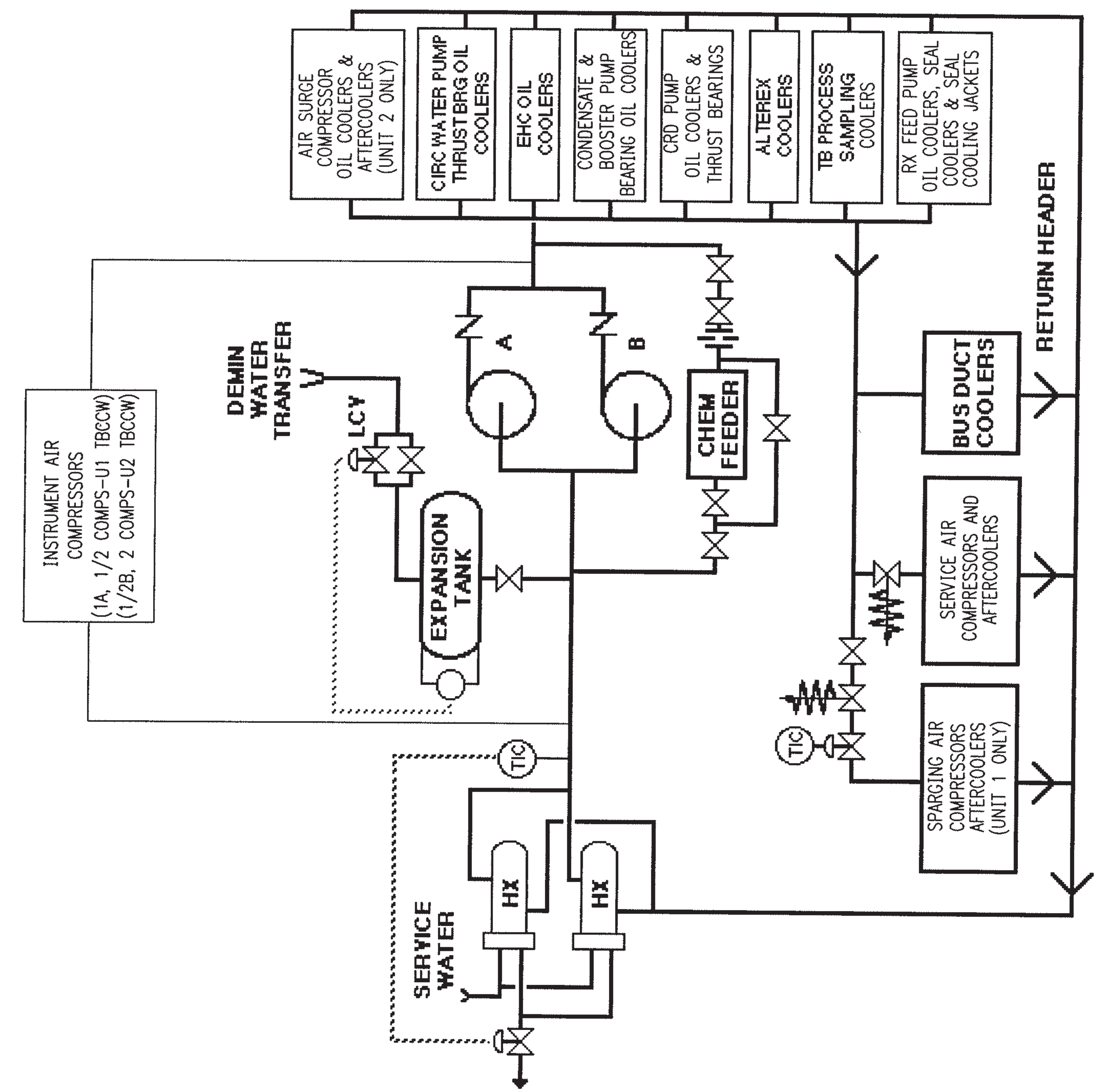


QUAD CITIES STATION UNITS 1 & 2

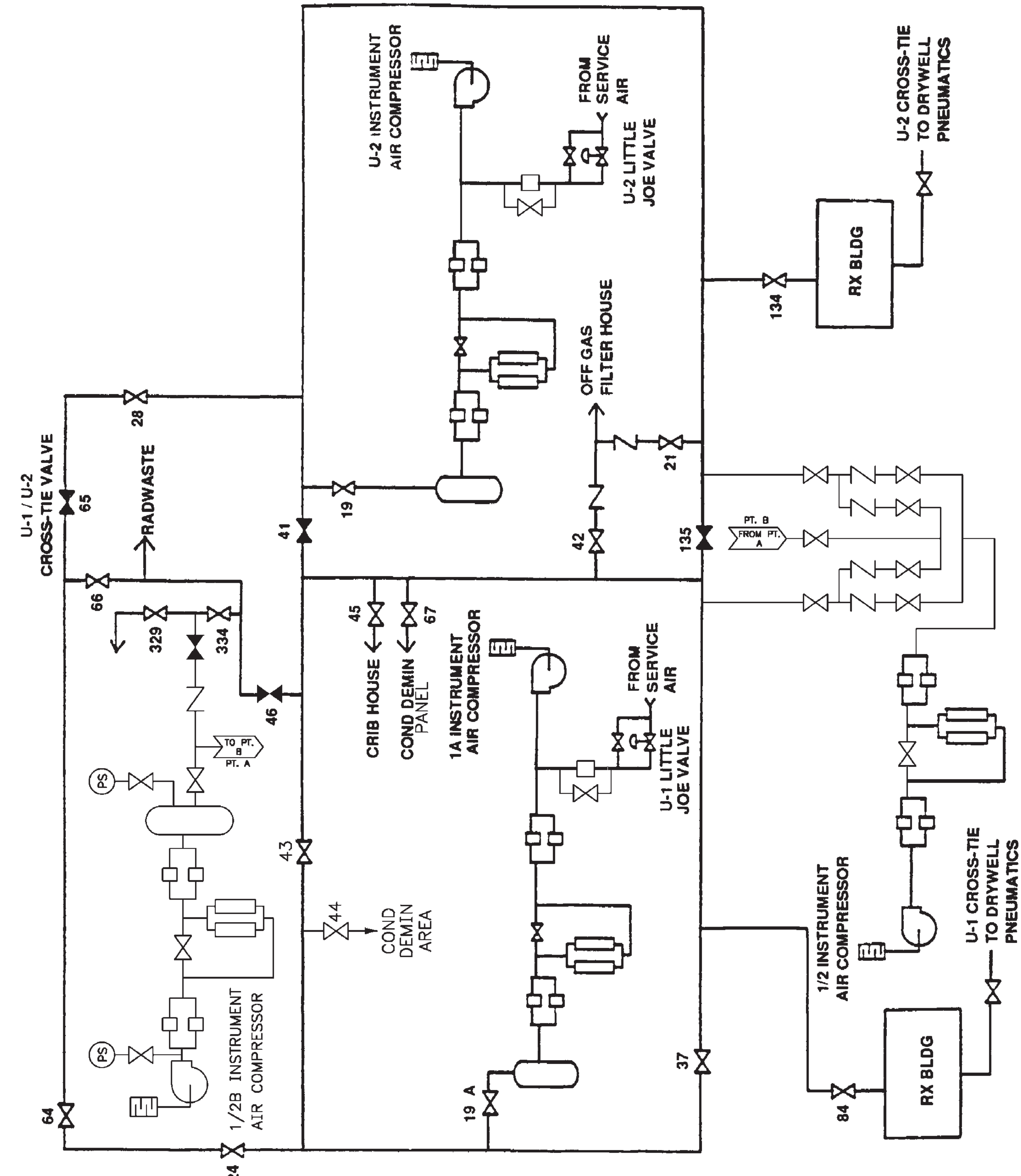
DIAGRAM OF REACTOR BLDG CLOSED COOLING WATER PIPING

FIGURE 9.2–3

REVISION 6, OCTOBER 2001



QUAD CITIES STATION UNITS 1 & 2
DIAGRAM OF TURBINE BUILDING CLOSED COOLING WATER PIPING
FIGURE 9.2-4
REVISION 10, OCTOBER 2009

