SECTION 9

AUXILIARY SYSTEMS

The Auxiliary Systems are supporting systems required for safe operation and servicing of the Reactor and the Reactor Coolant System and Engineered Safeguards Systems.

9.1 FUEL STORAGE AND HANDLING

The Fuel Handling and Storage System provides a safe, effective means of storing, transporting and handling fuel from the time it reaches the plant in an unirradiated condition until it leaves the plant after post-irradiation cooling. Each unit has a completely independent Fuel Handling and Storage System. The following description is for Unit 1 with Unit 2 having an identical system.

The system is designed to minimize the possibility of mishandling or of maloperations that could cause fuel damage and potential fission product release.

9.1.1 New Fuel Storage

9.1.1.1 Design Bases

The new fuel assemblies are received and stored dry in racks in the new fuel storage area, located in the Fuel Handling Building (see Plant Drawing 204836). New fuel is delivered to the reactor by lowering it into the transfer pool and taking it through the transfer system. The new fuel storage area is sized for storage of the fuel assemblies and control rods normally associated with the replacement of one-third of a core.

9.1.1.2 Safety Evaluation

The new fuel storage racks have been designed in accordance with the 1963 AISC Code. Seismic loads as well as dead load of fuel assemblies are considered in the design. The new fuel storage racks are designed so that it is impossible to insert the assemblies in other than the prescribed locations. The 21-inch nominal spacing between fuel assemblies will maintain a subcritical array even if the pool is flooded with unborated demineralized water.

Adequate shutdown margin is maintained for 17 x 17 fuel with 4.65 w/o (5) enrichment and no Integral Fuel Burnable Absorbers (IFBA) present. For consistency with the Region I (Exxon) spent fuel storage rack requirements (where new fuel must be placed before loading the core), only up to 4.25 w/o enriched 17 x 17 fuel assemblies without IFBA are allowed to be stored in the new (dry) fuel storage racks. Unirradiated fuel assemblies with enrichments greater than 4.25 w/oU-235 and less than or equal to 5.0 w/o U-235 are acceptable for storage with credit for a minimum number of IFBA pins. This minimum number of IFBA pins shall have an equivalent reactivity hold-down which is greater than or equal to the reactivity hold-down associated with N IFBA pins, at a nominal 2.35 mg B-10/linear inch loading (1.5X), determined by the equation below:

$$N = 42.67(E - 4.25)$$

The above equation is based on a more restrictive IFBA requirement for the Region I spent fuel racks and is conservative for the new fuel racks. E in the equation above is the fresh assembly design enrichment. A potential optimum moderation condition is precluded in the new fuel storage area by the following design features.

1. The Fuel Handling Building has no fire fighting hose stations,

2. The Fuel Handling Building has no installed aqueous fire suppression systems (e.g., sprinklers, fog, or sprays),

3. New fuel is covered with a protective metal plate during storage which prevents the introduction of low density water into the fuel racks from above.

The only accessible fire fighting hoses available for use in the new fuel storage area are connected to hose stations in the auxiliary building and will be equipped with straight-stream nozzles.

9.1.2 Spent Fuel Storage

The spent fuel storage pool is the storage space for irradiated spent fuel from the reactor. This pool is not required for any plant safety-related function.

9.1.2.1 Design Bases

The Spent Fuel Pool reracking project implemented in 1994 increased the fuel storage capacity from 1170 fuel assemblies to 1632 fuel assemblies. The reracking project retained 3 existing high density Exxon Nuclear Corporation modules containing 300 cells (Region I) and added 9 new maximum density Holtec modules containing 1332 cells (Region II) with a total storage capacity of 1632 fuel assemblies. The reracking provided an additional 10 years of storage capacity, which is expected to be sufficient up to the year 2008 for Unit 1 and 2012 for Unit 2.

The spent fuel storage racks are designed and shall be maintained with:

a. A maximum Keff equivalent of 0.95 with the storage racks filled with unborated water.

b. A nominal 10.5 inch center-to-center distance between fuel assemblies stored in Region I (flux trap type) racks.

c. A nominal 9.05 inch center-to-center distance between fuel assemblies stored in Region II (non-flux trap) racks.

d. Fuel assemblies stored in Region I racks shall meet one of the following limiting conditions.

   1. Unirradiated fuel assemblies with a maximum enrichment of 4.25 w/o U-235 have unrestricted storage.

   2. Unirradiated fuel assemblies with enrichments greater than 4.25 w/o U-235 and less than or equal to 5.0 w/o U-235, that do not contain Integral Fuel Burnable Absorber (IFBA) pins, may only be stored in the peripheral cells facing the concrete wall.

   3. Unirradiated fuel assemblies with enrichments (E) greater than 4.25 w/o U-235 and less than or equal to 5.0 w/o U-235, which contain a minimum number of IFBA pins shall have an equivalent reactivity hold-down which is greater than or equal to the reactivity hold-down associated with N IFBA pins, at a nominal 2.35 mg B-10/linear inch loading (1.5X), determined by the equation below.

$$N = 42.67\ (E-4.25)$$

4. Irradiated fuel assemblies with enrichments (E) greater than 4.25 w/o U-235 and less than or equal to 5.0 w/o, that have attained the minimum burnup (BU) as determined by the equation below, have unrestricted storage.

$$BU\ (MWD/kg\ U) = -26.212 + 6.1677E$$

e. Fuel assemblies stored in Region II racks shall meet one of the following limiting conditions.

1. Unirradiated fuel assemblies with a maximum enrichment of 5.0 w/o U-235 may be stored in a checkerboard pattern with intermediate cells containing only water or non-fissile bearing material.

2. Unirradiated fuel assemblies with a maximum enrichment (E) of 5.0 w/o U-235 may be stored in the central cell of any 3x3 array of cells provided the surrounding eight cells are empty or contain fuel assemblies that have attained the minimum burnup (BU) as determined by the equation below.

$$BU\ (MDW/kg\ U) = -15.48 + 17.80E - 0.7038E^2$$

In this configuration, none of the nine cells in any 3x3 array shall be common to cells in any other similar 3x3 array. Along the rack periphery, the non-fueled region is equivalent to 3 outer cells in a 3x3 array.

3. Irradiated fuel assemblies with a maximum enrichment (E) of 5.0 w/o U-235 that have attained the minimum burnup (BU) as determined by the equation below, have unrestricted storage.

$$BU\ (MWD/kg\ U) = -32.06 + 25.21E - 3.723E^2 + 0.3535E^3$$

4. Irradiated fuel assemblies with a maximum enrichment (E) of 5.0 w/o U-235 that have attained the minimum burnup (BU) as determined by the equation below, may be stored in a peripheral cell facing the concrete wall.

$$BU\ (MWD/kg\ U) = -25.56 + 15.14E - 0.602E^2$$

The reactor cavity, refueling canal and spent fuel storage pool are reinforced concrete structures with seam-welded stainless steel plate liners. These Seismic Category I structures are designed to withstand the anticipated earthquake loadings and to prevent gross liner leakage even in the event the reinforced concrete develops cracks.

Design criteria for spent fuel storage racks assure conformance with recognized codes and applicable Regulatory Guides as follows:

1. The spent fuel storage rack design is based on the requirements of the ASME Boiler and Pressure Vessel Code, Section III Subsection NF, Class 3 Linear Supports.

2. Regulatory Guide 1.13 - The design conforms with the Regulatory Guide, except that high radiation instrumentation does not actuate the filtration system for Unit 1.

3. Regulatory Guide 1.29 - The spent fuel storage racks are designed as Seismic Category I Structures.

4. Regulatory Guide 1.92 - Seismic load combinations of vibrational modes and three orthogonal component motions (two horizontal and one vertical) meet the provisions of the Regulatory Guide.

5. Design loads and load combinations meet the requirements of the Standard Review Plan, Section 3.8.4, Structural Design Criteria for Seismic Category I Structures Outside Containment and ASME Section III NF-3400.

6. During the design phase of the reracking in 1994, the following additional documents were used as a reference:

    1. OT Position paper for Review and Acceptance of Spent Fuel Pool Storage and Handling Applications, USNRC, 1978.

    2. USNRC Branch Technical Position ASB9-2, "Residual Decay Energy for Light Water Reactors for Long Term Cooling," Rev. 2, 1981.

