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April 20, 1988

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PLANT VOGTLE - UNIT 2
NRC DOCKET NUMBER 50-425
CONSTRUCTION PERMIT NUMBER CPPR-109
SPENT FUEL RACKS

Gentlemen:

In our letter of December 23, 1987, we transmitted a description of the spent fuel storage racks to be used in the Unit 2 spent fuel pool. That letter included a description of the racks, seismic analysis and criticality analysis. It did not address the increased heat loads on the spent fuel pool cooling system for the Unit 2 spent fuel pool. Proposed revisions to FSAR Section 9.1.3 to describe these effects are included in Attachment A to this letter.

The increased heat loads assumed in the spent fuel pool will also affect the Component Cooling Water and Nuclear Service Cooling Water analysis. The changes to these two systems are separate from the spent fuel rack review and will be transmitted by a separate letter.

The spent fuel pool cooling system for Units 1 and 2 are the same, however, the design heat loads for the Unit 2 pool are being increased. The Unit 2 spent fuel pool heat loads are being revised to incorporate:

1. The capability to fill all 2098 fuel assembly locations with spent fuel,
2. The capability to move spent fuel from the Unit 1 pool spent fuel racks after a sufficient decay period and store it in the Unit 2 pool spent fuel racks,
3. The capability to provide for a normal refueling full core unload to facilitate fuel shuffling and inspection, and
4. The capability to accommodate longer fuel cycles and the greater number of assemblies which would be discharged each cycle.

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FSAR Section 9.1.3 is being revised to describe the additional heat loads and the results of the analysis to demonstrate the ability of the spent fuel pool cooling system to maintain the Unit 2 spent fuel pool temperature within the Standard Review Plan Guidelines.

In addition to this spent fuel pool cooling system information it is necessary to make a revision to information contained in the summary report of the criticality analysis as attached to our letter of December 23, 1987. That report indicated in Sections 4.5.2.4 and 4.5.3 that the boraflex sheets are 4 inches (2.8%) longer than used in the analysis and that this amount is available to allow for shrinkage. The amount of extra boraflex should have been given as 3 inches, (2%). This change does not affect the results of the analysis but does change the allowance for shrinkage. Attachment "B" provides specific wording changes for the criticality summary report.

The revised Section 9.1.3 in conjunction with the information contained in this letter and our previous letter of December 23, 1987, completes our initial submittal in support of the new spent fuel racks. If additional information is required to complete the review, we recommend a meeting to expedite the identification and submittal of that information, so that the scheduled use of these racks for receipt of new fuel in October 1988 will not be affected.

Sincerely,

J. A. Bailey

J. A. Bailey
Project Licensing Manager

JAB/PDG/wkl
Attachments

xc: NRC Regional Administrator
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ATTACHMENT A

PROPOSED REVISION TO VEGP FSAR SECTION 9.1.3

TABLE 1.8-1 (SHEET 4 OF 5)

SRP Section	Specific SRP Acceptance Criteria	Summary Description of Differences	Where Discussed in FSAR
6.2.1.5 (Rev 2)	II.2, Minimum Containment Pressure Analysis for Emergency Core Cooling System Performance Capability Studies	The VEGP does not employ the heat transfer coefficients supplied in the SRP.	Paragraph 6.2.1.5.9
6.5.1 (Rev 1)	II.E, Engineered Safety Features (ESF) Atmosphere Cleanup Systems	The instrumentation provided for VEGP ESF atmosphere cleanup does not fully conform with the guidance of the SRP.	Paragraph 6.5.1.7
6.5.2 (Rev 1)	II.1.A, Containment Spray as a Fission Product Cleanup System	The VEGP is equipped with a semiautomatic switchover from injection to recirculation modes.	Paragraph 6.5.2.7
8.3.1 (Rev 2)	II.4.F.5, ac Power Systems (Onsite)	The diesel generator controls and monitoring instruments are not mounted on a vibration-free floor area, and vibration isolators have not been provided on the associated control cabinets.	Paragraph 8.3.1.5
9.1.3 (Rev 1)	II.1.D.4, Spent Fuel Pool Cooling and Cleanup Systems	Unit 1 Heat loads are calculated by a different method than the method stated in BTP 9-2.	Paragraph 9.1.3.7
9.1.4 (Rev 2)	II.5, Light Load Handling System	Kinetic energy of a dropped fuel handling tool lifted to the maximum height exceeds the kinetic energy of the tool and an assembly lifted to the normal height.	Paragraph 9.1.4.6
9.2.2 (Rev 1)	II.3.e, Reactor Auxiliary Cooling Water System	The VEGP will provide safety-grade instrumentation to detect loss of auxiliary component cooling water to the reactor coolant pump seals, but VEGP does not incorporate an automatic reactor coolant pump trip upon loss of auxiliary component cooling water.	Paragraph 9.2.8.6
9.2.5	II.1, Ultimate Heat Sink	Position C-1 of Regulatory Guide 1.27 requires that the heat sink be capable of providing cooling sufficient for 30 days.	Paragraph 9.2.5.6
9.4.5 (Rev 2)	II.4, ESF Ventilation System	The VEGP is not fully in conformance with Item 2 of Subsection A and item 1 of Subsection C of NUREG/CR-0660.	Paragraph 9.4.5.8

9.1.3 SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM (SFPCPS)

The SFPCPS is designed to remove the decay heat generated by stored fuel assemblies from the spent fuel pool water. This cooling is accomplished by taking high temperature water from the pool, pumping it through a heat exchanger, and returning the cooled water to the pool. A secondary function of the SFPCPS is to clarify and purify the spent fuel pool, transfer canal, and refueling water. A portion of the hot water discharged by the pump can be diverted through a water cleanup system and returned to the pool.

The SFPCPS is manually controlled and is capable of maintaining the pool water at a low enough temperature to prevent excessive vapor formation or evaporation from the water surface or to cause excessive discomfort to personnel during fuel handling operations. The SFPCPS is shown in figure 9.1.3-1. ~~The SFPCPSs for the two units are identical.~~ See Insert A

9.1.3.1 Design Bases

Spent fuel pool cooling system design parameters are given in table 9.1.3-1A for Unit 1 and table 9.1.3-1B for Unit 2.

A. Spent Fuel Pool Cooling System (SFPCS)

1. Spent Fuel Pool Cooling System-Unit 1

The SFPCS ~~for each~~ unit 1 is designed to remove the decay heat generated by the spent fuel assemblies removed from one-third of a reactor core 150 h after shutdown, plus one-third of a reactor core per year from the annual refueling of the previous 10 years. When this equivalent eleven-thirds of a core is in the pool, the system will maintain the spent fuel pool water temperature below 140°F if either of the two heat exchangers per unit is supplied with 105°F component cooling water at the design flowrate (4000 gal/min).

The design heat load was calculated following the guidance of ANS 5.1. The design heat load for the spent fuel pool heat exchangers is the equivalent eleven-thirds of a core as described above or 17.38 x 10^6 Btu/h.

