10.5 FUEL POOL COOLING AND CLEANUP SYSTEM

10.5.1 Power Generation Objective

The objective of the Fuel Pool Cooling and Cleanup System is to remove the decay heat from the fuel assemblies and maintain the fuel pool water within specified temperature limits.

10.5.2 Safety Design Basis

The Fuel Pool Cooling and Cleanup System shall be designed to remove decay heat from the fuel assemblies and maintain fuel pool water within specified temperature limits. Seismic design requirements are discussed in Section 10.5.5 safety evaluation.

10.5.3 Power Generation Design Basis

1. The Fuel Pool Cooling and Cleanup System shall minimize corrosion product buildup and control water clarity, so that the fuel assemblies can be efficiently handled underwater.

2. The Fuel Pool Cooling and Cleanup System shall minimize fission product concentration in the water which could be released from the pool to the Reactor Building environment.

3. The Fuel Pool Cooling and Cleanup System shall monitor fuel pool water level and maintain a water level above the fuel sufficient to provide shielding for normal building occupancy.

10.5.4 Description

The Fuel Pool Cooling and Cleanup System is shown in Figures 10.5-1a, 10.5-1b sheets 1, 2, 3, and 4, 10.5-1c, and 10.5-1d. The system cools the fuel storage pool by transferring the spent fuel decay heat through heat exchangers to the Reactor Building Closed Cooling Water System (see Table 10.5-1, Fuel Pool Cooling and Cleanup System Specifications. Water purity and clarity in the storage pool, reactor well, and dryer-separator storage pit are maintained by filtering and demineralizing the pool water through a filter demineralizer, which is shown in Figures 10.5-2 sheets 1, 2, 3, and 4.

The system for each fuel pool consists of two circulating pumps connected in parallel, two heat exchangers, one filter demineralizer subsystem, two skimmer surge tanks, and the required piping, valves, and instrumentation. Each pump has a design capacity equal to, or greater than, the system design flow and is capable of simultaneous operation. Four filter demineralizers are provided including one spare

filter demineralizer shared between the three active units, each with a design capacity equal to or greater than the design flow rate for a fuel pool. The pumps circulate the pool water in a closed loop, taking suction from the surge tanks, circulating the water through the heat exchangers and filter demineralizer, and discharging it through diffusers at the bottom of the fuel pool and reactor well (as required during refueling operations). The water flows from the pool surface through skimmer weirs and scuppers (wave suppressers) to the surge tanks. The fuel pool pumps and heat exchangers are located in the Reactor Building below the bottom of the fuel pool. The fuel pool filter demineralizers, which collect radioactive corrosion and fission products, are located in the Radwaste Building. The fuel pool concrete structure and metal liner are designed to withstand earthquake loads per project seismic requirements as a Class I system.

Fuel pool water is normally recirculated. The heat exchangers are designed to remove the decay heat load of the normal discharge batch of spent fuel (see Section 10.5.5). The heat exchangers in the Residual Heat Removal System are used in conjunction with the Fuel Pool Cooling and Cleanup System to supplement pool cooling in the event that a larger than normal amount of fuel is stored in the pool. Normal makeup water for the system is transferred from the condensate storage tank to the skimmer surge tanks to make up evaporative and leakage losses. A seismic Class I qualified source of makeup water is provided through the crosstie between the RHR system and the fuel pool cooling system. (The intertie between the RHRSW system and the RHR can be utilized to admit raw water as makeup.) Also, a standpipe and hose connection is provided on each of the two EECW headers which provides two additional fuel pool water makeup sources. Each hose is capable of supplying makeup water in sufficient quantity to maintain fuel pool water level under conditions of no fuel pool cooling.