9.1.2.2 System Description

A stainless steel lined spent fuel storage pool is provided for onsite storage of spent fuel assemblies until they are transferred to casks for storage at the Independent Spent Fuel Storage Installation (ISFSI) or shipped offsite. Sufficient space is available to hold approximately 8 full core offloads and the depth is sufficient to provide a minimum shielding depth over the top of the stored fuel of 10 feet of water. The pool is designed to prevent inadvertent drainage below a water elevation of 124 feet-8 inches. Storage racks located in the pool are physically arranged such that the assemblies are always maintained in a subcritical condition. Adjacent to the spent fuel pool and separated by a structural wall is the transfer pool. The transfer pool serves to facilitate the fuel transfer operation between the Fuel Handling Building and containment. It is also the pool where the spent fuel transfer or shipping cask is placed for loading/unloading. The cask is handled by the cask handling crane which is prevented by structural restraint from moving over the spent fuel pool.

Rack Modules for Region I (Retained Exxon Racks)

With the implementation of reracking in 1994, three previously installed Exxon racks were retained which are of poisoned flux trap construction to serve as Region I. Each rack module retained in the pool for this purpose consists of one hundred storage cells and has cross-sectional dimensions of 109.5" x 109.5". The locations of the existing modules are shown on Figures 9.1-3 and 9.1-3A.

The high density (poison) spent fuel racks' construction is shown on Figure 9.1-2A. The design utilizes a stiffened module base and an upper box structure consisting of plate diaphragms and a top grid. The storage module is constructed of stainless steel, mostly Type 304. The vertical loads are carried by the module base. Horizontal seismic loads are carried to the module base through the plate diaphragms.

The design of the high density spent fuel storage cells is illustrated on Figure 9.1-3B. Each cell is a square cross-section formed from an inner shroud of stainless steel, a center sheet of aluminum clad boron carbide (B_4C), and an outer shroud of stainless steel. This cell acts as storage space and provides sufficient neutron absorption to allow close spacing of spent fuel. The fuel weight is carried directly on the module base. A flared guide and transition section is provided at the top of each storage cell. This transition is designed to assure ease of entry and to preclude fuel assembly hang-up and damage. Swelling of the inner stainless steel shroud has been observed in a number of the spent fuel storage cells. The swelling is the result of hydrogen gas buildup from the corrosion of the aluminum in the Boral poison plates. The gas buildup has bowed or swollen the cells, thereby reducing the inner cell dimension. An ongoing program to monitor the condition of the spent fuel storage cells is being conducted. The hydrogen gas will be vented from the swollen cells to allow the shroud to return to some position closer to the original. This may allow the cell to be returned to service as an available spent fuel storage location. The hydrogen gas is radiologically stable and does not present a personnel hazard. The insignificant volume of gas released will not increase the hydrogen concentration in the area into the explosive range.

This condition was reviewed by the NRC in Supplement 4 of NUREG- 0517, Safety Evaluation Report, Salem Generating Station Unit 2, April 1980. It was concluded that the minor degradation of the boral poison plates resulting from the corrosion of the aluminum would not preclude the spent fuel storage cells from performing their intended function.

Rack Modules for Region II (New Holtec Racks)

With the implementation of reracking in 1994, nine existing Exxon racks were replaced with nine maximum density Holtec racks, shown on Figure 9.1-2B. The locations of new rack modules are shown on Figures 9.1-3 and 9.1-3A. These racks have a single poison panel between adjacent austenitic stainless steel surfaces and serve as Region II. The significant components of these racks are: 1) Box cell assembly, 2) Boral panel and Sheathing, 3) Formed and Periphery cells, 4) Baseplate, 5) Support legs.

See Figures 9.1-3C, 9.1-3D, 9.1-3E and 9.1-3F.

1) Box Cell Assembly

The box cells are fabricated from two precision formed channels by continuous seam welding. The inside (nominal) dimension of the box is 8.86 x 8.86 inches. Each box constitutes a storage location. See Figure 9.1-3C.

2) Boral Panel and Sheathing

Boral is used as the neutron absorber material. The boral panels are manufactured by using a homogenized particulate mixture of Boron carbide and aluminum powder sandwiched between thin aluminum sheets using a hot rolling process. The boral panels are placed in the customized flat depression region of the sheathing, which is laid on a side of the "box". The flanges of the sheathing are attached to the box on all four sides using intermittent weld. The sheathing serves to locate and position the boral panel accurately, and to preclude its movement under seismic conditions. See Figures 9.1-3D and 9.1-3E.

3) Formed and Periphery Cells

The boxes with integrally connected sheathing are arranged in a checkerboard array to form the storage cell rack module. This way, formed cells (interior boxes) are automatically created. The inter-box welding and pitch adjustment are accomplished by small longitudinal connectors. Flat plates are welded to the edges of the boxes at the outside boundary of the boxes to create the periphery cells. See Figure 9.1-3C.

4) Baseplate

The baseplate provides a continuous horizontal surface for supporting the fuel assemblies. See Figure 9.1-3F.

5) Support Legs

All support legs are adjustable type. The top portion is made of austenitic stainless steel material. The bottom portion is made of SA564 type 630 age hardened stainless steel to avoid galling problems. See Figure 9.1-3F.

9.1.2.3 Design Evaluation

Borated water is used to fill the spent fuel storage pool at a concentration to match that used in the reactor cavity and refueling canal during refueling operations. The fuel is stored in a vertical array with sufficient center-to-center distance between assemblies to assure $k_{eff} \leq 0.95$ even if unborated water is used to fill the pool. (Based on 17 x 17 fuel with enrichment as described in Section 9.1.2.1).

The spent fuel storage pool is provided with a Spent Fuel Cooling System which is discussed in Section 9.1.3.

The design of the Fuel Handling Building is such that it is physically impossible for a load greater than 5 tons to be carried over the spent fuel pool except during implementation of the rerack project. This is a result of both the physical arrangement of the Fuel Handling Building and limits on the fuel handling crane. Administrative controls prohibit loads greater than that of a fuel assembly to travel over the spent fuel pool. The maximum height at which a fuel assembly can be carried is restricted by limit switches on the crane to 15 inches over the top of the spent fuel racks. The spent fuel racks have been designed to absorb the energy released by a fuel assembly dropping from 15 inches above them for the Exxon racks and 36 inches for the Holtec racks.

During implementation of the re-rack project in 1994, temporary modification was made to the crane, which increased the capacity of the crane from 5 tons to 20 tons. No permanent attachment or welding to the crane was made. This temporary modification was removed at the completion of the project and the crane was brought back to its original capacity of 5 tons.

Special procedures were also implemented to prevent the possibility of a rack under transport from impacting stored fuel. Racks were also temporarily located in the transfer pool (two for Unit 1, one for Unit 2) to reduce the amount of fuel in the Spent Fuel Pool.

The spent fuel storage pool and new fuel storage pit are outside the area over which the fuel cask may travel by design (travel restricted by a limit stop switch). The cask handling crane travels only over the truck bay, decontamination pit and fuel transfer pool, as indicated on Plant Drawing 204836.

Gamma radiation is continuously monitored in the Fuel Handling Building. A high level signal is alarmed locally and is annunciated in the Control Rooms.

All fuel and waste storage facilities are contained and equipment designed so that accidental releases of radioactivity directly to the atmosphere are monitored and will not exceed the limits of 10CFR50.67.

A Controlled Ventilation System removes gaseous radioactivity from the atmosphere in fuel and waste treating areas of the Fuel Handling and Auxiliary Buildings and discharges it to the atmosphere via the plant vent. Radiation monitors are in continuous service in these areas to actuate high-activity alarms in the Control Rooms.

A nuclear criticality accident due to a fuel assembly misloaded in the Spent Fuel Pool has been analyzed. This relates to fuel assemblies loaded in a wrong region as specified in Section 9.1.2.1. One mislocated fuel bundle has been found to be acceptable as long as the soluble boron concentration is maintained above 600 ppm in the Spent Fuel Pool.

A nuclear criticality accident due to the installation of maximum density spent fuel storage racks has been analyzed. Reracked pool design factors that could affect the Spent Fuel Pool neutron multiplication factor have been addressed conservatively. It was concluded that the maximum Spent Fuel Pool neutron multiplication, with the addition of the maximum density racks, will not exceed the subcriticality limit of Keff less than or equal to 0.95 with unborated water.