Two maximum heat load cases are also evaluated in the design of the SFPCS. The maximum normal refueling case assumes a loading of one-third core per year for 9 years, plus 40 percent of a core from the preceding year's refueling and the most recent refueling (40 percent of a core) 150 h after shutdown.

INSERT A

The SFPCPS for the two units are identical, however, the expected heat removal requirements are greater for the Unit 2 pool than for the Unit 1 pool. Spent fuel pool cooling for the Unit 2 pool was evaluated for storage of 2098 assemblies. The Unit 1 pool spent fuel cooling system is evaluated for storage of 936 fuel assemblies. Some fuel assemblies discharged from Unit 1 will eventually be stored in the Unit 2 pool.

The maximum emergency core unload case assumes a loading of one-third core per year for 10 years and an additional full core loaded into the pool 330 h after the most recent refueling of 40 percent core was added. With two trains operating, the spent fuel pool temperature is maintained below 120°F and 150°F, respectively, for the maximum normal refueling and maximum emergency core unload cases. Assuming a single failure, the spent fuel pool temperature will not exceed 170°F in either case.

See Insert B

B. Spent Fuel Pool Dewatering Protection

System piping is arranged so that failure of any pipeline cannot drain the spent fuel pool below the water level required for radiation shielding.

C. Water Purification

The system's demineralizer and filters are designed to:

1. Provide adequate purification.
2. Permit unrestricted access for plant personnel.
3. Minimize pool surface dose rate during fuel handling operations in the spent fuel storage area.
4. Maintain optical clarity of the spent fuel pool water by use of the system's skimmers, strainers, and skimmer filter.

The water cleanup circuit contains a filter with 98-percent retention of suspended particulates ≥5 μm in diameter and a mixed bed demineralizer upstream of the filter. The cleanup system is designed for a flowrate of 100 gal/min and is sufficient to ensure circulation of the pool water volume and maintain the specified water chemistry.

The boron concentration in the pool water is maintained at approximately the same concentration as the refueling water (approximately 2000 ppm by weight boron). Provisions are made to add makeup water to the pool, both as demineralized water to compensate for evaporation and as borated water corresponding to the refueling water concentration.

INSERT B

2. Spent Fuel Pool Cooling System - Unit 2

The SFPCS for Unit 2 is designed to remove the decay heat generated by the spent fuel assemblies for the normal refueling, maximum normal refueling and maximum emergency core unloading cases.

The design heat load for each case was calculated following the guidance of NRC Branch Technical Position ASB 9-2, Rev. 2, dated July 1981. A fuel burnup of 45,000 MWD/MTU is assumed. The design heat load is based on an 18 month refueling cycle for both units, with 88 assemblies removed from the core during each refueling.

For the normal refueling case it is assumed that 88 assemblies are unloaded into the Unit 2 pool 150 hours after shutdown of Unit 2 reactor. At the same time it is assumed that 2,010 assemblies from previous refuelings are present in the pool. These assemblies consist of 968 Unit 2 assemblies from previous refuelings as well as 1,042 Unit 1 assemblies transferred from the Unit 1 pool into the Unit 2 pool after they have been decayed for 15 months in the Unit 1 pool. The heat load from the 88 assemblies 150 hours after shutdown of the reactor is 16.66 x 10^6 Btu/hr. The heat load from 2,010 assemblies from the previous refuelings is 11.63 x 10^6 Btu/hr. In addition there is a heat load of 0.38 x 10^6 Btu/hr., from the spent fuel pool pump work. With a design margin of 0.5 x 10^6 Btu/hr., the total heat input to the spent fuel pool is 29.17 x 10^6 Btu/hr. This heat load is used for the spent fuel pool cooling system analysis. During actual plant operation, Unit 1 fuel assemblies can be moved to the Unit 2 pool after they have decayed for 15 months in the Unit 1 pool or at any time the combined heat load of the Unit 1 and Unit 2 fuel assemblies is less than the heat load of 11.63 x 10^6 Btu/hr from previous refuelings described above. For the normal refueling case, the system will maintain the spent fuel pool water temperature below 140°F when either of the two heat exchangers are in operation.

For the maximum normal refueling case, to maximize the fuel decay heat input to the spent fuel pool, it is assumed that the entire core is unloaded into the pool 120 hours after the reactor shutdown. At this time, it is also assumed that 2,010 assemblies from previous refuelings are present in the pool. The composition of these assemblies is the same as that for the normal refueling case described above. These assemblies consist of Unit 2 assemblies from previous refuelings as well as Unit 1 assemblies transferred from the Unit 1 pool into the Unit 2 pool after they have decayed for 15 months in the Unit 1 pool. The total number of fuel assemblies thus assumed in the pool at 120 hours after reactor shutdown is 2098 plus a 5% margin which is conservative.

Additionally, the pool temperature is calculated assuming that these assemblies continue to remain in the pool throughout the refueling operation.

For the maximum normal refueling case, with two trains operating, the spent fuel pool temperature is maintained below 130°F and with one train operating, the temperature is maintained below 170°F.

For the maximum emergency core unloading case, it is assumed that the entire core is unloaded into the pool 150 hours after the emergency shutdown of the reactor. At this time it is also assumed that 88 assemblies from the most recent refueling with a decay time of 36 days and 1,817 assemblies from prior refuelings are present in the pool. These assemblies consist of 880 Unit 2 assemblies from previous refuelings as well as 937 Unit 1 assemblies transferred from the Unit 1 pool into the Unit 2 pool after they have decayed for 15 months in the Unit 1 pool.

For the maximum emergency core unloading case, with both trains operating, the spent fuel pool temperature is maintained below 135°F.

A summary of heat loads and spent fuel pool temperatures for the above cases is presented in Table 9.1.3.4.

Info Only
no changes

9.1.3.2 System Description

The Safety Class 3, Seismic Category 1 SFPCPS shown in figure 9.1.3-1 consists of two complete cooling trains. The SFPCPS conforms to the guidelines of Regulatory Guide 1.13, pertaining to the cooling and purification of the spent fuel storage facility. The SFPCPS (piping, pumps, valves, and heat exchangers) is designed to remain functional during and following a safe shutdown earthquake.

There are three sources of makeup water available. The reactor 3
makeup water storage tank serves as the Seismic Category 1 makeup water source for the spent fuel pool; makeup water can be pumped or gravity-fed into the discharge line from spent fuel pool pump A. Borated refueling water can be pumped or gravity-fed into the nonsafety-related purification loop. Demineralized water can be pumped directly into the Safety Class 3 return lines of each spent fuel cooling loop. The cooling water return lines of the cooling loops transport the reactor makeup water, refueling water, or demineralized water 19
into the spent fuel pool.

During equipment maintenance, water from the transfer canal is transferred to the recycle holdup tanks for temporary holdup. The borated water is returned to the transfer canal directly by the 3
recycle evaporator feed pump. Interconnecting piping between the 19
evaporator feed pumps and the spent fuel pool is nonnuclear safety related.