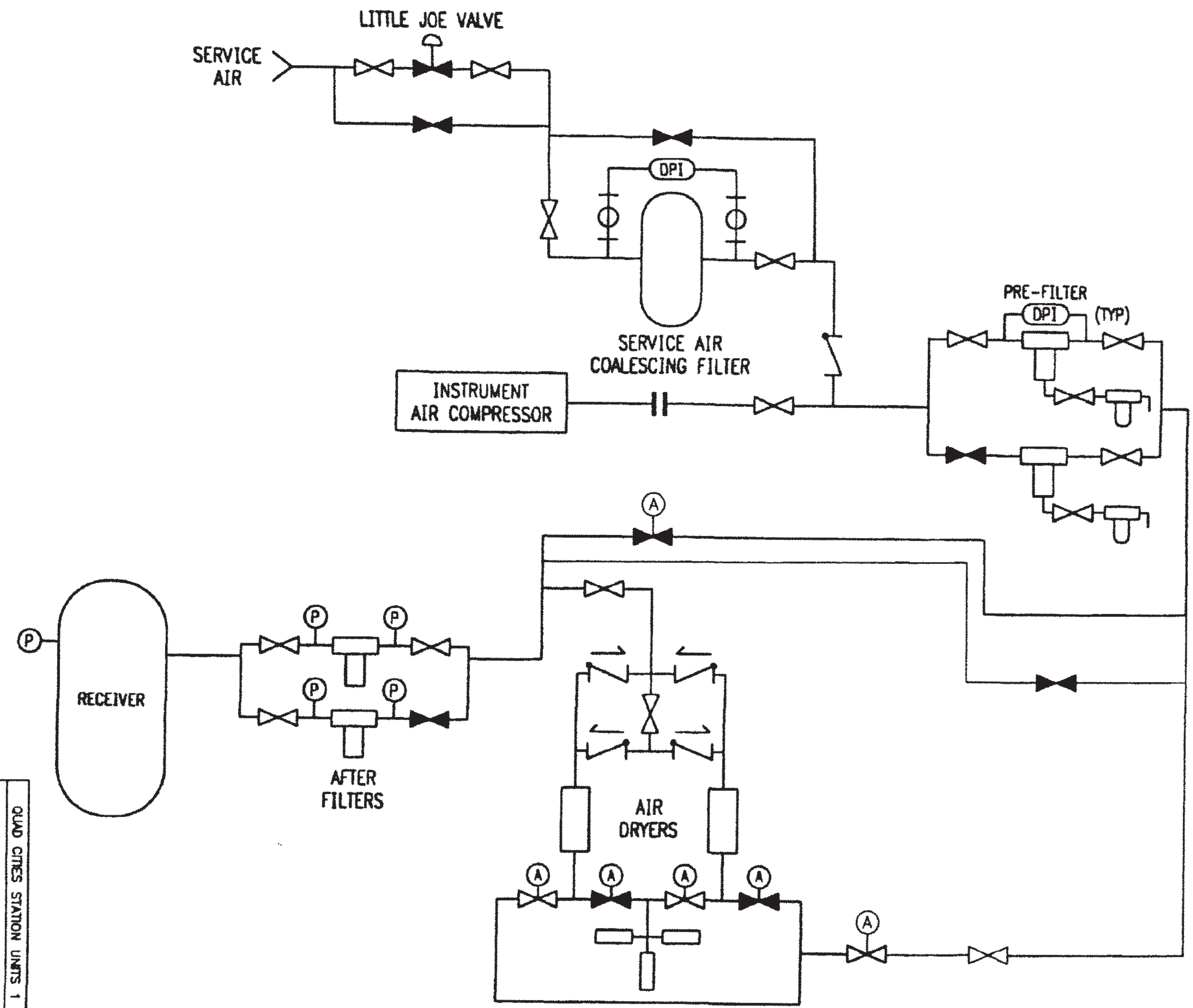


QUAD CITIES STATION UNITS 1 & 2

INSTRUMENT AIR SYSTEM

FIGURE 9.3–1

REVISION 10, OCTOBER 2009

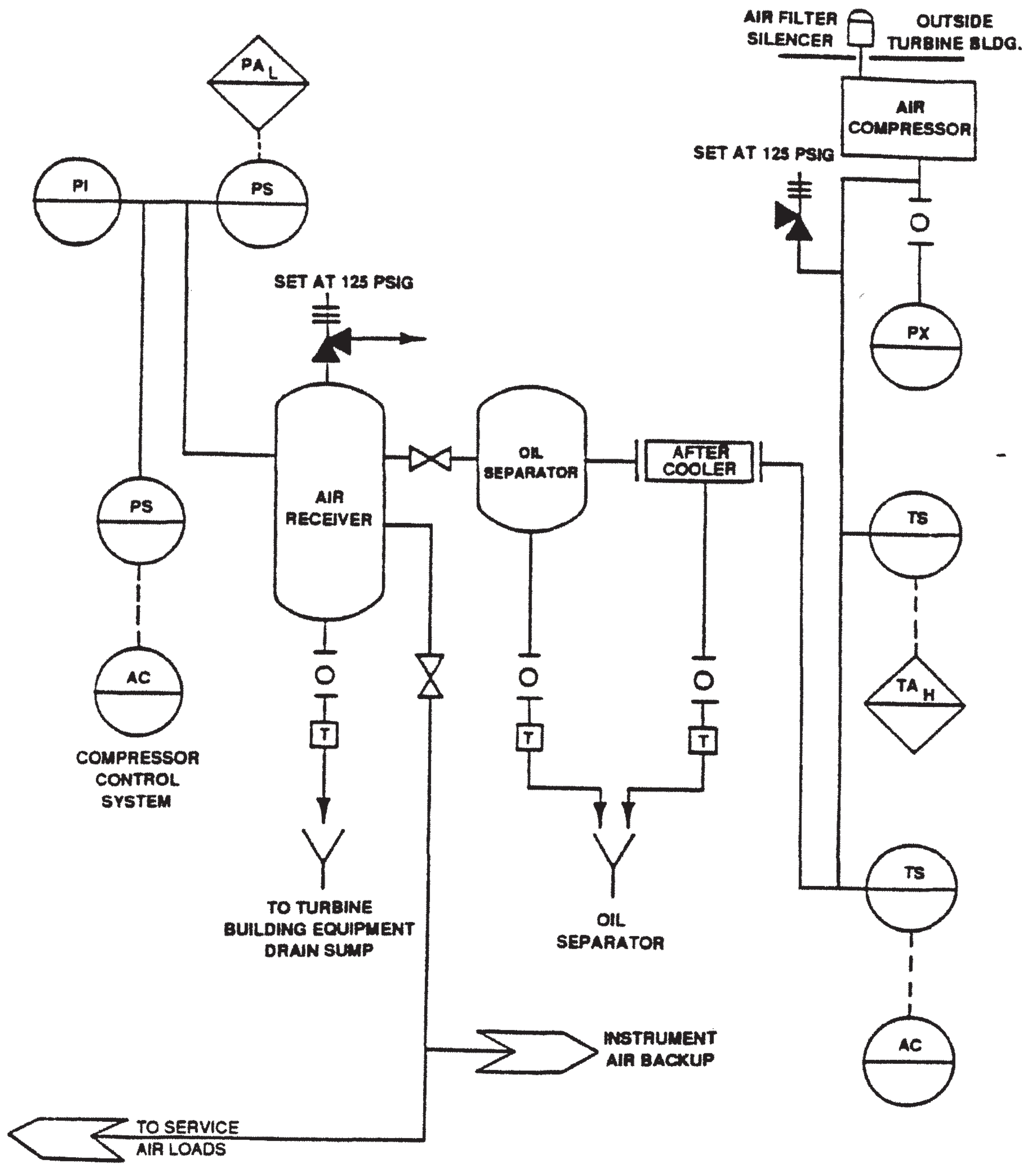


QUAD CITIES STATION UNITS 1 & 2

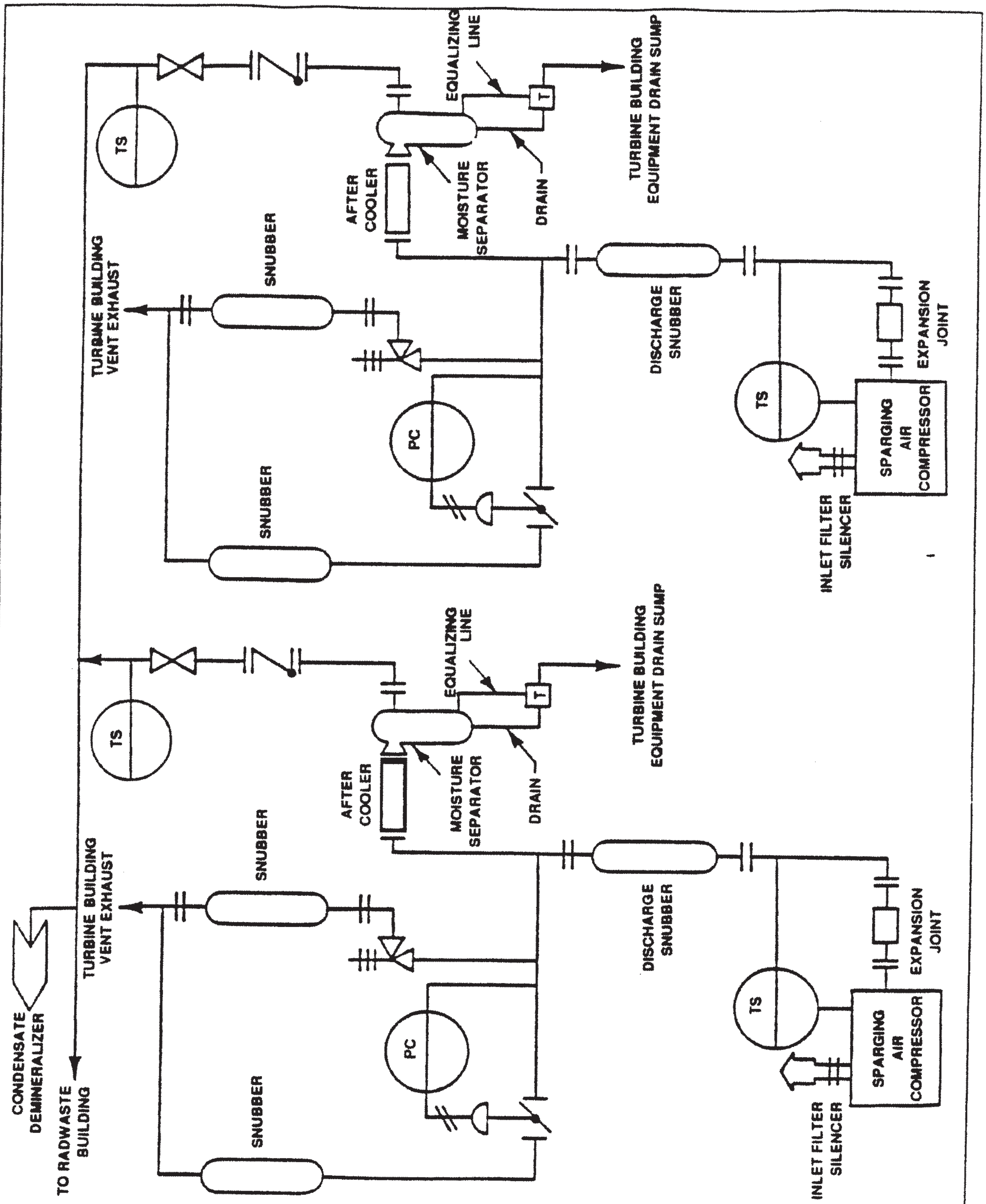