A rack-to-rack and rack-to-wall impact during a postulated seismic event was analyzed for the spent fuel storage racks for the as-built configuration. The analysis concluded that the rack configuration does not result in rack-to-rack impact in the cellular region for either unit, or rack-to-wall impact for Unit 1 during postulated seismic events. For Unit 2, a rack-to-wall impact is predicted in one location for the DBE case. The calculated value of the impact force is very small and will not cause any damage to the fuel cells, the rack, the wall or pool liner.

9.1.3 Spent Fuel Pool Cooling System

9.1.3.1 Design Bases

The following description is for Unit 1 with Unit 2 having an identical system.

The Spent Fuel Pool Cooling System is designed to remove from the spent fuel pool the heat generated by stored spent fuel elements. The system serves the spent fuel pool which is located in the Fuel Handling Building adjacent to the Containment Building. A secondary function is to clarify and purify spent fuel pool, transfer pool, and refueling water. The system design considers the need to totally unload a reactor at the time when spent fuel is in the fuel pool.

The system design incorporates redundant active components. The system is designed with anti-siphon holes to prevent draining of the spent fuel pool below the top of the stored fuel elements.

The Spent Fuel Pool Cooling System maintains the spent fuel pool at normal temperatures. Boron concentration in the pool fluid is maintained at a minimum of 800 ppm.

9.1.3.2 System Description

The schematic diagram for the Spent Fuel Pool Cooling System is shown on Plant Drawings 205233 and 205333. The Spent Fuel Pool Cooling System consists of three subsystems: the Cooling System, the Purification System, and the Skimmer System.

Austenitic stainless steel piping is used in the Spent Fuel Pool Cooling System. All piping and components of the system are designed to the applicable codes and standards listed in Table 9.1-1.

The cooling loop consists of the spent fuel pool pumps and the spent fuel pool heat exchanger. The purification loop consists of the spent fuel pool pump, the spent fuel pool filter, the spent fuel pool demineralizer, the refueling water purification pump, and the refueling water purification filter. The skimmer loop consists of the skimmer pump, strainer, and filter.

During the heat removal operation, fuel pool water flows from the spent fuel pool to a spent fuel pool pump suction, and is pumped through the tube side of the heat exchanger, and is returned to the pool. The suction line, which is protected by a strainer, is located at an elevation 4 feet below the pool normal water level, while the return line terminates in the pool at an elevation approximately 6 feet above the top of the fuel assemblies. If the spent fuel pool pump fails, the second pump supplies 100-percent backup.

The Spent Fuel Pool Cooling System has its maximum duty during the refueling operation when the decay heat from the spent fuel is the highest.

Piping and valves are installed which allow the Units 1 and 2 heat exchangers to be cross connected. During normal plant operation, the heat exchangers operate independently to meet the cooling requirements of the individual units. However, if heat load is unusually high, both heat exchangers may be used in parallel to minimize the temperature rise in the spent fuel pool. The cross connect also allows one heat exchanger to be used to alternatively cool the spent fuel pools in both units during times when one heat exchanger is out for maintenance.

While the heat removal operation is in process, a portion of the spent fuel pool water, 100 gpm, may be diverted through the spent fuel pool demineralizer and spent fuel pool filter to maintain spent fuel pool water clarity and purity. Transfer canal water may also be circulated through the same demineralizer and filter. This is accomplished by having the gate between the transfer pool and the spent fuel pool removed. This purification loop is sufficient for removing fission products and other contaminants which may be introduced if a leaking fuel assembly is transferred to the spent fuel pool.

The demineralizer may be isolated, by manual valves, from the heat removal portion of the Spent Fuel Pool Cooling System. By so doing, it may be used together with the refueling water purification filter to clean and purify the refueling water while spent fuel pool heat removal operations proceed. Connections are provided to the isolated loop such that the refueling water may be pumped from either the refueling water storage tank (RWST) or the refueling cavity, through the demineralizer and filter, and discharged to either the refueling cavity or the RWST.

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

Boron may be added to the pool from the Chemical and Volume Control System (CVCS). Borated water from the plant sources may be supplied from the RWST via the refueling water purification pump connection, or by placing a temporary line from the boric acid blender, located in the CVCS directly into the pool. Demineralized water is also added to the pool for makeup purposes by a connection in the recirculation return line.

The pool water may be separated from the water in the transfer pool by a sluice gate. The gate is installed so that the transfer pool may be drained for maintenance on the fuel transfer equipment. The draining is accomplished by pumping transfer pool water into the spent fuel pool with a portable pump. The excess water from the spent fuel pool is directed to a holdup tank in the CVCS or to the decontamination for temporary storage.

With the implementation of reracking in 1994 the spent fuel storage capacity in the pool was increased from 1170 fuel assemblies to 1632 fuel assemblies. The decay heat load calculation was conservatively performed in accordance with the provisions of USNRC Branch Technical Position ASB9-2, "Residual Decay Energy for Light Water Reactors for Long Term Cooling," Rev. 2, July 1981. Three discharge Cases were considered in Cycle 25, 37 years' accumulation of spent fuel:

Case 1) The reactor is shutdown and is cooled for 168 hours. Then, a batch of 88 assemblies with 1642.5 days full power operation is discharged to the pool at a rate of 7 assemblies per hour.

Case 2) Same as case 1 except instead of 88 assemblies, 193 assemblies (Full Core Offload) is discharged.

Case 3) The reactor is back to operation after a refueling shutdown in Cycle 24. Thirty days later, the reactor experiences unplanned shutdown. The full core of 193 assemblies is transferred to the pool 168 hours after the reactor shutdown. Sixty eight assemblies in the core are assumed to have 30 days full power operation and 125 assemblies are assumed to have 1642.5 days full power operation.

The results of the above cases are as follows:

Case 1) 195 hours after the reactor shutdown, the pool will experience a maximum temperature (bulk pool) of 149 degrees F, with one pump and one heat exchanger in operation.

Case 2) 205 hours after the reactor shutdown, the pool will experience a maximum temperature of 180 degrees F, with one pump and one heat exchanger in operation.

Case 3) 204 hours after the reactor shutdown, the pool will experience a maximum temperature of 180 degrees F, with one pump and one heat exchanger in operation.

In 1998, additional spent fuel pool heat removal analyses were performed. The analyses addressed potential full-core off-loads during upcoming refueling outages as well as end of plant life. These analyses concluded one pump and one heat exchanger can maintain pool temperature below 149°F under all combinations of decay time and CCW temperature except minimum decay times and very high cooling water temperatures. Under these later conditions, in vessel decay-time would be extended or parallel heat exchanger operation would be used to maintain pool temperature below 149°F. In addition, provisions have been made for the installation of an additional heat exchanger, should this be required in the future.

Amendments Nos. 289 and 273 for Units 1 and 2, respectively, changed the Technical Specification requirements to allow fuel movement in the containment to commence 80 hours after the reactor has become subcritical between October 15^{th} through May 15^{th}. Supporting analyses demonstrated that Spent Fuel Pool temperature limits will be maintained based on reduced Ultimate Heat Sink temperatures (i.e., below the design value of 90°F) experienced during this time frame and the projected Spent Fuel Pool decay heat load with the pool at full capacity. For the remainder of the year, the decay time limit is 168 hours. A core offload has the potential to occur during both applicable time frames. In order not to exceed the analyzed Spent Fuel Pool cooling capability to maintain the water temperature below 180°F, two decay time limits are provided. In addition, PSEG has developed and implemented a Spent Fuel Pool Integrated Decay Heat Management Program as part of the Salem Outage Risk Assessment. This program requires a pre-outage assessment of the Spent Fuel Pool heat loads and heatup rates to assure available Spent Fuel Pool cooling capability prior to offloading fuel.

Prior to each refueling, the decay heat management program methodology is used to:

- Calculate that the water temperature will not exceed 149°F following full core offload, using only one heat exchanger for each spent fuel pool and to provide to the Operations staff the required component cooling water temperature to achieve such results; and,

- Calculate that the water temperature will not exceed 180°F following full core offload with one heat exchanger available for both spent fuel pools and to provide to the Operations staff the required component cooling water temperature to achieve such results.