Each cooling train incorporates one heat exchanger and pump. One purification loop, with demineralizer and filter and associated piping, valving, and instrumentation, services both cooling loops. One surface skimmer loop is also provided. Each cooling train is designed to service the spent fuel pool with the design spent fuel assembly loading described in paragraph 9.1.3.1 and to maintain the bulk fluid temperature of the pool below 140°F. With both trains in service with the design spent fuel assembly loading, the bulk fluid temperature of the pool is maintained below 120°F.

The SFPCPS removes decay heat from fuel stored in the spent fuel pool. Spent fuel is placed in the pool during the refueling sequence and stored there until it is shipped offsite. Heat is transferred from the SFPCPS through the heat exchanger to the component cooling system.

When either cooling train is in operation, water flows from the spent fuel pool to the spent fuel pool pump suction, 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 ft below the normal spent fuel pool water level, while the return line contains an antisiphon hole near the surface of the water to prevent gravity drainage of the pool.

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No Changes

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

The demineralizer and filter can be isolated from the heat removal portion of the SFPCPS to allow purification and cleanup of 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 the refueling water system through the demineralizer and filter and discharged either to the refueling cavity, the refueling water storage tank, or the recycle holdup tanks.

To assist further in maintaining spent fuel pool water clarity, the water surface is cleaned by a skimmer loop. Water is removed from the surface by two skimmer strainers, pumped through a filter, and returned to the pool surface at three locations remote from the skimmers. Water clarity in the refueling canal is maintained by the use of a reactor cavity filtration unit during refueling operations. The reactor cavity filtration unit takes suction from the refueling canal, circulates the water through a filter assembly, and discharges the water back into the canal.

The spent fuel pool is initially filled for use with water that is at the same boron concentration as that in the refueling water storage tank (RWST). Demineralized water from an external source could be tanked to the plant and transferred to the pool by temporary connections. Boron may be added to the fuel transfer canal from the chemical and volume control system and then pumped to the spent fuel pool by temporary connections. However, a more direct way to initially fill the spent fuel pool would be to add water from the reactor makeup storage tank or borated water from the RWST. Demineralized water can be added for makeup purposes, i.e., to replace evaporative losses, through a connection in each cooling train's purification return loop.

The pool water may be separated from the water in the transfer canal by a gate. The gate is installed so that the transfer canal may be drained to allow maintenance of the fuel transfer equipment. The water in the transfer canal may be transferred to the recycle holdup tanks in the boron recycle system. When required, the water may 19 then be returned directly to the transfer canal by the recycle evaporator feed pumps (boron recycle system).

9.1.3.3 Component Description

Codes and classifications for the SFPCPS are given in table 3.2.2-1. Equipment design parameters are given in table 9.1.3-2.

A. Spent Fuel Pool Pumps

Two identical pumps are installed in parallel in the heat removal portion of the SFPCPS. Each pump is sized to deliver sufficient coolant flow through its associated spent fuel pool heat exchanger to meet the system cooling requirements. In addition to the spent fuel pool heat removal duty, the pumps may also be used in the transfer and clarification of the transfer canal water.

The pumps are horizontal, centrifugal units, with all wetted surfaces being stainless steel or an equivalent corrosion-resistant material. The pumps are controlled manually from a local station.

B. Spent Fuel Pool Skimmer Pump

The 100-gal/min spent fuel pool skimmer pump circulates surface water through two skimmer strainers and a filter and returns it to the pool.

C. Spent Fuel Pool Heat Exchangers

Heat exchangers are the shell and U-tube type. Spent fuel pool water circulates through the tubes while component cooling water circulates through the shell. The tubes and other surfaces in contact with the pool water are austenitic stainless steel; the shell is carbon steel. The tubes are welded to the tube sheet to prevent leakage of pool water. ~~The heat exchangers have a design heat load capacity of 17.38 x 10^6 Btu/h or the equivalent of eleven-thirds of a core (one-third core 150 h after shutdown plus ten-thirds core from the previous refuelings).~~

THE heat exchangers for the Unit 1 and Unit 2 spent fuel pools are identical; however, the performance of the heat exchanger is calculated for a heat removal requirement of 17.38 x 10^6 BTU/h for the Unit 1 pool and 29.17 x 10^6 BTU/h for the Unit 2 pool.

D. Spent Fuel Pool Demineralizer

The flushable, mixed bed demineralizer is designed to provide adequate fuel pool water purity for unrestricted access to the pool working area while maintaining visual clarity. Design flow is 100 gal/min.

~~No overtemperature protection is required for the spent fuel pool demineralizers. The temperature of the spent fuel cooling water for the maximum refueling case will not exceed the temperature at which the ion removal capability of the resin would be adversely affected (approximately 160°F) as long as one of the two cooling trains is in operation.~~ See insert C

E. Spent Fuel Pool Backflushable Filter

The spent fuel pool filter is designed for a flow of approximately 250 gal/min. A 5-μm filter is used to improve the pool water clarity by removing insoluble particles which obscure visibility.

F. Spent Fuel Pool Skimmer Filter

The spent fuel pool skimmer filter is designed for a rated flow of 100 gal/min. A 5-μm filter cartridge is used to remove insoluble particles.

G. Spent Fuel Pool Strainers

Strainers are located in each spent fuel pool pump suction line for removal of relatively large particles which might otherwise clog the spent fuel pool demineralizers or damage the spent fuel pool pumps.

H. Spent Fuel Pool Skimmer/Strainers

Two spent fuel pool skimmer/strainers are designed to remove debris and recirculate water from the surface of the spent fuel pool. The elevation of the skimmers can be adjusted over a range of 2 ft.

I. Valves

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

INSERT C

Overtemperature protection is not required for the spent fuel pool demineralizers. For the maximum normal refueling case the spent fuel pool cooling water temperature will not exceed 130°F when both cooling trains are in operation. With failure of one train, the pool temperature may reach 170°F. The ION removal capacity of the resins is significantly reduced at this temperature. An alarm in the control room is provided to warn the operator of the increase in spent fuel pool temperature to take corrective action.

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J. 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.

K. Reactor Cavity Filtration Unit

The reactor cavity filtration unit consists of a motor, pump, and four cartridge filters. This unit improves the refueling canal clarity by removing insoluble particles which obscure visibility.

9.1.3.4 System Operation

A. Startup, Normal Operation, and Cooldown

The SFPCPS is not directly associated with either plant startup, normal operation, or shutdown but is operated when there is need to cool, clarify, or purify the pool water. All situations are dependent upon the pool fuel loading and upon the elapsed time that the spent fuel has been in the pool.

One spent fuel pool pump is started manually on or before a high water temperature alarm, after assurance that cooling water is being furnished to the associated spent fuel pool heat exchanger.

The spent fuel pool water chemistry may then be checked at local sample points. If purification is required, a portion (approximately 100 gal/min) of the system flow is diverted through the spent fuel pool demineralizer and filter and returned to the pool. However, if only undissolved solids are to be removed, this flow may be circulated directly through the filter. A local sample connection is provided in the purification return line so that the effectiveness of either the filter or the demineralizer may be checked as well as the boron concentration.