INSTRUMENT AIR COMPRESSOR TRAIN LAYOUT UNIT 2

FIGURE 9.3-2

REVISION 6, OCTOBER 2001



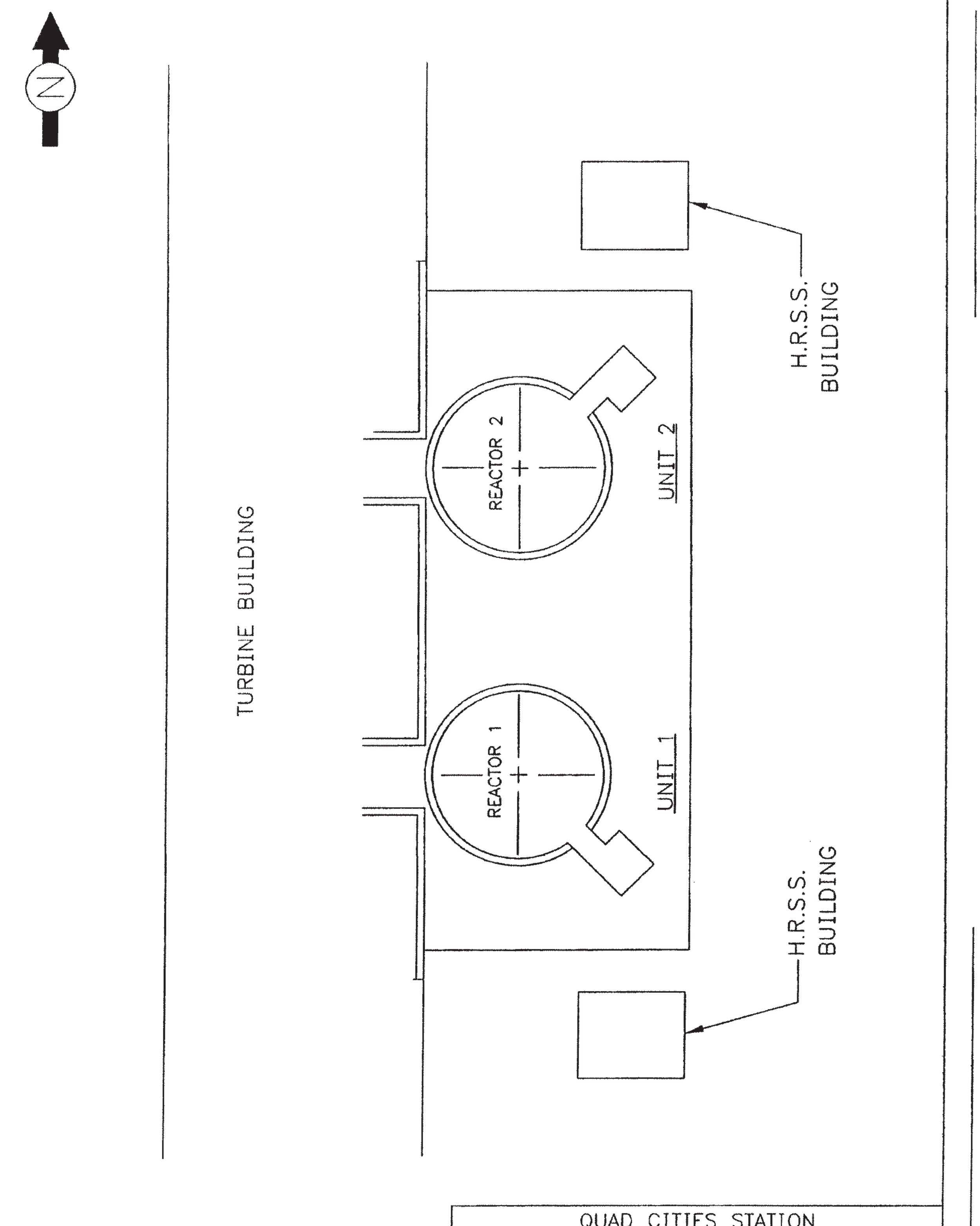
QUAD CITIES STATION UNITS 1 & 2
TYPICAL SERVICE AIR COMPRESSOR CONFIGURATION
FIGURE 9.3-3 REV. 2, DEC. 1993