Prior to initiating core offload activities, the assumptions used in the Integrated Decay Heat Management Program calculations are validated. The validation includes:

- Ensuring the availability of both spent fuel pool heat exchangers, each with an available spent fuel pit pump, to support spent fuel pool cooling for a full core offload; and,

- Verifying that actual component cooling water supply temperatures are consistent with the decay heat management calculation input values.

Additionally, spent fuel pool high temperature alarm capability is maintained to alert the operators in the event that water temperature exceeds the peak temperature predicted by the decay heat management program for each refueling outage.

Spent Fuel Pool Cooling System component design data are listed in Table 9.1-2. The following is a description of each component utilized in the Spent Fuel Cooling System.

Spent Fuel Pool Heat Exchanger

The spent fuel pool heat exchanger is of the shell and U-tube type with the tubes welded to the tube sheet. Component cooling water circulates through the shell, and spent fuel pool water circulates through the tubes. The tubes are austenitic stainless steel and the shell is carbon steel.

Spent Fuel Pool Pumps

The spent fuel pool pumps circulate water in the Spent Fuel Pool Cooling System. All wetted surfaces of the pumps are austenitic stainless steel, or equivalent corrosion resistant material. The pumps are operated manually from a local station.

Spent Fuel Pool Filter

The spent fuel pool filter removes particulate matter larger than 5 microns from the spent fuel pool water. The filter cartridge is of synthetic fiber and the vessel shell is austenitic stainless steel.

Spent Fuel Pool Strainer

A stainless steel strainer is located at the inlet of the spent fuel pool cooling suction line for removal of relatively large particles which might otherwise clog the spent fuel pool demineralizer.

Spent Fuel Pool Demineralizer

The demineralizer is sized to pass 100 gpm of the loop circulation flow to provide adequate purification of the fuel pool water for unrestricted access to the working area and to maintain optical clarity.

Refueling Water Purification Pump

The refueling water purification pump circulates water in a loop between the RWST and the spent fuel pool demineralizer and the refueling water purification filter. All wetted surfaces of the pump are austenitic stainless steel. The pump is operated manually from a local station.

Refueling Water Purification Filter

The refueling water purification filter removes particulate matter larger than 5 microns from the refueling water purification flow.

Spent Fuel Pool Cooling System Valves

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

Spent Fuel Pool Cooling System Piping

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

Spent Fuel Pool Skimmers

Two spent fuel pool skimmers are provided to remove water from the surface of the spent fuel pool. The skimmer heads are manually

positioned to take water from any elevation from the water surface to 4 inches below the surface. The elevation of the skimmers' head can be manually adjusted over a total range of 2 feet.

Spent Fuel Pool Skimmer Pump

The spent fuel pool skimmer pump circulates surface water through a strainer, a filter, and returns it to the pool.

Spent Fuel Pool Skimmer Strainer

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

Spent Fuel Pool Skimmer Filter

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

9.1.3.3 Design Evaluation

The most serious failure of this system would be complete loss of water in the spent fuel pool. To protect against this possibility, the spent fuel pool cooling suction connection enters near the normal water level so that the pool cannot be gravity-drained. The cooling water return lines contain anti-siphon holes to prevent the possibility of gravity draining the pool. For beyond design basis accident mitigation, the tell-tale liner leakoff drain lines have isolation capability to maintain spent fuel pool inventory in the unlikely event that liner failure is anticipated as a result of a complete loss of spent fuel pool cooling. There are no drains or permanently connected systems to the spent fuel pool (Seismic Class I) which, in the event of failure, could cause loss of coolant from the pool that would uncover the fuel. Also, provisions have been made to supply makeup to the spent fuel pool as noted below.

Salem fuel pool cooling systems were designed with substantial reliability. Original design features included a seismic Class II piping stress analysis (upgraded to Class I in 1981), location in seismic Category I buildings, safety-related heat exchangers, a safety-related heat sink (CCW to service water), redundant pumps, and electric power supplied by independent 460 volt 1E buses (backed by emergency diesel generators). Under the original design, the system could be expected to remain functional following any design accident or natural phenomena, except a design basis earthquake (DBE). Since the system components were not seismically qualified, post-DBE functionality was not assured. In that case, if an earthquake caused a sustained loss of forced cooling with recently discharged fuel in the pool, decay heat would have been removed by pool boiling.

As a result of self-assessments performed on the fuel pool and associated structures, systems and components (SSCs) in 1995, concerns were identified that called into question the ability of these SSCs to perform their design basis functions under loss of normal fuel pool cooling conditions as a result of a design basis earthquake where the heat load in the pools could cause the pool temperature to exceed 180°F. These concerns were resolved by a seismic upgrade of the Spent Fuel Pool Cooling System to render temperatures above 180° F non-credible. The upgrade not only evaluated the capability of the system to remain functional following a seismic event, but also evaluated potential single active failures and various external hazards (such as flooding, missiles, seismic-nonseismic interactions, etc.) that could result in interruption of forced cooling. The evaluation concluded pool temperature would be maintained 180°F and below under normal, abnormal, and accident conditions.

The use of the heat-exchanger cross connect is controlled by appropriate procedures. Four manual valves, two per unit, have to be opened to cross connect the heat exchangers. Prior to placing a high heat load in a pool which would require heat exchangers in parallel to minimize the temperature transient, the heat load in the spent fuel pool to be isolated is evaluated to ensure it can tolerate a temporary interruption of cooling. Similarly, before taking one heat exchanger out of service for maintenance, the heat loads in both spent fuel pools are evaluated to verify that the remaining heat exchanger can be used in an alternating fashion to cool both spent fuel pools.

Water loss from the spent fuel pool due to the accidental opening of a sluice gate when the transfer pool is empty will not occur due to the redundancy in the sluice gates. Two sluice gates separate the spent fuel pool from the transfer pool.

A heavy load handling accident would not result in water leakage severe enough to uncover the spent fuel. The maximum load carried over the spent fuel pool is that of a fuel assembly; however, it is not possible to drop a fuel assembly on the spent fuel pool liner plate.

Pool water level indication is provided by individual high and low water level alarms. The alarms are actuated by deviation from normal water level (Elevation 128 feet-8 inches) of plus or minus

6 inches. The alarms are annunciated in the Fuel Handling Building at the spent fuel pool and in the Control Room.

Annunciation of an alarm will be confirmed by visually checking the spent fuel pool water level. Alarms may be expected to occur occasionally due to gradual changes in pool water temperature and surface evaporation. If needed, makeup will be added. Alarms occurring with unusual frequency or for reasons not readily apparent will be further investigated. Frequent inspections will be made of the Fuel Handling Building sump to identify any abnormalities. In addition, a high sump level alarm is provided in the Control Room.

The normal source of makeup water to the spent fuel pool is the Demineralized Water System which distributes water from two 500,000-gallon demineralized water tanks. The tanks and the distribution system do not have seismic classification. Makeup is also available from the primary water storage tank via the primary water makeup pumps (Seismic Class II) and from the CVCS holdup tanks via the holdup tank recirculation pump (Seismic Class II).

Valves have been installed on the existing 6-inch spare nozzles on both RWSTs (364,500 gallons each). These tanks are Class I (seismic). For beyond design basis scenarios, a portable pump, with appropriate suction and discharge connections and hose, has been provided with the capability to deliver approximately 100 gpm makeup water flow from one of the RWSTs directly to the spent fuel pool. The valves installed on the RWSTs will be locked, closed and capped, and will be under administrative control. The portable pump and hose will also be under administrative control to ensure constant and timely availability.

Up to 100 gallons per minute of makeup is also available from the RWST via the refueling water purification loop.

If a leaking fuel assembly is stored in the spent fuel pool, a small quantity of fission products may enter the cooling water. Fission products and other contaminants are removed by the spent fuel pool purification loop.

A failure analyses of system pumps, heat exchangers and valves is presented in Table 9.1-3.

The spent fuel pool water is maintained at normal temperatures except in circumstances as previously described. Boron concentration in the pool fluid is maintained at a minimum of 800 ppm.

9.1.3.4 Tests and Inspections

The active components of the system are in continuous use during normal plant operation and no additional periodic tests are required. Periodic visual inspections and preventive maintenance are conducted following normal industrial practice.

9.1.4 Fuel Handling System

The Fuel Handling System consists of equipment and structures utilized for handling new and spent fuel assemblies in a safe manner during refueling and fuel transfer operations. The Fuel Handling System is shown on Figure 9.1-5.