The spent fuel pool pump may also be used to transfer water from the fuel pool to the recycle holdup tanks. This capability may be used to transfer water from the spent fuel pool for temporary holdup or to recycle and reuse the water at a later time. 19

No Changes
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To maintain water surface clarity, a separate cleaning loop, the spent fuel pool skimmer/strainer loop, is also provided. This subsystem, which is started manually, collects surface water from the pool strains and filters it, and returns it to the pool at three remote locations. By proper location of the two skimmer/strainers and the three return lines, cleaning of the complete pool surface is accomplished.

B. Refueling

The SFPCPS has its maximum duty during the refueling operation when the decay heat from the spent fuel is the highest. The system is normally placed in operation prior to the transfer of any fuel and continues in operation as long as required to maintain temperature and water purity within prescribed limits. In addition, the reactor cavity filtration unit may be placed into service during refueling to maintain suitable water clarity for conducting fuel handling operations.

9.1.3.5 Safety Evaluation

A. Availability and Reliability

The SFPCPS has no emergency function during an accident. A cooling train may be shut down for limited periods of time for maintenance or replacement of malfunctioning components. In the event of the failure of a spent fuel pool pump or loss of cooling to a spent fuel pool heat exchanger, the second cooling train provides backup capability which ensures continued cooling of the spent fuel pool. A failure mode and effects analysis for the cooling portion of the SFPCS is provided in table 9.1.3-3.

The result of the unlikely failure of both spent fuel cooling loops would be a rise in pool water temperature followed by an increase in evaporative losses. These losses could be made up indefinitely from the reactor makeup water system, the refueling water system, or the demineralized water system.

Each of the above sources can supply makeup water to the spent fuel pool via the cooling water return lines. In addition, the boron recycle evaporator feed pumps can pump from the recycle holdup tanks directly into the spent fuel pool 19

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via the transfer canal when the gate between the pool and canal is open.

B. Spent Fuel Pool Dewatering

The most serious failure of this system would be complete loss of water in the storage pool. In accordance with Regulatory Guide 1.13, the design of the SFPCPS limits the loss of coolant that could be caused by maloperation or failure of system components such that spent fuel does not become uncovered.

The spent fuel pool cooling pump suction connections are located near the normal water level so that the pool cannot be gravity drained. Each return line contains an antisiphon hole to prevent the possibility of gravity draining of the pool via these lines. Finally, the lines to and from the skimmer/strainers are located near the normal water level.

The accidental opening of the gate between the spent fuel pool and the transfer canal, if the canal is dry, would lower the water level approximately 6 ft, leaving about 18 ft of water over the top of the spent fuel assemblies.

Makeup water sources are provided to replace evaporative and minor leakage losses. These sources include the refueling water storage tank, the reactor makeup water storage tank, the demineralized water storage tank, and the recycle holdup tanks. Makeup to the spent fuel pit should be started upon a low-level alarm signal from the spent fuel pool level instrumentation. 7

The spent fuel pool, transfer canal, and spent fuel cask loading pit have stainless steel liners welded to embedments in the walls and floors. At every liner weld seam continuous drains are provided for leak detection. These are interconnected and drain to a collection point which is monitored to determine whether leakage is occurring.

C. Water Quality

Only a very small amount of water is interchanged between the refueling canal and the spent fuel pool, as fuel assemblies are transferred in the refueling process. Whenever a fuel assembly with defective cladding is transferred from the fuel transfer canal

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to the spent fuel pool, a small quantity of fission products may enter the spent fuel cooling water. The purification loop removes fission products and other contaminants from the water. By maintaining radioactivity concentrations, excluding tritium, in the spent fuel pool water at or below 5×10^{-3} µCi/g for dominant gamma-emitting isotopes, the dose rate at the surface of the pool is 2.5 mrem/h or less.

9.1.3.6 Tests and Inspections

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

No special equipment tests are required, since system components are normally in operation when spent fuel is stored in the fuel pool.

Sampling of the fuel pool water for gross activity and particulate matter concentration is conducted periodically. The layout of the components of the SFPCPS is such that periodic testing and inservice inspection of this system are possible. Details of the inservice inspection program are outlined in section 6.6.

A. Instrumentation Application

The instrumentation provided for the SFPCPS is discussed in the following paragraphs. Alarms and indications are provided as noted.

B. Temperature

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

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

C. Pressure

Instrumentation is provided to measure and give local indication of the pressures in the spent fuel pool pump suction and discharge lines and in the skimmer pump discharge line. Instrumentation is also provided at locations upstream and downstream from the skimmer filter and the spent fuel pool filter so that pressure differential across these filters can be determined. High differential pressure across the spent fuel pool filter is annunciated locally and in the control room.

D. Flow

Instrumentation is provided to measure and give local indication of the purification loop flow downstream of the spent fuel pool filter.

E. Level

Instrumentation is provided to give an alarm in the control room when the water level in the spent fuel pool reaches either the high-level or low-level setpoint. A local alarm is also provided for low-level setpoint. 19

F. Radiation

Gamma radiation is continuously monitored in the fuel handling building. A high-level signal is alarmed locally and annunciated in the control room. This is described in detail in subsection 12.3.4.

9.1.3.7 Standard Review Plan Evaluation

A. Unit 1

Heat loads are calculated by a different method than the method stated in Branch Technical Position (BTP) ASB 9-2, Revision 2, dated July 1981.

An analysis has been performed to compare BTP-ASB-9-2 methods of decay heat calculation with standard Westinghouse methods. The results of this analysis indicate that the application of these two methodologies do not lead to significant differences in calculated decay heat. Calculated differences are about 1 6 percent. For specific plants, fuel pool temperature is not particularly sensitive to such differences in decay heat. A 1-percent increase in decay heat fraction increases fuel pool temperature by less than 0.2°F, while a 10-percent increase in decay heat fraction would increase pool temperature by less than 2.0°F. Thus the differences in the values calculated by either the Westinghouse methodology or by BTP-ASB-9-2 are slight.

B. Unit 2

Heat loads are calculated by the method stated in NRC Branch Technical Position ASB 9-2, Revision 2, dated July 1981.

TABLE 9.1.3-1A

Unit 1

SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM DESIGN PARAMETERS

Spent fuel pool storage capacity(a)	14/3 cores
Spent fuel pool water volume (gal)(b)	447,030
Nominal boron concentration of the spent fuel pool water (ppm)	2000
Maximum normal refueling case	
Decay heat production (Btu/h)	19.8×10^6
Spent fuel pool water temperature with both cooling trains in operation (°F)	118.2
Spent fuel pool water heat inertia, time to heat from 118.2°F to 212°F assuming no heat loss (h)	18.5
Maximum emergency core unload case	
Decay heat production (Btu/h)	49.1×10^6
Spent fuel pool water temperature with both cooling trains in operation (°F)	137.5
Spent fuel pool water heat inertia, time to heat from 137.5°F to 212°F assuming no heat loss (h)	5.9

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a. One core equals 193 fuel assemblies. ~~Each~~ Unit 1 storage pool has a capacity of 936 fuel assemblies.

b. Volume of spent fuel pool without racks or fuel assemblies.