QUAD CITIES STATION
UNITS 1 & 2

SPARGING AIR SYSTEM ARRANGEMENT

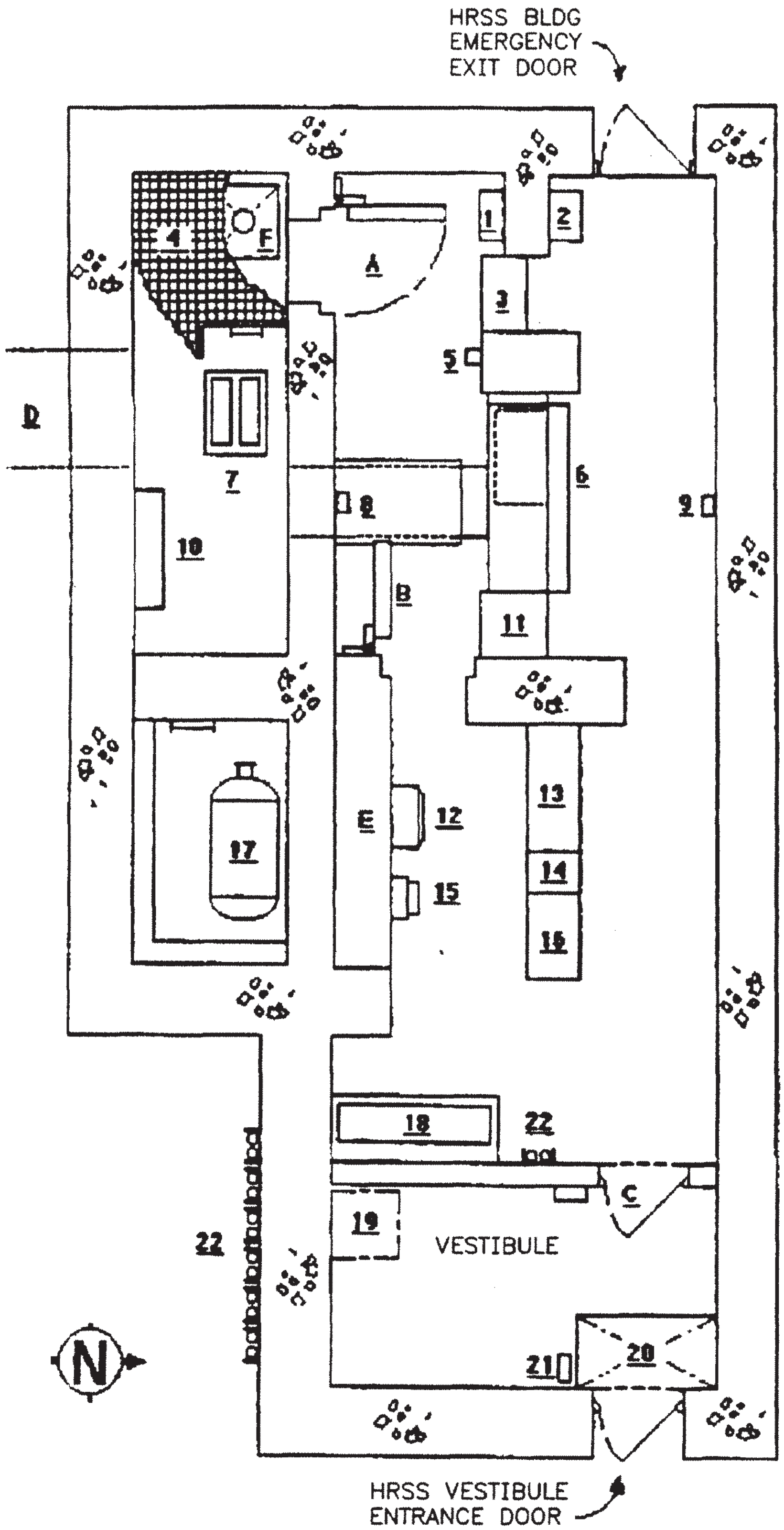
FIGURE 9.3-4
REV. 2, DEC. 1993



QUAD CITIES STATION
UNITS 1 & 2

LOCATION OF HRSS BUILDING

FIGURE 9.3-5
REV. 9, OCTOBER 2007



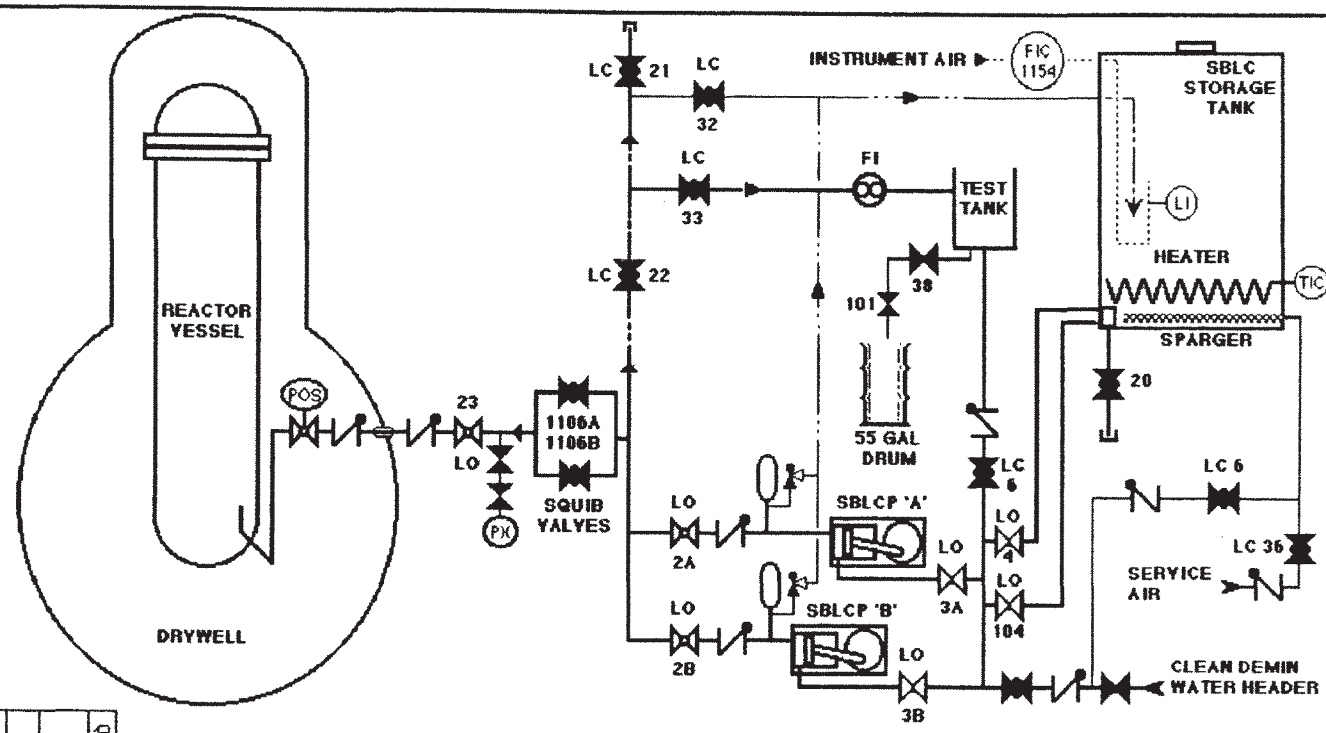
A – PIT AREA ACCESS DOOR
B – REAR PANEL AREA ACCESS DOOR
C – DOOR WITH GLASS PANEL
D – PIPE TRENCH TO RX BLDG
E – SHIELD WALL
F – BUILDING SUMP PUMP

1 – N/A
2 – N/A
3 – CAS (AIR) SAMPLE PANEL
4 – PLATFORM EL 598'-3.75"
5 – N/A
6 – HRSS (LIQUID) SAMPLE PANEL
7 – HRSS WASTE PUMPS
8 – RADIATION MONITOR #1
9 – RADIATION MONITOR #2