The design of the Fuel Handling System conforms to the recommendations of Regulatory Guide 1.13.

The Fuel Handling System components are not generally designed to Class I (seismic) requirements because they do not fit within the definition of Class I (seismic) structures. Those components are designed to Class III requirements. The spent fuel racks, spent fuel pool and spent fuel pool bridge structure, however, are designed to Class I (seismic) requirements. Other components of the Fuel Handling System are not required to operate following a design basis seismic event.

9.1.4.1 System Design and Operation

9.1.4.1.1 System Description

The reactor is refueled with equipment designed to handle the spent fuel under water from the time it leaves the reactor until it is placed in a cask for storage at the Independent Spent Fuel Storage Installation (ISFSI) or shipment from the site. Underwater transfer of spent fuel provides an effective, economic and transparent radiation shield, as well as a reliable cooling medium for removal of decay heat. Boric acid is added to the water to ensure subcritical conditions during refueling.

In the reactor cavity, fuel is removed from the reactor vessel, transferred through the water and placed in the fuel transfer system by a manipulator crane. In the spent fuel pool, fuel is removed from the transfer system and placed in storage racks with a long manual tool suspended from the fuel handling crane.

9.1.4.1.2 Refueling Operation

The refueling operation follows a detailed procedure which provides a safe, efficient refueling operation. The following significant points are assured by the refueling procedure:

1. The refueling water and the reactor coolant will contain sufficient boron concentration such that together with the control rods are sufficient to keep the core approximately 5 percent $\Delta k/k$ subcritical during the refueling operations. (Required Refueling Boron concentration is reported in the COLR).

2. The water level in the refueling canal will be high enough to keep the radiation levels within acceptable limits when the fuel assemblies are being removed from the core. This water also provides adequate cooling for the fuel assemblies during transfer operations.

While one unit is being refueled, there will be no restrictions on the operation of the other unit. Refueling of one unit will not affect the safety aspects of the other unit.

9.1.4.1.3 Refueling Procedure

The following is a summary only of various steps taken for reactor refueling. The sequence and details may differ in actual procedure.

Preparation

1. The reactor is shut down, borated to refueling concentration, and cooled to ambient conditions.

2. A radiation survey is made and the containment is entered.

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5. CRDM cables are disconnected.

6. Reactor vessel flange area head insulation is removed.

7. The canal drain valves are closed and the fuel transfer tube flange is removed.

8. The in-core instrumentation thimble guides are disconnected at the seal table and extracted downward through the bottom of the reactor vessel.

9. The reactor vessel head nuts are loosened with the hydraulic tensioner.

10. The reactor vessel head studs are removed to storage.

11. Guide studs are installed and remainder of the stud holes are plugged.

12. The reactor vessel cavity seal is installed.

13. Checkout of the fuel transfer device and manipulator crane is started.

14. Final preparation of underwater lights and tools is made. Checkout of manipulator crane and Fuel Transfer System is completed.

15. The reactor cavity is filled with water to the vessel flange.

16. The reactor vessel Integrated Head Assembly (IHA) is unseated and raised 1 foot with the polar crane.

17. The reactor vessel IHA is taken to the storage pedestal.

18. The reactor cavity is filled with water to refueling level.

19. The control rod drive shafts are unlatched.

20. The reactor vessel internals lifting rig is lowered into position by the polar crane and latched to the support plate.

21. The reactor vessel internals are lifted out of the vessel and placed in the underwater storage rack.

22. The core is now ready for refueling.

Refueling

The refueling sequence is now started with the manipulator crane. The sequence is as follows:

1. Core Shuffle

    A. Spent fuel is removed from the core and placed into the Fuel Transfer System for removal to the spent fuel pool.

    B. Partially spent fuel is transferred from the intermediate region of the core to the vacated positions in the center region.

    C. Partially spent fuel is transferred from the outer region of the core to vacated positions in the intermediate region.

    D. Fuel assemblies are brought in from the spent fuel pool through the Transfer System and loaded into the outer region.

    E. Whenever fuel is added to the reactor core, source range counts are monitored to ensure unexpected count rate increases do not occur.

2. Full Core Offload

    A. All spent fuel and partially spent fuel is systematically unloaded from the core and placed in the Fuel Transfer System for removal to the spent fuel pool.

B. All insert changeouts are then performed in the spent fuel pool using RCCA change fixture BPRA handling tool and thimble plug handling tool.

C. New fuel and partially spent fuel is systematically brought in from the spent fuel pool and reloaded into the reactor core.

D. Whenever fuel is added to the reactor core, source range counts are monitored to ensure unexpected count rate increases do not occur.

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Reactor Reassembly

1. The fuel transfer car is parked and the fuel transfer tube isolation valve closed.

2. The reactor vessel internals' package is picked up by the polar crane and replaced in the vessel. The reactor vessel internals' lifting rig is removed to storage.

3. The full-length control rod drive shafts are relatched to the RCC elements.

4. The manipulator crane is parked.

5. The reactor vessel O-ring grooves are cleaned and new O-rings installed on reactor head.

6. Drain cavity of water.

7. The flange surface is manually cleaned.

8. The reactor vessel IHA is picked up by the polar crane and positioned over the reactor vessel.

9. The reactor vessel IHA is slowly lowered.

10. The reactor vessel IHA is seated.

11. The reactor vessel to cavity seal is vented and removed.

12. Lift head again for final inspection.

13. The guide studs are removed to their storage rack. The stud hole plugs are removed.

14. The head studs are installed and retorqued.

15. The canal drain valves are opened and the fuel transfer tube flange is installed.

16. In-core flux thimbles are inserted back into core area.

17. Electrical leads are reconnected to CRDMS.

18. Reactor vessel head insulation is installed.

19. Control rod drives are checked.

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21. Intentionally Left Blank.

22. Equipment access door is closed and sealed at the end of the refueling process.

9.1.4.1.4 Major Structures Required for Refueling

Reactor Cavity

The reactor cavity is a reinforced concrete structure that forms a pool above the reactor when it is filled with borated water for refueling.

The cavity is filled to a depth that limits the radiation at the surface of the water to 2.5 mR/hr during those brief periods when a fuel assembly is transferred over the reactor vessel flange.

The reactor vessel flange is sealed to the bottom of the reactor cavity by a cavity seal which is installed prior to flooding the cavity for refueling operations.

The cavity is large enough to provide storage space for the reactor upper and lower internals, the control cluster drive shafts, and miscellaneous refueling tools.

The floor and sides of the reactor cavity are lined with stainless steel.

Refueling Canal

The refueling canal is a passageway extending from the reactor cavity to the inside surface of the reactor containment. The canal is formed by two concrete shielding walls which extend upward to the same elevation as the reactor cavity. The floor of the canal is at a lower elevation than the reactor cavity to provide the greater depth required for the fuel transfer upending device and the control cluster changing fixture located in the canal. The transfer tube enters the reactor containment and protrudes through the end of the canal. Canal wall and floor linings are similar to the reactor cavity.

Decontamination Facilities

A decontamination pit located in the fuel handling area has been provided for the decontamination of spent fuel shipping casks prior to their loading on trucks for shipment offsite.

The decontamination pit is also used to prepare the multi-purpose canister (MPC) for dry storage operations at the ISFSI. The HI-TRAC transfer cask containing the MPC is moved from the fuel transfer pool to the decontamination pit after fuel loading. In the decontamination pit, the MPC lid is welded to the canister shell and the MPC fuel cavity is drained, dried, and backfilled with helium. Certain MPC welds are leak tested and the transfer cask/MPC is moved to the truck bay for additional storage preparation activities.

New Fuel Storage Pit

A dry pit with storage racks having a safe geometry is provided in the fuel handling area for storage of approximately one-third of a core. This pit is located outside of the area over which a spent fuel transfer/shipping cask may travel.

Fuel Transfer Pool

The fuel transfer pool serves to facilitate the fuel transfer operation between the Fuel Handling Building and containment. It is also the pool where the spent fuel transfer and shipping casks are placed for loading.