TABLE 9.1.3-1B

Unit 2

SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM DESIGN PARAMETERS

Spent fuel pool storage capacity[a]	~~14/3 cores~~ 2098 fuel assemblies
Spent fuel pool water volume (gal)[b]	437,840
Nominal boron concentration of the spent fuel pool water (ppm)	2000
See Insert D	
Maximum normal refueling case	
Decay heat production (Btu/h) @ 120 hours after shutdown	51.2 ~~19.8~~ $\times 10^6$
Spent fuel pool water temperature with both cooling trains in operation (°F)	~~118.2~~ 130
Spent fuel pool water heat inertia, time to heat from ~~118.2~~°F 130° to 212°F assuming no heat loss (h)	~~18.5~~ 5.9
Maximum emergency core unload case	
Decay heat production (Btu/h) @ 150 hours after shutdown	55.39 ~~49.1~~ $\times 10^6$
Spent fuel pool water temperature with both cooling trains in operation (°F)	~~137.5~~ 135
Spent fuel pool water heat inertia, time to heat from 135°F ~~137.5°F~~ to 212°F assuming no heat loss (h)	~~5.9~~ 5.1

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a. One core equals 193 fuel assemblies. ~~Each storage pool has a capacity of 936 fuel assemblies.~~

b. Water volume of spent fuel pool with racks and 2098 assemblies in the spent fuel pool.

INSERT D

Normal refueling case

Decay heat production (Btu/h) at 150 hours after shutdown.	28.29×10^6
Spent fuel pool water temperature with both cooling trains in operation (°F).	115
Spent fuel pool water heat inertia, time to heat from 115°F to 212°F assuming no heat loss (h).	12.7

TABLE 9.1.3-2 (SHEET 1 OF 2)

SPENT FUEL POOL COOLING AND PURIFICATION SYSTEM COMPONENT DESIGN PARAMETERS

Spent Fuel Pool Pump		
Number	2	
Design pressure (psig)	150	
Design temperature (°F)	200	
Design flow (gal/min)	2300	
Material	Stainless steel	
Spent Fuel Pool Skimmer Pump		
Number	1	
Design pressure (psig)	150	
Design temperature (°F)	200	
Design flow (gal/min)	100	
Material	Stainless steel	
Refueling Water Purification Pumps		
Number	1	
Design pressure (psig)	120	
Design temperature (°F)	140	
Design flow (gal/min)	200	
Material	Stainless steel	
Spent Fuel Pool Heat Exchangers(a)		
Number	2	
Type	Shell and U tube	
Design heat transfer (Btu/h)	17.38×10^6	
Required capacity (Btu/h/°F)	2.0×10^6	
	Shell	Tube
Design pressure (psig)	150	150
Design temperature (°F)	200	200
Design flow (lb/h)	1.98×10^6	1.14×10^6
Inlet temperature (°F)	105	128
Outlet temperature (°F)	114	113
	Shell	Tube
Fluid circulated	Component cooling water	Spent fuel pool water
Material	Carbon steel	Stainless steel

TABLE 9.1.3-2 (SHEET 2 OF 2)

Spent Fuel Pool Demineralizer	
Number	1
Type	Flushable
Design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	100
Resin volume (ft^3)	30
Material	Stainless steel
Spent Fuel Pool Backflushable Filter	
Number	1
Design pressure (psig)	375
Design temperature (°F)	200
Design flow (gal/min)	250
Filtration requirement	98% retention of particles above 5 μm
Material, vessel	Stainless steel
Spent Fuel Pool Skimmer Filter	
Number	1
Internal design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	100
Filtration requirement	98% retention of particles above 5 μm
Material, vessel	Stainless steel
Spent Fuel Pool Strainer	
Number	2
Design temperature (°F)	200
Rated flow (gal/min)	2300
Perforation (in.)	Approximately 0.2
Material	Stainless steel
Spent Fuel Pool Skimmer/Strainer	
Number	2
Design temperature (°F)	200
Design flow (gal/min)	50
Perforation (in.)	1/16
Material	Stainless steel

(a) See Insert E

INSERT E

(a) The heat exchanger design and sizing is based on the parameters as shown. The spent fuel pool temperature analyses for Unit 2 utilize the same physical parameters for the heat exchanger. However, the heat exchanger performance is calculated based on the maximum heat load for each case and the overall performance of the heat removal systems that transfer the heat from the spent fuel pool to the ultimate heat sink.

TABLE 9.1.3-3A (SHEET 1 OF 10)

Unit 1

FAILURE MODE AND EFFECTS ANALYSIS FOR COOLING PORTION OF SFPCPS

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
1	Spent fuel pit pump P6-002 (train A)	Circulates spent fuel pit water through heat exchanger to maintain below ~~[illegible]~~°F 140°F for maximum ~~fuel load for core unloading~~ normal refueling case. (note a)	All except loss of offsite power (see general remarks)	Stops running due to electrical protection	Pump trip alarm in control room, local amber indication on HS-10627, and low local pump discharge pressure indication on PI-0627A. If condition persists for extended time (see general remarks), high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available ~~(item a)~~ to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus within 40 s after the loss of power.
				Fails to start upon command or spurious stop	Same as above, except no pump trip alarm and no amber light in control room. Pump status light on HS-10627 is green.	Same as above	
2	Spent fuel pit pump P6-005 (train B)	Circulates spent fuel pit water through heat exchanger to maintain below ~~[illegible]~~ 140°F for maximum ~~fuel load for core unloading~~ normal refueling case (note a)	All except loss of offsite power (see general remarks)	Stops running due to electrical protection	Pump trip alarm in control room, local amber indication on HS-10628, and low local pump discharge pressure indication on PI-0627B. If condition persists for extended time (see general remarks), high spent fuel pit temperature alarm from TISH-626 in control room.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power
				Fails to start upon command or spurious stop	Same as above, except no pump trip alarm and no amber light in control room. Pump status	Same as above	

TABLE 9.1.3-3A(SHEET 2 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					light on HS-10628 is green.		bus within 40 s after the loss of power.
3	Spent fuel pit heat exchanger E6-001 (train A)	Transfers spent fuel pit heat load to component cooling water system 1203	All	Tube leakage from spent fuel pit into component cooling water (shell) side	Low spent fuel pit level alarm LSHL-625, high component cooling water surge tank level alarm LIT-1846, and high component cooling water return flow radiation alarm RE-017A in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus within 40 s after the loss of power. Also, spent fuel can never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.
				Tube leakage from component cooling water into spent fuel pit water (see general remarks)	Component cooling water surge tank low level alarm LIT-1846 and/or operation of makeup valve LV-1850 plus grab sample of spent fuel pit water to detect presence of chromates; also, rise in heat exchanger outlet temperature TI-628A, small spent fuel pit level rise, and possible alarm LSHL-625 in control room.	Same as above	
				External shell (component cooling water) side leakage	Component cooling water surge tank low level alarm LIT-1846 and/or operation of makeup valve LV-1850 plus flood alarms in the control room from spent	Same as above	