The reactor well and dryer-separator pit are filled for refueling by transferring water from condensate storage to the reactor vessel via various pathways such as the Condensate and Feedwater Systems, the Core Spray System, and the Residual Heat Removal System. During the filling operation, water temperature is monitored for reactivity/shutdown margin considerations. A flow path can be established from the reactor well through the skimmer surge tanks to the fuel pool coolant system filters/demineralizers. This flow path allows filtering of water in the reactor well when filled. Following refueling, the water is drained to condensate storage.
The circulation patterns within the reactor well and storage pool are established by the placement of the diffusers and skimmers so as to sweep particles dislodged during refueling operations away from the work area and out of the pools. The normal flow pattern may be altered by taking suction from the bottom of the dryer-separator storage pit to control particles dislodged from parts transferred to the dryer-separator storage pit. Suction may also be taken from the bottom of the reactor well. A portable, submersible-type, underwater vacuum cleaner is provided to remove crud and miscellaneous objects from the pool walls and floor.

Pool water clarity and purity are maintained by a combination of filtering and ion exchange. The filter demineralizer maintains a pH range of 5.6 to 8.6 for compatibility with fuel racks and other equipment.

Material is removed from the circulated water by the pressure precoat filter demineralizer unit in which finely divided powdered ion exchange resin serves as a disposable filter medium. The resin is replaced when the pressure drop is excessive, the ion exchange resin is depleted, or as required by plant conditions. Backwashing and precoating operations are controlled from the Radwaste Building. The spent filter medium is flushed from the elements and transferred to the waste backwash receiver tank by backwashing with air and condensate. New ion exchange resin is mixed in a precoat tank and transferred as a slurry by a precoat pump to the filter where the solids deposit on the filter elements. The holding pump maintains circulation through the filter in the interval between the precoating operation and the return to normal system operation.

The filter demineralizer units are designed to operate with water flowing at approximately 2 gpm/sq ft. Powdered ion exchange resin or resin mixed with cellulose is used as a filter medium. The holding element for the filter material is a stainless steel mesh, mounted vertically in a tube sheet and replaceable as a unit. Venting is possible from below the tube sheet and from the upper head of the filter vessel. The upper head is removable for installation and replacement of the holding elements. The filter vessel is constructed of phenolic resin-coated carbon steel. A poststrainer is provided in the effluent stream of the filter demineralizer to limit the migration of the filter material. The strainer element is capable of withstanding a differential pressure greater than the developed pump head for the system.

The ion exchange resin is a mixture of finely ground cation and anion resins in proportions as determined by service requirements. The cation resin is supplied in the fully regenerated hydrogen form. The anion resin is supplied in a fully regenerated hydroxide form.

The maximum pressure drop across the filter and associated process valves and piping at the time for filter media replacement should not exceed the value shown in Table 10.5-1. A holding pump is connected to each filter demineralizer. This pump starts automatically to maintain sufficient flow through the filter media to retain it on the filter elements during loss of system flow. The holding flow rate is 0.1 gpm/sq ft of filter area. The backwash system is used to completely remove resins and accumulated sludge from the filter demineralizers with a minimum volume of water. Backwash slurry is drained to a local waste backwash receiver tank. The precoat system is designed to rapidly apply a uniform precoat of filter media to the holding elements of a filter demineralizer. The precoat tank is carbon steel coated with phenolic materials and sized to provide adequate volume for one precoating. An agitator is furnished with the tank for mixing. One centrifugal precoat pump and associated piping and valves are provided to precoat any filter demineralizer and

recirculate the water to the precoat tank or suction side of the precoat pump at a rate of 1.5 gpm/sq ft of filter area. The precoat system is also capable of cleaning or decontaminating any filter demineralizer unit with a detergent or citric acid solution. The filter demineralizer units are located separately in shielded cells. Sufficient clearance is provided to permit removal of the filter elements from the vessels. Each cell contains only the filter demineralizer and piping. All inlet, outlet, recycle, vent, drain, and other valves are located on the outside of one shielding wall of the room, together with necessary piping and headers, instrument elements and controls. Penetrations through shielding walls are located so as not to compromise radiation shielding requirements.