9.1.4.1.5 Major Equipment Required for Refueling

Reactor Vessel Stud Tensioner

The stud tensioner is a hydraulically operated (oil as the working fluid) device provided to permit preloading and unloading of the reactor vessel closure studs at cold shutdown conditions. Stud tensioners were chosen in order to minimize the time required for the tensioning or unloading operations. Three tensioners are provided and they are applied simultaneously to three studs 120° apart. One hydraulic pumping unit operates the tensioners which are hydraulically connected in parallel. The studs are tensioned to their operational load in two steps to prevent high stresses in the flange region and unequal loadings in the studs. Relief valves are provided on each tensioner to prevent over tensioning of the studs due to excessive pressure. Charts indicating the stud elongation and load for a given oil pressure are included in the tensioner operating instructions. In addition, micrometers are provided to measure the elongation of the studs after tensioning.

Reactor Vessel Head Lifting Rig

The reactor vessel integrated head assembly and lifting devices are shown on Figure 9.1-6A.

The three vertical legs, platform assembly, and sling assembly (tripod) are permanently attached to the three reactor vessel head lifting lugs. The total estimated weight of the Integrated Head Assembly is approximately 191 tons including studs, nuts and washers, or 172.5 tons without studs, nuts and washers.

The maximum drop height of the reactor vessel head is 39 feet.

The Integrated Head Assembly (IHA) Lift Rig is made up of a combination of the existing lift rig eye and a new lift assembly. The existing load cell linkage connects the polar crane hook and the existing lift eye when installing and removing the IHA. With respect to the tripod lifting eye, load bearing members are no stressed beyond one-fifth the ultimate strength when subjected to the static and dynamic load of the IHA. With respect to the remainder of the IHA lift rig assembly, load bearing members are not stressed to greater than one-tenth of the ultimate strength when subjected to the static and dynamic loads of the IHA.

All primary load-bearing members are constructed with material purchased to ASTM Standards. All welding and nondestructive testing of the IHA Lifting Rig (excluding the existing lift eye) is performed in accordance with approved reference [8] and applicable codes. All welding and nondestructive tests of the lift eye and load cell linkage are in accordance with approved Westinghouse Process Specification and ASME Boiler and Pressure Vessel Codes.

The following loading data apply to the IHA lifting rig.

1. The design load rating for the IHA lifting rig is 200 tons.

2. Preoperational load tests for the IHA lifting rig are the actual weight of the assembled IHA and done at the plant site, followed by nondestructive testing of key load bearing areas.

3. The maximum operating load for the IHA lifting rig is 172.5 tons

4. The IHA is permanently attached to the reactor vessel. Therefore, load testing prior to lifting the IHA is impractical.

Missile Shield Structure Lifting Rig

The integrated head assembly missile shield, including the IHA lifting device, is shown in Figures 9.1-7A.

The missile shield structure is a 181-inch diameter, 2-inch thick steel plate that is part of the Integrated Head Assembly.

Reactor Internals Lifting Rig

The internals lifting rig is a three-legged structural frame device which connects the main crane hook to the upper or lower internals package for handling operations. It connects to the internals flanges by means of screw threads. The internals lifting rig is shown on Figure 9.1-9.

The maximum drop height of the core barrel assembly is 69 feet, which is the limit of travel of the polar crane hook with the upper core barrel assembly and lifting rig attached.

Load bearing members of the rig are not stressed to greater than one-fifth of the ultimate strength when subjected to the static weight of the rig and the lower internals package. All primary load bearing members are constructed with materials purchased to ASTM Standards. All welding and nondestructive testing is done in accordance with approved Westinghouse Design Specifications or the ASME Boiler and Pressure Vessel Codes.

The following loading data apply to the reactor internals lifting rig:

1. Preoperational load tests for the internals lifting rig is the actual weight of the lower internals (estimated at 136 tons with lifting rig) followed by nondestructive testing of key load bearing areas.

2. The maximum operating load for the internals lifting rig is approximately 171 tons. The maximum polar crane capacity is 230 tons.

3. The Westinghouse NES operating instructions for the lifting rig include nondestructive testing of key areas prior to lifting as a routine precaution.

Manipulator Crane

The manipulator crane is a rectilinear bridge and trolley crane with a vertical mast extending down into the refueling water. The bridge spans the reactor cavity and runs on rails set into the floor along the edge of the reactor cavity. The bridge and trolley motions are used to position the vertical mast over a fuel assembly in the core.

A long tube with a pneumatic gripper on the end is lowered down from the mast to grip the fuel assembly. The gripper tube is long enough so the upper end is still contained in the mast when the gripper end contacts the fuel. A winch mounted on the trolley raises the gripper tube and fuel assembly up into the mast tube. The fuel, while inside the mast tube, is transported to its new position.

All controls for the manipulator crane are mounted on a console on the trolley. The bridge is positioned on a coordinate system laid out on one rail. The electrical readout system on the console indicates the position of the bridge. With the aid of a scale the trolley is positioned on the bridge structure. The scale is read directly by the operator at the console. The drives for the bridge, trolley and winch are variable speed, including a separate inching control on the winch. Electrical interlocks and limit switches on the bridge and trolley drives protect the equipment. In an emergency, the bridge, trolley and winch can be operated manually using a handwheel on the motor shaft.

In addition to the travel limit switches on the bridge and trolley drives, the following safety features are incorporated in the system:

1. Bridge, trolley, and winch drives are mutually interlocked to prevent simultaneous operation of any two drives.

2. Bridge and trolley main motor drive operation is prevented except when the GRIPPER TUBE UP position switch is actuated.

3. The engage and disengage solenoid valves in the air line to the gripper are de-energized except when zero suspended weight is indicated by a force gage. A backup protection for this interlock is the mechanical weight actuated lock in the gripper which prevents operation of the gripper under load even if air pressure is applied to the operating cylinder.

4. Hoist drive circuit in the up direction is opened when the GRIPPER IS DISENGAGED or when the EXCESSIVE SUSPENDED WEIGHT switch is actuated by a loading in excess of 110 percent of a fuel assembly weight. Fuel loading procedures require close observance of the load cell readout and stopping crane motion on predetermined load differentials during fuel assembly movement in the core.

5. Hoist drive circuit in either direction is operated only when either the OPEN and CLOSED indicating switch or the gripper is actuated.

6. Bridge and trolley drives are interlocked in the direction of the Transfer System so that the bridge is prevented from traveling beyond the core area unless the trolley is aligned with the refueling canal centerline. The trolley drive is locked out when the bridge is moved beyond the edge of the core.

Suitable restraints are provided between the bridge and trolley structures and their respective rails to prevent derailing due to the Design Basis Earthquake (DBE). The manipulator crane is designed to prevent disengagement of a fuel assembly from the gripper under the DBE.

Fuel Handling Crane

The fuel handling crane is a semi-gantry type crane used to transport new or spent fuel assemblies between their shipping container, storage racks and upending device. Fuel assemblies are handled by means of a special tool suspended from the crane hook. When handling spent fuel, the hook travel and tool length are designed to limit the maximum lift of a fuel assembly to a safe shielding depth.

The fuel handling crane is a separate structure from the spent fuel pool bridge, although they can be coupled together to enable the two to travel as a single unit. The fuel handling crane and its components are designed as Seismic Category 2. The crane components are designed to remain intact during a design basis seismic event.

Fuel Transfer System

The Fuel Transfer System, shown on Figure 9.1-5, is an electrically driven underwater conveyor car that runs on tracks extending from the refueling canal through the transfer tube and into the transfer pool. The conveyor car receives a fuel assembly in the vertical position from the manipulator crane. The fuel assembly is lowered to a horizontal position for passage through the tube, and then is raised to a vertical position in the transfer pool.

During plant operation the conveyor car is stored in the refueling canal. A blind flange is bolted on the transfer tube to seal the reactor containment. A valve seals the transfer tube on the Fuel Building side.

New Fuel Elevator

New fuel is lowered into the transfer pool in the New Fuel Elevator. The carriage (basket) of the New Fuel Elevator is also specially designed to support and position fuel assemblies during fuel repairs, as well as to handle new fuel assemblies during new fuel transfer. When the New Fuel Elevator is used for fuel repairs, elevator hard stops are installed on the rails above the elevator basket to prevent inadvertently raising an irradiated fuel assembly above a safe shielding water depth.