TABLE 9.1.3-3A (SHEET 3 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					fuel pit heat exchanger room sump and/or wall-mounted level switches LSH-9802 and/or LSH-9798 in control room; small rise in spent fuel pit temperature, possible alarm TISH-626, and small rise in heat exchanger discharge temperature TI-628A.		
				Tube (spent fuel pit) side blockage	Rise in spent fuel pit temperature and possible alarm TISH-626 plus rise in heat exchanger outlet temperature TI-628A.	Same as above	
4	Spent fuel pit heat exchanger E6-002 (train B)	Transfers spent fuel pit heat load to component cooling water system 1203	All	Tube leakage from spent fuel pit into component cooling water (shell) side	Low spent fuel pit level alarm LSHL-625, high component cooling water surge tank level alarm LIT-1847, and high component cooling water return flow radiation alarm RE-017B in control room.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling function for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and ~~takes over 3 h after~~ heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus with 40 s after the loss of power. Also, spent fuel can
				Tube leakage from component cooling water into spent fuel pit water (see general remarks)	Component cooling water surge tank low level alarm LIT-1847 and/or operation of makeup valve LV-1851 plus grab sample of spent fuel pit	Same as above	

TABLE 9.1.3-3A(SHEET 4 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					water to detect presence of chromates; also, rise in heat exchanger outlet temperature TI-628B, small spent fuel pit level rise, and possible alarm LSHL-625 ~~room~~ in control room.		never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.
				External shell (component cooling water) side leakage	Component cooling water surge tank low level alarm LIT-1847 and/or operation of makeup valve LV-1851 plus flood alarms in the control room from spent fuel pit heat exchanger room sump and/or wall-mounted level switches LSH-9803 and/or LSH-9799 in control room; small rise in spent fuel pit temperature, possible alarm TISH-626, and small rise in heat exchanger discharge temperature TI-628B.	Same as above	
				Tube (spent fuel pit) side blockage	Rise in spent fuel pit temperature and possible alarm TISH-626 plus rise in heat exchanger outlet temperature TI-628B.	Same as above	

TABLE 9.1.3-3A(SHEET 5 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
5	Manual valve U6-001, normally open gate valve (train A)	Isolates suction of pump P6-002 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and low local pump discharge pressure indication on PI-0627A. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
6	Manual valve U6-003, normally open gate valve (train B)	Isolates suction of pump P6-005 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and low local pump discharge pressure indication on PI-0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; t~~rain B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
7	Manual valve U6-005, locked open gate valve (train A)	Isolates pump P6-002 from heat exchanger E6-001 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and local pump shutoff pressure indication on PI-0627A. If condi-	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.

TABLE 9.1.3-3A(SHEET 6 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					tion persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	
				External (stem) leakage	Visual inspection	Same as above	
8	Manual valve U6-007, locked open gate valve (train B)	Isolates pump P6-005 from heat exchanger E6-002 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and local pump shutoff pressure indication on PI-0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
9	Manual valve U6-009, locked open gate valve (train A)	Isolates heat exchanger E6-001 from spent fuel pit for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and local pump shutoff pressure indication on PI-0627A. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.

TABLE 9.1.3-3A (SHEET 7 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
				External (stem) leakage	Visual inspection	Same as above	
10	Manual valve U6-010, locked open gate valve (train B)	Isolates heat exchanger E6-002 from spent fuel pit for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and local pump shutoff pressure indication on PI-0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
11	Manual valve HV-8754A, normally open butterfly valve (train A)	Provides manual flow control and flow balancing in train A spent fuel pit cooling loop	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and local pump shutoff pressure indication on PI-0627A. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
12	Manual valve HV-8754B, normally open butterfly valve (train B)	Provides manual flow control and flow balancing in train B spent fuel	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and local pump shutoff pressure indication on PI-	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks on item 1.

TABLE 9.1.3-3A(SHEET 8 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
		pit cooling loop			06278. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room	the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	
13	Check valve U6-004	Prevents backflow of spent fuel pit water through purification loop, if latter fails	All	Fails open with line break in non-Q purification loop	Loss of spent fuel pit water with low level alarm LSHL-625 in control room.	None; break in non-Q piping can be isolated with valves U6-057, U6-058, and U6-053.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power but within 40 s after the loss of power.
14	Manual valve U6-028, normally open diaphragm valve (train A); valve normally closed if train B in service.	Isolates pump P6-002 discharge from non-Q purification loop	All	Fails or left open with faulted purification loop	Low spent fuel pit level alarm LSHL-0625 in control room plus spent fuel pit temperature rise and possible high temperature alarm TISH-626.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cool-

TABLE 9.1.3-3A (SHEET 9 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
				External (stem) leakage	Visual inspection	Same as above	ing is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus within 40 s after the loss of power. Also, spent fuel can never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.
15	Manual valve U6-030, normally closed diaphragm valve (train B); valve normally open if train A in service.	Isolates pump P6-005 discharge from non-Q purification loop	All	Fails of left open with faulted purification loop	Low spent fuel pit level alarm LSHL-0625 in control room plus spent fuel pit temperature rise and possible high temperature alarm TISH-626.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes over 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 131°F and heatup rate for no cooling is 5.1°F/h. For maximum emergency core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h. The spent fuel pit pump is shed automatically upon loss of offsite power but can be

TABLE 9.1.3-3A(SHEET 10 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
							manually loaded onto the emergency ac power bus within 40 s after the loss of power. Also, spent fuel can never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.

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a. During maximum emergency core unloading case, the spent fuel pool temperature is below 140°F when two trains of spent fuel pool cooling ~~system~~ are in operation. A single failure is not required to be postulated for this case.