The system instrumentation is provided for both automatic and remote-manual operations. Fuel pool skimmer surge tank high, low, and low-low water level switches are provided. The fuel pool skimmer surge tank high and low level switches provide level change indications in the control room and the pump area and annunciates in the Main Control Room. Control of flow to or from the reactor well is accomplished manually during refueling. A level indicator mounted at the valve rack is provided to monitor reactor well water level during refueling. A fuel pool high water level switch operates a local indicator light. A fuel pool high water level condition would be indicated by the fuel pool skimmer surge tank level alarms in the Main Control Room. A fuel pool low water level switch alarms in the Main Control Room as a Fuel Pool System Abnormal Common Alarm. The trip point is adjustable over the range of skimmer weir adjustment. Seismic requirements are discussed in Section 10.5.5 safety evaluation.

The Fuel Pool System Abnormal Main Control Room Common Alarm initiates on pump low discharge pressure, low fuel pool level, Gate seal or drywell to reactor well seal leakage, or refueling bellows leakage and for Unit 1 the individual alarm status is available on ICS. Spent fuel pool level requirements are provided in Technical Specifications Section 3.7.6. Verification that fuel pool level is within allowed limits is performed by direct observation or by use of the low level alarm.

The pumps are controlled from the control room. Pump low-suction pressure automatically turns off the pumps in case of improper valve alignment. A pump low-discharge pressure alarm indicates in the Main Control Room. The controls for the remote manually controlled valves which discharge the fuel pool water to the condenser hotwell and condensate storage tank are located on the pump local panel. The open or closed condition of each of these valves is indicated by lights on the pump local panel.

The flow rate through each of the filter demineralizers is indicated by flow indicators in the pump area and on the radwaste panel. The flow indicators on the pump area panel can be seen by the operators from the vicinity of the fuel pool cooling system.

A high rate of leakage through the refueling bellows assembly, drywell to reactor seal, or the fuel pool gates is indicated by lights on the instrument rack in the pump area and is alarmed in the Main Control Room. The refueling bellows drains have been welded closed. Seismic requirements are discussed in Section 10.5.5 safety evaluation.

The filter demineralizers are controlled from a panel in the Radwaste Building. Differential pressure and conductivity instrumentation is provided for each filter demineralizer unit to indicate when backwash is required. Suitable alarms, differential pressure indicators, and flow indicators are provided to monitor the condition of the filter demineralizers.

Instrumentation is provided to monitor wide range spent fuel pool level between the top of the spent fuel assemblies and the normal water level. The system consists of two redundant level channels utilizing guided wave radar to measure spent fuel pool level. Each channel includes a level element at the fuel pool, a level indicating transmitter, and a remotely located indicator. The instrumentation system is designed to meet NRC Order EA-12-051 requirements.

10.5.5 <u>Safety Evaluation</u>

Unloading the reactor core and the associated increase in fuel pool heat load is a controlled evolution. Administrative controls are used to ensure that fuel pool heat load does not exceed available cooling capacity. The capacity of the Fuel Pool Cooling and Auxiliary Decay Heat Removal (see FSAR Section 10.22) Systems, considering seasonal cooling water temperatures and current heat exchanger conditions, is utilized to maintain the fuel pool temperature at or below 125°F during normal refueling outages (average spent fuel batch discharged from the equilibrium fuel cycle). The RHR System can be operated in parallel with the Fuel Pool Cooling System (supplemental fuel pool cooling) to maintain the fuel pool temperature less than 150°F if a full core off load is performed.

The flow rate is designed to be larger than that required for two complete water changes per day of the fuel pool or one change per day of the fuel pool, reactor well, and dryer-separator pit. The maximum system flow rate is twice the flow rate needed to maintain the specified water quality.

The majority of the Fuel Pool Cooling and Cleanup System and the Reactor Building Closed Cooling Water System are not seismically Class I qualified; however, these are seismically robust systems that are expected to be able to remain functional or be restored to operation following a seismic event. Due to the large thermal capacitance of the spent fuel pool there is sufficient time following a loss of FSP cooling that forced cooling of the FSP can be restored prior to the FSP water boiling (references 1 and 2).