Cask Handling Crane

The cask handling crane is a bridge and trolley crane used to: 1) transfer new fuel containers from the truck bay to the lay down area near the new fuel storage area, 2) move spent fuel shipping casks from the transfer pool to the decontamination pit and to the truck bay, and 3) move spent fuel transfer casks from the transfer pool to the decontamination pit and to the truck bay. The cask handling crane complies with the requirements of ASME NOG-1-2004. Compliance with ASME NOG-1-2004 is an acceptable method for satisfying NUREG 0554 and NUREG 0612, as identified in NRC Standard Review Plan (SRP) 9.1.5 Revision 1.

The trolley frame complies with ASME NOG-1-2004 Sections NOG-4430 and NOG-4343. The trolley wheels comply with NOG-1-2004 Section NOG-5452.

The hoist breaking system includes one power control breaking system and two holding brakes. Energizing the holding breaks releases the main hoist driveline for operation. In the event of a drive fault the holding breaks are immediately set. The hoist holding breaks and emergency breaks are designed in accordance with ASME NOG-1-2004 Section NOG-5414. Mechanical holding breaks automatically activate when electric power is off or mechanically tripped by over speed or overload. The holding break is single failure proof. Each holding break has a torque rating equal to or greater than 125% of full load hoisting torque at the point of application.

The rope drum complies with ASME NOG-1-2004 Section NOG-5411. The drum safety structure will limit motion of the drum following failure. Wire ropes are rated for 115 tons for the main hoist and 10 tones for the auxiliary hoist and comply with NOG-1-2004 Section NOG-5425. A wire rope spooking monitor is provided.

The load block complies with NOG-1-2004 Section NOG-5420 and is submersible. The block shall remain balanced following the failure of one wire rope. The CHC is capable of withstanding tube blocking, load hang up and other severe overloads as defined by NOG-1-2004 Section NOG-6110.

The main and auxiliary hoist and trolley are single failure proof and comply with ASME NOG-1-2004.

The following load data apply to the cask handling crane:

Design Load Rating - Tons (5 to 1 S.F.)	Test Load, Tons	Max. Operating Load, Tons	Live Test Load, Tons
115	144	115	144

NOTE: The cask handling crane can be load tested for a lower capacity using the standards below, and may be used to lift loads lower than those listed above.

The applicable codes and standards for the cask handling crane follow.

Federal

Safety Code for Overhead and Gantry Cranes, USA Standard B 30.2.0 - 1967 (Now ANSI B 30.2.0 - 1967)

New Jersey

New Jersey Administrative Code, Title 12, Chapter 148, Overhead and Gantry Cranes

Other

Electric Overhead Crane Institute Specification No. 61 (Now superseded by Crane Manufacturers Association of America Specification No. 70)

ASME NOG-1-2004, Rules for Construction of Overhead and Gantry Cranes

One or more of these codes and standards covers the design, fabrication, installation, and testing of the cranes. The hooks, cables, hoists, trolleys, and bridges are tested after erection to a minimum of 125 percent of their design load rating and thereby testing the supporting structure and rails.

Polar Gantry Crane (Containment Crane)

The polar gantry crane was fabricated by Whiting Corporation. Earthquake analysis was performed by using the Jet Propulsion Laboratory Structural Analysis Computer Program No. SL-S780 as modified by the Illinois Institute of Technology Research Institute. Floor response spectrum at the crane rail level was supplied by Conrad Associates. A critical damping factor of 1 percent was used. The maximum stresses induced from the DBE do not exceed 90 percent of the yield strength of the materials used in each gantry crane member.

Rail lugs and stops, which are used to prevent the gantry from overturning or rolling during earthquake motion, are designed to withstand the vertical and horizontal earthquake excitations simultaneously as well as overturning or rolling. Heavy anchor bolts, rail clamps and rail lugs are provided to withstand the uplift force and prevent the crane from being dislodged.

In terms of detailed description the polar crane is the same as the cask handling crane with the following exceptions:

1. 16 parts of cable support the block

2. The two independent braking systems are both electric and described with the addition of eddy-current brakes for control braking

3. Class 162 resistors

The codes and standards identified for the cask handling crane also apply to the polar crane.

The following load data apply to the polar crane:

Design Load Rating - Tons (5 to 1 S.F.)	Test Load, Tons	Max. Operating Load, Tons	Live Test Load, Tons
230 (460)*	500	230 (460)*	288

*Special reeving required for 460 tons.

The design of gearing, shafting, cables, and keys is based on the loads that are applied to each particular part with a factor of safety of at least 5, based on the average ultimate strength of the materials. There are two independent braking systems, each capable of stopping and holding the rated load at any position.

Administrative controls shall be in effect during handling of objects over an opened reactor vessel.

Rod Cluster Control Changing Fixture

Rod cluster control elements are transferred from one fuel assembly to another by means of the RCC changing fixture. Five major subassemblies comprise the changing fixture including: (1) frame and track structure, (2) carriage, (3) guide tube, (4) gripper, and (5) drive mechanism. The carriage is a movable container supported by the frame and track structure. The tracks provide a guide for the four flanged carriage wheels and allow horizontal movement of the carriage during changing operations. Positioning stops on both the carriage and frame locate each of the three carriage compartments directly below the guide tube. Two of these compartments are designed to hold individual fuel assemblies while the third is made to support a single RCC element. Situated above the carriage and mounted on the refueling canal wall is the guide tube. This assembly provides for the guidance and proper orientation of the gripper and RCC element as they are being raised or lowered. The gripper is a pneumatically actuated mechanism responsible for engaging the RCC element. It has two flexure fingers which can be inserted into the top of the RCC element when air pressure is applied to the gripper piston. Normally the fingers are locked in a radially extended position. Mounted on the operating deck is the drive mechanism assembly. Its components include: 1) manual carriage drive mechanism, 2) revolving stop operating handle, 3) pneumatic selector valve for actuating the gripper piston, and 4) electric hoist for elevation control of the gripper. The RCC change fixture is located in the containment and, since it is not in the proximity of the spent fuel pool, there is no likelihood of its dropping or falling and damaging stored fuel.

Spent Fuel Shipping Cask

The multi-purpose canister (MPC) used for dry spent fuel storage at the ISFSI is dual-purpose certified for storage in a concrete HI-STORM overpack under 10CFR72 (Certificate of Compliance (CoC) 1014) and for transportation in a sealed metal HI-STAR overpack under 10CFR71 (CoC 9261). It is expected that the sealed MPCs will be transferred directly from ISFSI storage into the HI-STAR overpack for shipping without having to move the MPC back to the spent fuel pool to repackage the fuel. However, the option for PSEG to move spent fuel in the spent fuel pool directly into a shipping cask in the fuel transfer pool is being retained. The specific shipping cask that would be used if this option is pursued has not been selected.

Spent Fuel Transfer Cask

Dry storage of spent fuel at the ISFSI involves the use of the HI-TRAC transfer cask inside the Fuel Handling Building. The HI-TRAC transfer cask is lifted and handled only with a single-failure-proof lifting system, as defined in NUREG-0612, Section 5.1.6. The lifting system includes the cask handling crane (CHC) and a lift yoke. There are no lift height limits for the transfer cask when lifted by the CHC lifting system.

Lift Yoke

A specially designed lift yoke is used to lift and handle the HI-TRAC transfer cask inside the Fuel Handling Building with the CHC.

The lift yoke is considered a special lifting device as defined in NUREG-0612, Section 5.1.6, and is part of the CHC single-failure-proof lifting system. The lift yoke is designed to engage the CHC hook at its top and engage the two HI-TRAC transfer cask lifting trunnions via lift links extending from the bottom of the yoke. The lift yoke is also used to transfer the loaded MPC between the HI-TRAC transfer cask and the HI-STORM overpack in the Fuel Handling Building truck bay. In this configuration, slings, meeting the guidance in NUREG-0612, Section 5.1.6, for single-failure-proof lift devices, are connected between the lift yoke and lift brackets on the MPC to raise or lower the MPC. The MPC lift brackets are designed as single-failure-proof lifting devices per NUREG-0612.

9.1.4.2 Design Evaluation

Gamma radiation levels in the containment and fuel storage areas are continuously monitored. These monitors provide an audible alarm at the initiating detector indicating an unsafe condition. During reactor vessel head removal and while loading and unloading fuel from the reactor, the boron concentration is maintained at the most restrictive of the following reactivity conditions:

a) A K-effective (k_{eff}) of 0.95 or less at All Rods In (ARI), Cold Zero Power (CZP) conditions with a 1% $\Delta k/k$ uncertainty added.

b) A k_{eff} of 0.99 or less at All Rods Out (ARO), CZP conditions with a 1% $\Delta k/k$ uncertainty added.

c) A boron concentration of greater than or equal to 2000 ppm, which includes a 50 ppm conservative allowance for uncertainties.