10 – SAMPLE COOLER RACK
11 – IN-LINE CHEM ANALYSIS PANEL
12 – AMPLIFIER CABINET
13 – HRSS CONTROL PANEL
14 – CAP CONTROL PANEL
15 – HVAC CONTROL PANEL & DRYER
16 – CAS CONTROL PANEL
17 – HRSS WASTE TANK
18 – MCC
19 – SAMPLE CASK CART STORAGE
20 – STEP OFF PAD AREA
21 – FRISKER
22 – GAS CYLINDER STORAGE

QUAD CITIES STATION
UNITS 1 & 2

DIAGRAM OF UNIT 2 HRSS BLDG
FLOOR PLAN EL 595'-0"

FIGURE 9.3-6
REVISION 5, JUNE 1999

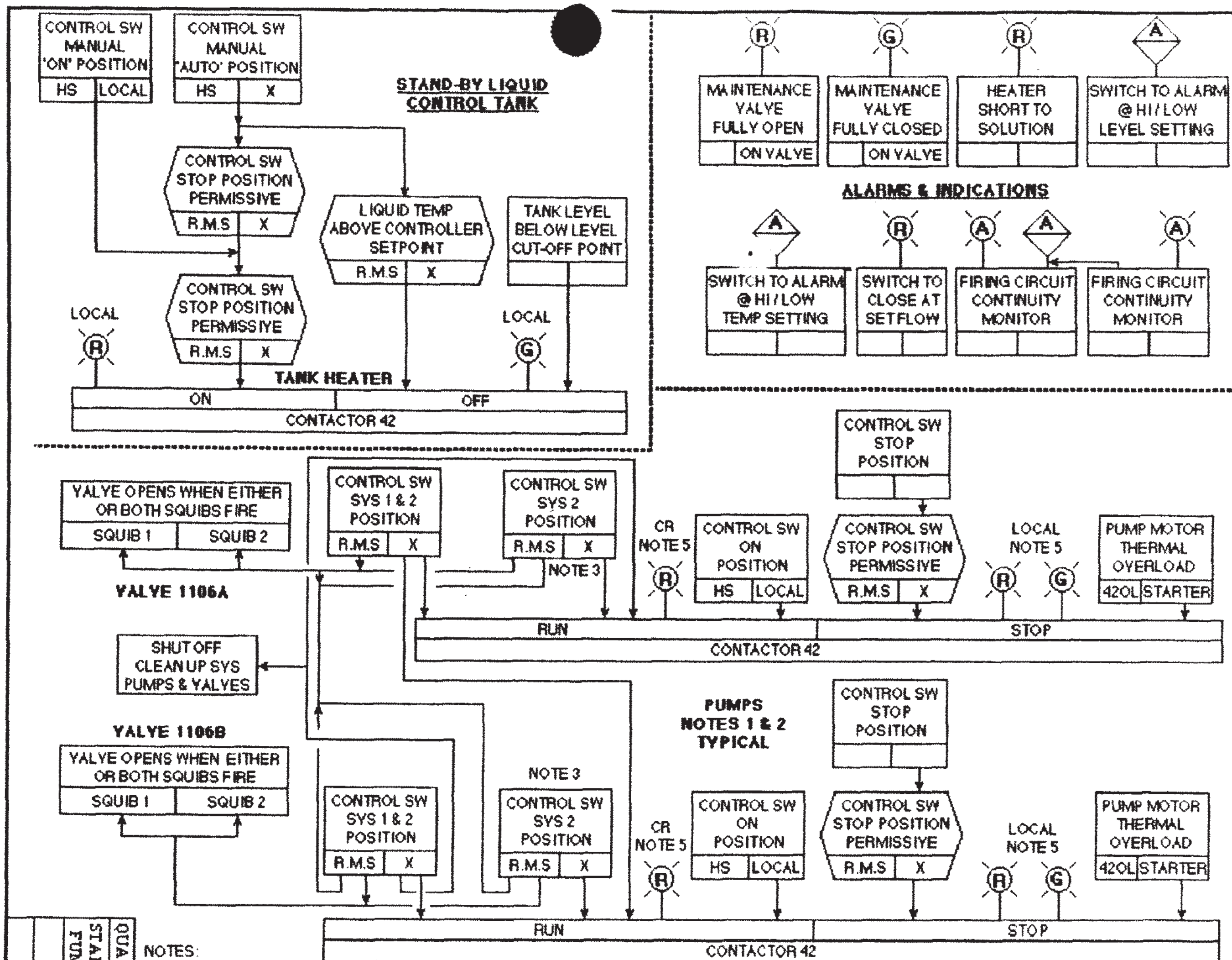


QUAD CITIES STATION UNITS 1 & 2

DIAGRAM OF STANDBY LIQUID CONTROL PIPING

FIGURE 9.3-7

REV. 3, DECEMBER 1995



NOTES:

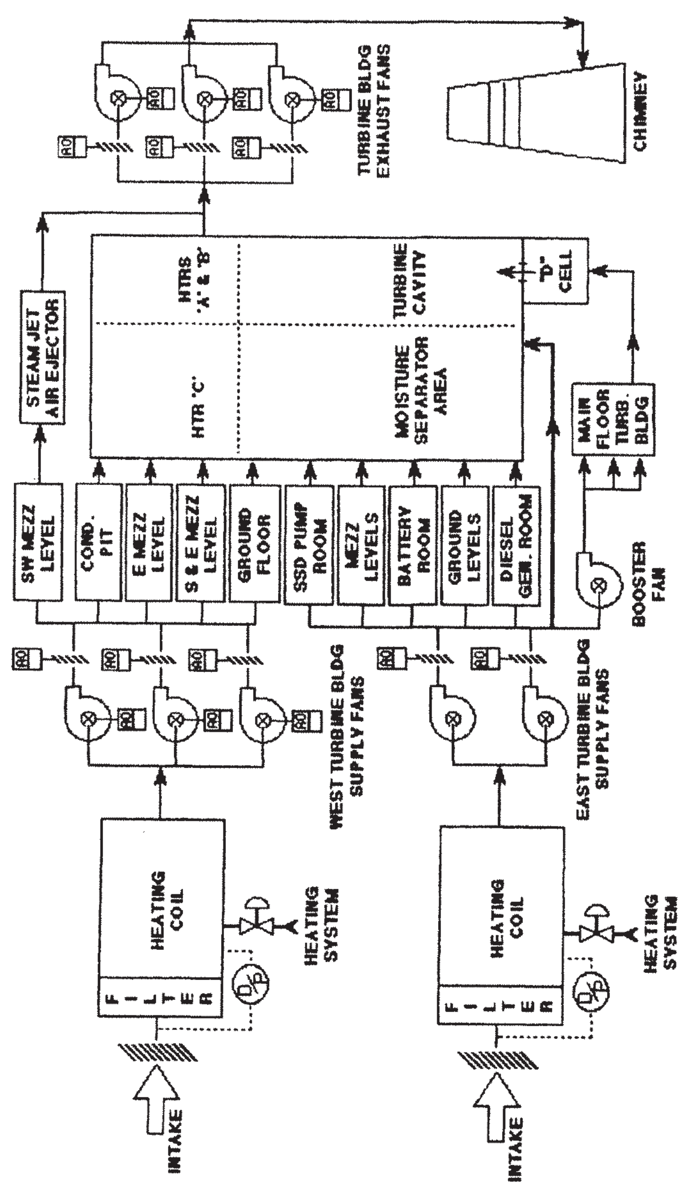
1. SYSTEM ELECTRICAL POWER SHALL BE EMERGENCY AC BUSSES WITH PUMP 1102A AND VALVE 1106A ON A DIFFERENT BUS THAN PUMP 1102B AND VALVE 1106B
2. CONTROL POWER FOR THE STANBY LIQUID PUMP AND EXPLOSIVE VALVE SHALL BE TAKEN FROM THE BUSSES FEEDING THE PUMP MOTORS.
3. RMS CONTROL SWITCH IS KEYLOCK IN OFF POSITION. MAINTAIN CONTACT IN "SYS" POSITIONS. SWITCH BYPASSES CONTINUITY MONITOR IN "SYS" POSITIONS TO FIRE VALVE SQUIBS.
4. CONTINUITY INDICATING LIGHTS ON WHEN FIRING CIRCUIT HAS CONTINUITY THROUGH BOTH SQUIBS. ANNUNCIATOR TRIPS& LIGHT GOES OFF UPON LOSS OF CONTINUITY IN EITHER SQUIB.
5. PUMP PILOT LIGHTS SHALL FUNCTION AS FOLLOWS:
   RED = "ON" WHEN PUMP RUNNING
   GREEN = ":ON" WHEN PUMP IS STOPPED
   BOTH "OFF" WHEN PUMP MANUALLY SHUTS OFF FOR MAINTENANCE
6. CONTINUITY MONITOR TO BE CURRENT LIMITED AND FUSED TO PREVENT ACCIDENTAL FIRING OF VALVES BY ANY MODE OF FAILURE OF THE MONITOR CIRCUIT.
7. LIGHTS TO BE "ON" WHEN STANDBY LIQUID SOLUTION IS FLOWING TO REACTOR, INDICATING SQUIB VALVES OPEN.
8. LOCATION NUMBERS FOR RMS ARE SHOWN IN ONE POSITION ONLY. AN "X" IN THE LOCATION OF OTHER POSITIONS INDICATES THAT THEIR BLOCKS ARE AN INTEGRAL PART OF THE NUMBERED SWITCH ASSY'Y BUT A DIFFERENT POSITION ON THE SWITCH HANCLE.