To assure adequate makeup under all normal and off normal conditions, the RHR/RHRSW crosstie provides a permanently installed seismic Class I qualified makeup water source to the FSP. Two additional sources of FSP water makeup are provided via a standpipe and hose connection on each of the two EECW headers. The RHR/RHRSW cross tie and each EECW header is capable of supplying makeup water in sufficient quantity to maintain fuel pool water level under conditions of no fuel pool cooling.

Two diffusers are placed in both the reactor well and the fuel pool to distribute the return water as efficiently and with as little turbulence as possible, and to minimize stratification of either temperature or contamination. Flow control valves at the operating floor enable the operator to achieve optimum recirculation patterns to control and maintain the specified water quality and operational conditions. The circulating pump motors are powered from their corresponding unit 480-V shutdown board. These boards receive power from the diesel generators on loss of normal auxiliary power. They are considered nonessential loads and will be operated as required under accident conditions.

Automatic isolation and bypassing of the nonseismically designed filter demineralizer portion of the system (that portion of the system in the Radwaste Building) and automatic isolation of the nonseismically designed reactor well recirculation piping are actuated upon a low-level signal in the skimmer surge tank. Reactor well recirculation piping diffusers through the first normally closed isolation valve is seismically qualified.

Redundant level instrumentation is provided in the skimmer surge tank for actuation of the motor operated valves on low level as well as for annunciation in the control room of high and low levels. The fuel pool skimmer surge tank high and low level switches provide level change indications in the control room and the pump area for Units 2 and 3. For Unit 1, the fuel pool skimmer surge tank high and low level switches provide change indications in the pump area and are inputs to the Fuel Pool System Abnormal Main Control Room Common Alarm.

The dryer/separator pit and the reactor well structures have been analyzed and it was determined that a design basis earthquake will not cause a failure during the refueling mode (MODE 5) with the well pit full of water. (This analysis includes the refueling bellows, drywell-to-reactor-well seal, bulkhead plates, and the upper portion of the drywell.)

Each fuel storage pool is designed so that no single failure of structures or equipment will cause inability to (1) maintain irradiated fuel submerged in water, (2) reestablish normal fuel pool water level, or (3) safely remove fuel from the plant. In order to limit the possibility of pool leakage around pool penetrations, each pool is lined with stainless steel. In addition to providing a high degree of integrity, the

lining is designed to withstand abuse that might occur when the spent fuel cask is moved about. Drains in the drywell, reactor well, and fuel transfer canal are seismically qualified through the first normally closed valve or temporary plugs are inserted before initiation of the refueling mode (MODE 5). The 1-1/2-inch refueling bellows drains are permanently sealed. The bellows is drained by means of a portable pump after refueling. Each check valve in the fuel pool cleanup return diffuser lines is provided with a siphon breaking vent pipe in order to prevent siphoning of fuel pool water to no more than 6 inches below the normal water level. Interconnected drainage paths are provided behind the liner welds. These paths are designed to (1) prevent pressure buildup behind the liner plate, (2) prevent the uncontrolled loss of contaminated pool water to relatively cleaner locations within the secondary containment, (3) provide expedient liner leak detection and measurement. These drainage paths are formed by welding channels behind the liner weld joints and are designed to permit free gravity drainage to the floor drain collection tank via the floor drain sump.

References:

1. CNL-15-162, Letter from TVA to the NRC, dated August 27, 2015, "Status of Effort to Resolve Non-Conformance Related to Potential Loss of Spent Fuel Pool Cooling," (L44 150827 002)

2. Letter from NRC to Mr. David Lockhbaum, dated November 2, 2015 (ADAMS Accession No. ML15132A625)

10.5.6 Inspection and Testing

No special tests are required because at least one pump, heat exchanger, and filter demineralizer are normally in operation while fuel is stored in a pool. The spare unit is operated periodically to handle abnormal heat loads or to replace a unit for servicing. Routine visual inspection of the system components, instrumentation, and trouble alarms is adequate to verify system operability.