TABLE 9.1.3-3B(SHEET 1 OF 10)

Unit 2

FAILURE MODE AND EFFECTS ANALYSIS FOR COOLING PORTION OF SFPCPS

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
1	Spent fuel pit pump P6-002 (train A)	Circulates spent fuel pit water through heat exchanger to maintain 170 below ~~180~~°F for maximum ~~fuel load~~ normal ~~for core~~ refueling ~~unloading~~ case (Note a)	All except loss of offsite power (see general remarks)	Stops running due to electrical protection	Pump trip alarm in control room, local amber indication on HS-10627, and low local pump discharge pressure indication on PI-0627A. If condition persists for extended time (see general remarks), high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available ~~(item a)~~ to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature is 170°F with one train operating and 130°F with two trains operating ~~is 131°F and~~ The heatup rate for no cooling is ~~5.1°F/h~~. 13.9°F/h. ~~For maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h~~. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus within 40 s after the loss of power.
				Fails to start upon command or spurious stop	Same as above, except no pump trip alarm and no amber light in control room. Pump status light on HS-10627 is green.	Same as above	
2	Spent fuel pit pump P6-005 (train B)	Circulates spent fuel pit water through heat exchanger to maintain 170 below ~~180~~°F for maximum ~~fuel load~~ normal ~~for core~~ refueling ~~unloading~~ case (Note a)	All except loss of offsite power (see general remarks)	Stops running due to electrical protection	Pump trip alarm in control room, local amber indication on HS-10628, and low local pump discharge pressure indication on PI-0627B. If condition persists for extended time (see general remarks), high spent fuel pit temperature alarm from TISH-626 in control room.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature is 170°F with one train operating and 130°F with two trains operating ~~is 131°F and~~ The heatup rate for no cooling is ~~5.1°F/h~~. 13.9°F/h ~~For maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h~~. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power
				Fails to start upon command or spurious stop	Same as above, except no pump trip alarm and no amber light in control room. Pump status	Same as above	

TABLE 9.1.3-3B(SHEET 2 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					light on HS-10628 is green.		bus within 40 s after the loss of power.
3	Spent fuel pit heat exchanger E6-001 (train A)	Transfers spent fuel pit heat load to component cooling water system 1203	All	Tube leakage from spent fuel pit into component cooling water (shell) side	Low spent fuel pit level alarm LSHL-625, high component cooling water surge tank level alarm LIT-1846, and high component cooling water return flow radiation alarm RE-017A in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For ~~maximum~~ normal refueling case, spent fuel pit temperature is 170°F with one train operating ~~is 131°F and~~ and 130°F with two trains operating The heatup rate for no cooling is ~~5.1°F/h~~. 13.9°F/h. ~~For maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h~~. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus within 40 s after the loss of power. Also, spent fuel can never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.
				Tube leakage from component cooling water into spent fuel pit water (see general remarks)	Component cooling water surge tank low level alarm LIT-1846 and/or operation of makeup valve LV-1850 plus grab sample of spent fuel pit water to detect presence of chromates; also, rise in heat exchanger outlet temperature TI-628A, small spent fuel pit level rise, and possible alarm LSHL-625 in control room.	Same as above	
				External shell (component cooling water) side leakage	Component cooling water surge tank low level alarm LIT-1846 and/or operation of makeup valve LV-1850 plus flood alarms in the control room from spent	Same as above	

TABLE 9.1.3-3B(SHEET 3 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					fuel pit heat exchanger room sump and/or wall-mounted level switches LSH-9802 and/or LSH-9798 in control room; small rise in spent fuel pit temperature, possible alarm TISH-626, and small rise in heat exchanger discharge temperature TI-628A.		
				Tube (spent fuel pit) side blockage	Rise in spent fuel pit temperature and possible alarm TISH-626 plus rise in heat exchanger outlet temperature TI-628A.	Same as above	
4	Spent fuel pit heat exchanger E6-002 (train B)	Transfers spent fuel pit heat load to component cooling water system 1203	All	Tube leakage from spent fuel pit into component cooling water (shell) side	Low spent fuel pit level alarm LSHL-625, high component cooling water surge tank level alarm LIT-1847, and high component cooling water return flow radiation alarm RE-017B in control room.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling function for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature is 170°F with one train operating ~~is 131°F and takes over 3 h after cooling 5.1°F/h.~~ and 130°F with two trains operating. The heat up rate for no cooling is 13.9°F/hr ~~For maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h.~~ The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus with 40 s after the loss of power. Also, spent fuel can
				Tube leakage from component cooling water into spent fuel pit water (see general remarks)	Component cooling water surge tank low level alarm LIT-1847 and/or operation of makeup valve LV-1851 plus grab sample of spent fuel pit	Same as above	

TABLE 9.1.3-3B(SHEET 4 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					water to detect presence of chromates; also, rise in heat exchanger outlet temperature TI-628B, small spent fuel pit level rise, and possible alarm LSHL-625 ~~room~~. in control room.		never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.
				External shell (component cooling water) side leakage	Component cooling water surge tank low level alarm LIT-1847 and/or operation of makeup valve LV-1851 plus flood alarms in the control room from spent fuel pit heat exchanger room sump and/or wall-mounted level switches LSH-9803 and/or LSH-9799 in control room; small rise in spent fuel pit temperature, possible alarm TISH-626, and small rise in heat exchanger discharge temperature TI-628B.	Same as above	
				Tube (spent fuel pit) side blockage	Rise in spent fuel pit temperature and possible alarm TISH-626 plus rise in heat exchanger outlet temperature TI-628B.	Same as above	

TABLE 9.1.3-3B(SHEET 5 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
5	Manual valve U6-001, normally open gate valve (train A)	Isolates suction of pump P6-002 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and low local pump discharge pressure indication on PI-0627A. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
6	Manual valve U6-003, normally open gate valve (train B)	Isolates suction of pump P6-005 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and low local pump discharge pressure indication on PI-0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; t~~rain B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
7	Manual valve U6-005, locked open gate valve (train A)	Isolates pump P6-002 from heat exchanger E6-001 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and local pump shutoff pressure indication on PI-0627A. If condi-	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.

TABLE 9.1.3-3B(SHEET 6 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
					tion persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	
				External (stem) leakage	Visual inspection	Same as above	
8	Manual valve U6-007, locked open gate valve (train B)	Isolates pump P6-005 from heat exchanger E6-002 for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and local pump shutoff pressure indication on PI-0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; tra~~in B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
9	Manual valve U6-009, locked open gate valve (train A)	Isolates heat exchanger E6-001 from spent fuel pit for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and local pump shutoff pressure indication on PI-0627A. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.

TABLE 9.1.3-38 (SHEET 7 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
				External (stem) leakage	Visual inspection	Same as above	
10	Manual valve U6-010, locked open gate valve (train B)	Isolates heat exchanger E6-002 from spent fuel pit for maintenance	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and local pump shutoff pressure indication on PI-0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; tr~~ain B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
				External (stem) leakage	Visual inspection	Same as above	
11	Manual valve HV-8754A, normally open butterfly valve (train A)	Provides manual flow control and flow balancing in train A spent fuel pit cooling loop	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10627, and local pump shutoff pressure indication on PI-0627A. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks of item 1.
12	Manual valve HV-8754B, normally open butterfly valve (train B)	Provides manual flow control and flow balancing in train B spent fuel	All	Inadvertent closure	Pump trip alarm in control room, local amber indication on HS-10628, and local pump shutoff pressure indication on PI-	None; tr~~ain B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after	For valve closure cases, it is presumed that pump in same train is operating and will trip if valve is closed. Also, see general remarks on item 1.