Adequate shielding for radiation is provided during reactor refueling by conducting all spent fuel transfer and storage operations under water. This permits visual control of the operation at all times while maintaining low radiation levels, less than 2.5 mR/hr for periodic occupancy of the area by operating personnel. Pool water level is monitored, and water removed from the pool must be pumped out since there are no gravity drains.

Direct communication between the Control Room and the refueling cavity manipulator crane is available whenever changes in core geometry are taking place.

This provision allows the Control Room operator to inform the manipulator operator of any impending unsafe condition detected from the main control board indicators during fuel movement.

Detailed instructions are available for use by refueling personnel. These instructions, safety limits and conditions and the design of the fuel handling equipment incorporating built-in interlocks and safety features, provide assurance that no incidents occur during the refueling operations that result in a hazard to public health and safety.

When core geometry is being changed, core subcritical neutron flux is continuously monitored by at least two neutron monitors, each with continuous visual indication and one with audible indication in the containment. When core geometry is not being changed, at least one neutron flux monitor is in service. This permits maintenance of the instrumentation. Normally a "high flux at shutdown" condition will cause the containment evacuation horn to sound. During shutdown, and while welding is in progress inside containment, automatic sounding of the containment evacuation horn is defeated. Instead, the control room operator evaluates high flux at shutdown alarms. If produced by welding (a spike is seen on the source range recorders) no action is taken. If no spike is seen, the operator will assume that high radiation exists and will manually sound the containment evacuation horn.

At least one residual heat removal pump is operable. The residual heat removal pump is used to maintain a uniform boron concentration. When changes in core geometry are taking place, one charging pump capable of injecting borated water to the reactor coolant is available at all times.

When the ECCS or Containment Spray System is specified to be operable, the RWST contains not less than the minimum required to permit circulation after the loss-of-coolant accident (LOCA) and has a boron concentration of not less than refueling concentration requirements.

The RWST capacity is 400,000 gallons. For the initial fuel loading, a shutdown k_{eff} of 0.90 or less is required. This is obtained by using refueling water with a boron concentration of 2000 ppm.

The core design process for the first and all subsequent cores ensures that cold shutdown and refueling conditions always can be achieved and maintained. Analysis of LOCA incidents shows that the quantity of water in storage is sufficient for limiting core temperatures and containment pressure following any incident.

9.1.4.3 Analysis of Load-Drop Accidents

The physical limitations on maximum drop height are set by the limit of travel of the polar crane hook; however, no components are lifted to a height greater than that necessary for maneuverability during handling operations. The total analyzed IHA drop weight is 369.9 Kips. In addition to that head weight, the drop height considered is 39 ft., which is the actual height to clear the lift rig for the internals. The most severe and bounding case is the case of the inclined drop, with impact above the supported hot leg nozzle. For that case, the calculated ductility demand is 18.7, which is acceptable as it is smaller than the maximum allowable value of 20.0 [6].

No reduction in dynamic load was taken due to the damping effect of the head falling through 26 feet of water.

It is very unlikely that the dropping of the reactor vessel head would disrupt the flow of coolant to and from the reactor vessel and refueling canal.

Some local yielding of the nozzles (supports) may occur which could cause relative displacement between the vessel seal ledge and concrete seal support ring which could cause seal failure. However, loss of refueling water above the seal has no safety significance, since no fuel handling is in progress during reactor vessel head handling operations.

During the postulated drop of the reactor vessel head or upper core barrel assembly to the reactor vessel, some fuel rods may fail with subsequent release of the fission gases. The radiation monitoring system, however, will detect the released radioactive gas and immediately isolate the reactor containment.

No heavy loads are handled over equipment required for the safe shutdown of the plant during the movement of fuel from the reactor cavity to the spent fuel pool or vice versa, or the movement of a cask. The handling of fuel is all within the reactor cavity, fuel transfer canal and spent fuel pool. The cask is moved within certain areas of the Fuel Handling Building. No equipment required for safe shutdown is located in any of these areas.

The physical arrangement of the Fuel Handling Building is such that the transfer pool is separated from the spent fuel pool. The cask can travel only over the transfer pool and is only lifted with the single-failure-proof cask handling crane lifting system. For this reason, no analysis of cask drop in the transfer pool was required, nor was any performed.

9.1.4.4 Tests and Inspections

Prior to initial fueling, preoperational checkouts of the fuel handling equipment were performed to ensure proper performance of the fuel handling equipment and to familiarize plant operating personnel with operation of the equipment.

Prior to subsequent refueling operations, the equipment is inspected for operability and certain components, such as the fuel transfer car and manipulator crane, are operated to ensure reliable performance prior to moving irradiated fuel.

9.1.4.5 Dry Spent Fuel Storage

After a sufficient time of storage in the spent fuel pool, spent fuel may be moved into dry storage at the on-site Independent Spent Fuel Storage Installation (ISFSI). The ISFSI is located north of Hope Creek Generating Station and is licensed to store spent fuel from both Salem and Hope Creek. The ISFSI is operated under the general license provision of 10CFR72, Subpart K, which requires the use of an NRC-certified spent fuel storage cask. PSEG uses the HI-STORM 100 System for dry spent fuel storage, listed under Certificate of Compliance (CoC) 1014 in 10CFR72.214. The CoC holder licenses the dry storage cask system generically. For additional details on the generic design and operation of the spent fuel storage casks and the ISFSI, refer to the HI-STORM 100 CoC, Ref. 10 and Final Safety Analysis Report, Ref. 11. PSEG's use of the generic HI-STORM 100 cask design to store Salem spent fuel at the on-site ISFSI is described in the PSEG 10CFR72.212 Evaluation Report, available in DCRMS.

9.1.5 Control of Heavy Loads

A list of overhead handling systems from which heavy loads can be dropped, resulting in damage to safety-related equipment, is given in Table 9.1-4. Compliance of these systems with the requirements of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," are evaluated in detail in References 1 and 2. These evaluations considered the following factors:

1. Load paths and the location of safety-related components.

2. Measures to ensure heavy load are moved within safe pathways.

3. Written procedures for heavy load handling.

4. Procedures for inspection, testing, maintenance and (crane) operator training.

5. Verification of crane design against the guidelines of industry standards such as CMAA-70 (3) and ANSI B30.2-76 (4).

As a result of the initial study (1), lifting devices are being more clearly marked to indicate lift capacity and to distinguish monorail lifting and non-lifting devices. As a result of the follow-up study (2) Public Service Electric & Gas considers the entire program on the evaluation of heavy loads to be complete.

The RV Head drop analysis was redone [6] due to the replacement of the Original Reactor Vessel Closure Head.

9.1.6 References for Section 9.1

1. Quadrex Corporation, "Six-Month Response for Control of Heavy Loads 2, Salem Nuclear Station," December 17, 1981.

2. VTD 315130 Sheet 2, Quadrex Corporation, "Nine-Month Response for Control of Heavy Loads, Salem Nuclear Station Units 1 and 2," February 11, 1985.

3. Crane Manufacturer's Association of America, "Specification for Electric Overhead Traveling Cranes," CMAA-70, 1970.

4. American National Standards Institute, "American National Standard for Overhead and Gantry Cranes," ANSI B30.2.0, 1976.

5. Bradfute, J.L., et. al., "Criticality Analysis of the Salem Units 1 and 2 Fresh Fuel Racks," NFU-VTD-WW-94-08 00, January 1994.

6. VTD 326664, Salem Units 1 & 2 RV Head Drop Evaluation.

7. VTD 317525, Evaluation Of Overhead Handling Systems and Load Drop Consequences for Salem Nuclear Station Units 1 & 2.

8. VTD 326623, AREVA design Specification for an Integrated Head Assembly for Salem Unit 2 and Unit 1.

9. American Society of Mechanical Engineers, "Rules for Construction of Overhead and Gantry Cranes," ASME NOG-1-2004.

10. VTD 400004, Certificate of Compliance for Spent Fuel Storage Casks.

11. VTD 400006, Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System.