QUAD CITIES STATION UNITS 1 & 2

STANDBY LIQUID CONTROL SYSTEM FUNCTIONAL CONTROL DIAGRAM

FIGURE 9.3-8

REV. 3, DECEMBER 1995

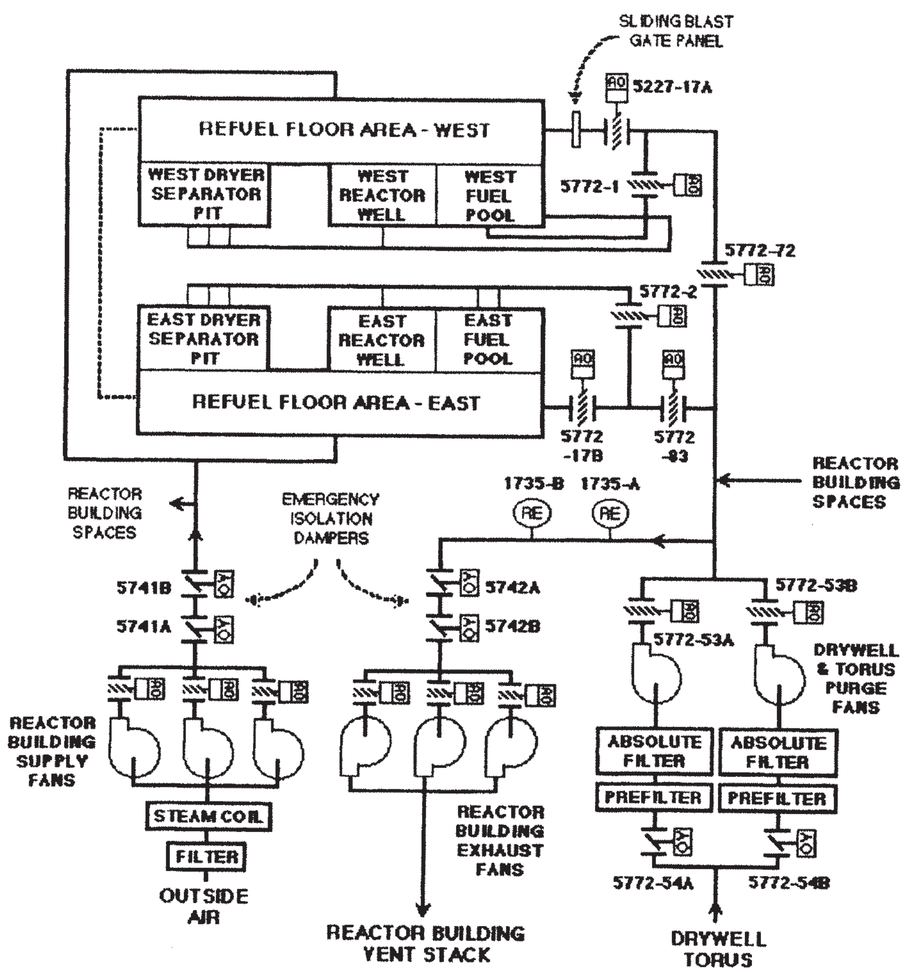


QUAD CITIES STATION UNITS 1 & 2

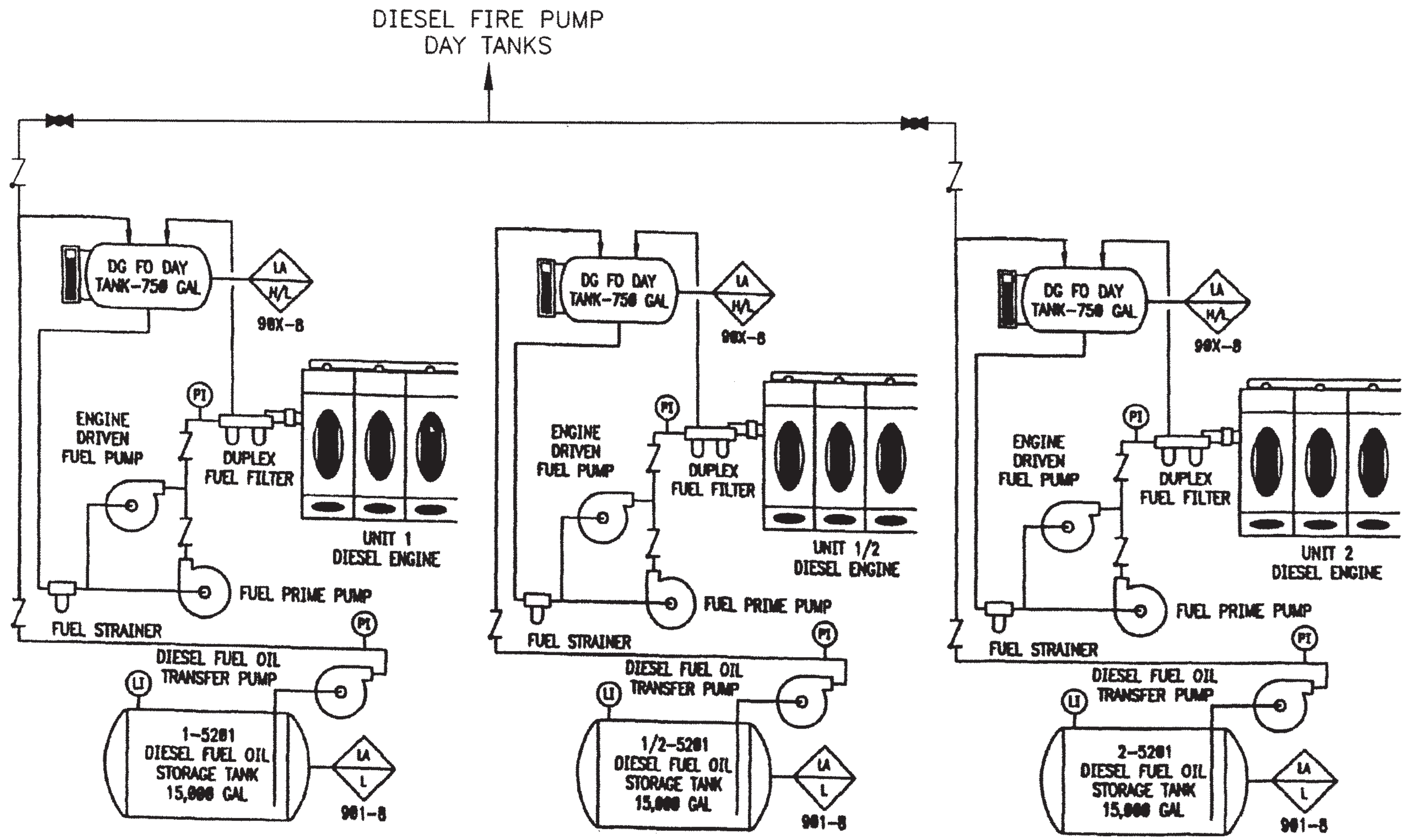
DIAGRAM OF TURBINE BUILDING VENTILATION

FIGURE 9.4-1

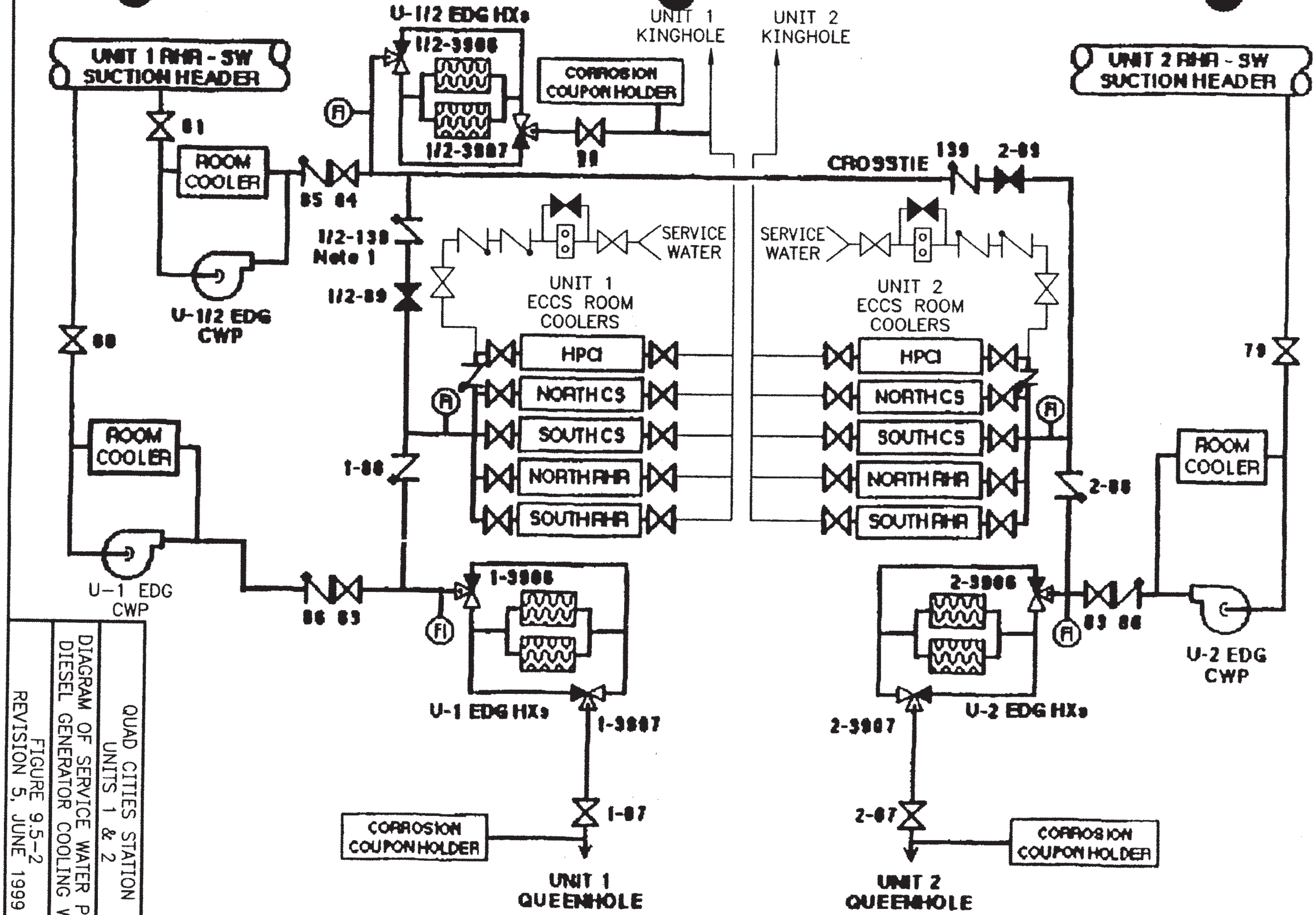
REVISION 6, OCTOBER 2001



QUAD CITIES STATION UNITS 1 & 2
DIAGRAM OF REACTOR BLDG VENT AND DRYWELL AIR COND
FIGURE 9.4-3
REVISION 6, OCTOBER 2001