TABLE 9.1.3-38 (SHEET 8 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
		pit cooling loop			0627B. If condition persists for extended time, high spent fuel pit temperature alarm from TISH-626 in control room	the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	
13	Check valve U6-004	Prevents backflow of spent fuel pit water through purification loop, if latter fails	All	Fails open with line break in non-Q purification loop	Loss of spent fuel pit water with low level alarm LSHL-625 in control room.	None; break in non-Q piping can be isolated with valves U6-057, U6-058, and U6-053.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 170°F and 130°F with two trains operating ~~is 131°F and~~ The heatup rate for no cooling is ~~5.1°F/h~~. 13.9°F/h ~~For maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h~~. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power but within 40 s after the loss of power.
14	Manual valve U6-028, normally open diaphragm valve (train A); valve normally closed if train B in service.	Isolates pump P6-002 discharge from non-Q purification loop	All	Fails or left open with faulted purification loop	Low spent fuel pit level alarm LSHL-0625 in control room plus spent fuel pit temperature rise and possible high temperature alarm TISH-626.	None; train B available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating is 170°F and 130°F with two trains operating ~~is 131°F and~~ The heatup rate for no cooling is ~~5.4~~°F/h. 13.9 ~~For maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cool-~~

TABLE 9.1.3-38 (SHEET 9 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
				External (stem) leakage	Visual inspection	Same as above	~~ing is 12.7°F/h~~. The spent fuel pit pump is shed automatically upon loss of offsite power but can be manually loaded onto the emergency ac power bus within 40 s after the loss of power. Also, spent fuel can never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.
15	Manual valve U6-030, normally closed diaphragm valve (train B); valve normally open if train A in service.	Isolates pump P6-005 discharge from non-Q purification loop	All	Fails of left open with faulted purification loop	Low spent fuel pit level alarm LSHL-0625 in control room plus spent fuel pit temperature rise and possible high temperature alarm TISH-626.	None; ~~train B and redundant~~ train A available to provide 100 percent of required cooling capacity. In the most limiting case, it takes ~~over~~ 3 h after the loss of spent fuel pit cooling functions for the water to reach the boiling point; hence, there is ample time for the operator to actuate the redundant pump.	Activation of redundant train is manual. For maximum normal refueling case, spent fuel pit temperature with one train operating ~~is 131°F and~~ is 170°F and 130°F with two trains operating The heatup rate for no cooling is ~~5.1°F/h~~ 13.9°F/h ~~for maximum core unloading case, the spent fuel pit temperature with one train operating is 170°F and heatup rate for no cooling is 12.7°F/h~~. The spent fuel pit pump is shed automatically upon loss of offsite power but can be

TABLE 9.1.3-3B(SHEET 10 OF 10)

Item No.	Description of Component	Safety Function	Plant Operating Mode	Failure Mode	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
							manually loaded onto the emergency ac power bus within 40 s after the loss of power. Also, spent fuel can never be uncovered since the suction line connections are located 4 ft below the normal water level. Siphoning of spent fuel pit water is precluded by small holes in the water return lines. During normal operation, component cooling water pressure in the spent fuel pit heat exchanger is higher than that of the spent fuel pit water.

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a. During maximum emergency core unloading case, the spent fuel pool temperature is below 135°F when two trains of spent fuel pool cooling are in operation. A single failure is not required to be postulated for this case.

TABLE 9.1.3-4

SUMMARY OF UNIT 2 HEAT LOADS AND PEAK TEMPERATURES

	HEAT LOAD(a) $X10^6$ Btu/h	TIME AFTER REACTOR SHUTDOWN hours	SPENT FUEL POOL TEMPERATURE	
			ONE TRAIN °F	TWO TRAINS °F
NORMAL REFUELING CASE	29.17	150 hours	140	115
MAXIMUM NORMAL REFUELING CASE	52.08	120 hours	170	130
MAXIMUM EMERGENCY CORE UNLOADING CASE	56.22	150 hours	180(b)	135

(a) Heat load consists of decay heat from the fuel, heat load from pump work and design margin.

(b) A single failure is not required to be postulated for this case per SRP 9.1.3.

Attachment B

Replacement Pages for:

"Criticality Safety Analysis for Vogtle Electric Generating Plant Spent Fuel Storage Racks" that was transmitted to NRC with letter GN-1422 of December 22, 1987.

Replace page 14 of the report with attached, revised page 14

Replace page 16 of the report with attached, revised page 16

4.5.2.3 Boraflex Width Tolerance Variation

The reference storage cell design uses a Boraflex blade width of 7.75 ± 0.63 inches. A positive increment in reactivity occurs for a decrease in Boraflex absorber width. For a reduction in width of the maximum tolerance, 0.063 inch, the calculated positive reactivity increment is $+0.0004\Delta k$. However, to allow for radiation-induced shrinkage in width of the Boraflex and for possible small edge affects, the width tolerance was increased to 0.25 inches corresponding to an uncertainty of $\pm 0.0017\Delta k$.

4.5.2.4 Boraflex Integrity

The stability and integrity of the Boraflex absorber material under irradiation has recently been investigated (11) and further irradiation testing is currently underway. Available information confirms there is no loss of boron during irradiation although there is some radiation induced shrinkage. Under irradiation, Boraflex becomes a hard ceramic-like material and apparently shrinks 2 to 2-1/2 percent. At a very high radiation dose, there is evidence of a small edge deterioration. In the Vogtle racks, the Boraflex sheets are installed in a gap of sufficient size to allow unimpeded shrinkage and thereby preclude any mechanism that might cause gaps to develop.

To allow for shrinkage, the Boraflex sheets are initially 3 inches longer (approximately 2%) than would otherwise be necessary. Width shrinkage is accommodated by increasing the tolerance to ±0.25 inches from the nominal 0.063 inches. In both cases, shrinkage would increase the boron concentration in the Boraflex although no credit is taken for this increased the storage rack cell (four-assembly cluster at closest approach), indicated a negligible change in reactivity as determined by differential PDQ-7 calculations.

4.5.3 Reactivity Effects of Boraflex Axial Length

Based upon diffusion theory constants edited in the CASMO-2E output (reference design and a special case with water replacing the Boraflex), one-dimensional axial calculations were made to evaluate the reactivity effect of reduced Boraflex axial lengths. Reduced length of the Boraflex leaves small regions of active fuel without poison at each end of the fuel assembly. The unpoisoned region at each end is referred to as "cutback".

The axial calculations used a thick (30 cm.) water reflector, neglecting the higher absorption of the stainless-steel structural material at the ends of the fuel assembly. Results of the calculations showed that the k_{eff} remains less than the reference k_{∞} of the storage cells until the axial reduction in Boraflex length (cutback) exceeds four inches top and bottom corresponding to a required overall Boraflex length of 136 inches. Thus, the axial neutron leakage more than compensates for the 4-inch design cutback and the reference k_{∞} remains a conservative over-estimate of the true k_{eff}. In manufacturing the racks, a 4-inch cutback is used at the bottom of the rack. However, an initial Boraflex length of 139 inches is used which provides an allowance of 3 inches (approximately 2%) at the top of the racks to accommodate radiation-induced shrinkage of the Boraflex without exceeding the allowable cutback.