QUAD CITIES STATION UNITS 1 & 2
DIAGRAM OF DIESEL GENERATOR FUEL OIL PIPING
FIGURE 9.5-1 REVISION 8, OCTOBER 2005

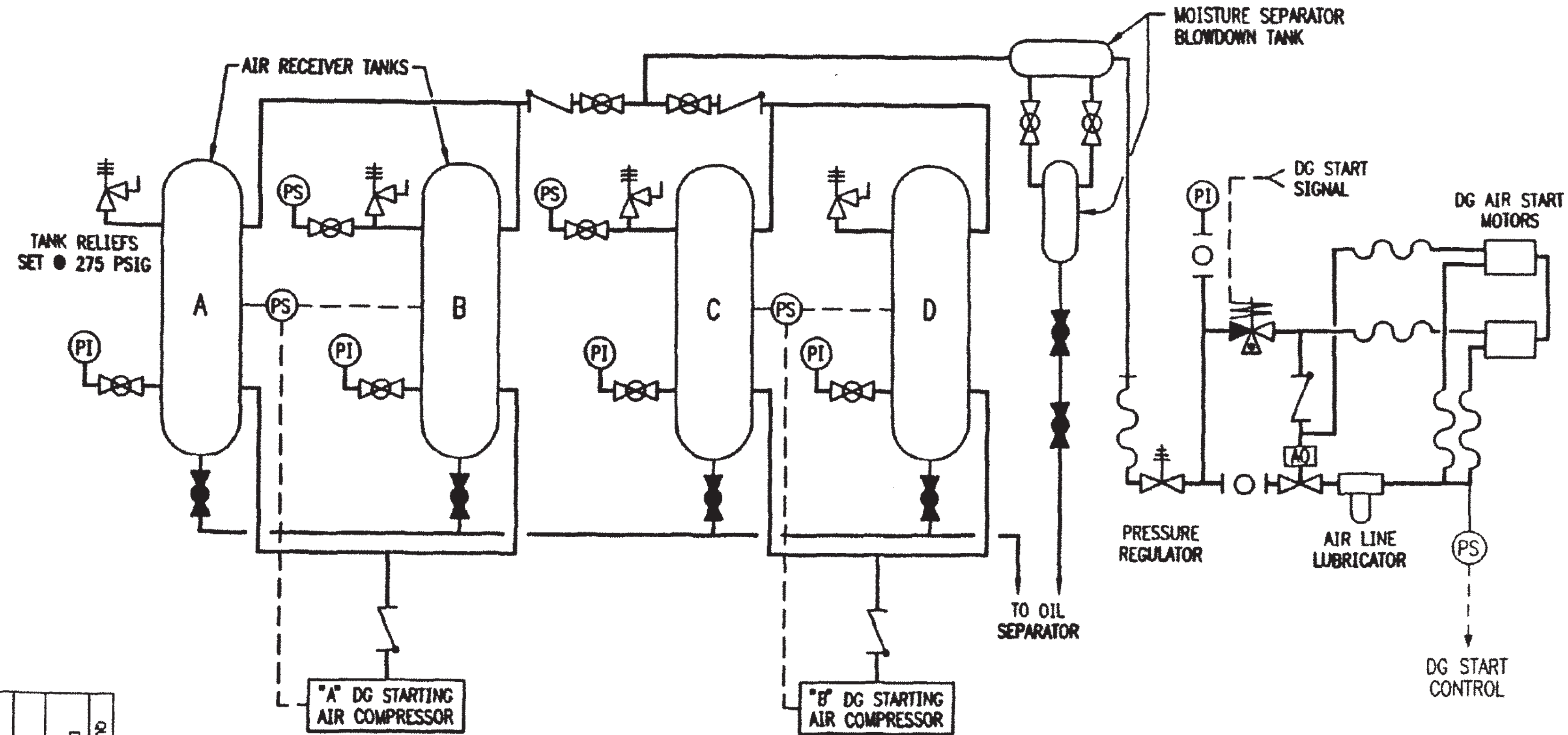


Note 1: Valve 1/2-138 has no internals

QUAD CITIES STATION
UNITS 1 & 2

DIAGRAM OF SERVICE WATER PIPING
DIESEL GENERATOR COOLING WATER

FIGURE 9.5-2
REVISION 5, JUNE 1999



UNIT 1, 1/2 AND 2 DG STARTING AIR SYSTEMS

QUAD CITIES STATION UNITS 1 & 2

DIAGRAM OF SERVICE AIR PIPING
DIESEL GENERATOR AIR START

FIGURE 9.5-3

REVISION 6, OCTOBER 2001