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United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. George W. Knighton, Chief
Licensing Branch No. 3
Division of Licensing

References: (a) Construction Permits CPPR-135 and CPPR-136, Docket Nos. 50-443 and 50-444

Subject: Open Item Response: (SRP 9.1.3; Auxiliary Systems Branch)

Dear Sir:

In response to the open item regarding the Spent Fuel Pool Cooling Subsystem, we have revised FSAR Sections 9.1.2 and 9.1.3 as delineated on the attached annotated FSAR Pages 9.1-3, 9.1-3a, 9.1-4, 9.1-5, 9.1-6, 9.1-7, 9.1-8, 9.1-8a, 9.1-8b, 9.1-9, 9.1-10, Table 9.1-1, Table 9.1-2, and Table 9.1-3.

The attached FSAR pages will be incorporated in OL Application Amendment 48.

Very truly yours,

YANKEE ATOMIC ELECTRIC COMPANY

J. DeVincentis
Project Manager

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ALL/fsf

cc: Atomic Safety and Licensing Board Service List

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the fuel racks will preclude criticality resulting from placing a fuel element on the top of the rack. Grill work between rows of fuel racks provides a positive mechanical method of preventing insertion in positions not designated for fuel storage. Spaces between elements within the rack have physical barriers to prevent insertion of elements between fuel positions.

The new fuel storage facilities (storage vault and racks) are designed to maintain the fuel spacing during a safe shutdown earthquake (SSE). All critical components (walls, racks) are designed to meet seismic Category I requirements. (See Section 3.7 and Subsection 3.8.4.)

The cask handling crane and the spent fuel bridge and hoist are designed in compliance with Crane Manufacturer Association of America (CMAA) Specification 70, "Specification for Electric Overhead Traveling Cranes," 29CFR1910 and 29CFR1923 requirements. The cranes are not seismic Category I components; however, in compliance with Regulatory Position C2 of Regulatory Guide 1.29, the cranes design parameters are specified to provide adequate quality control of fabrication and control of design so that in the event of a DBE or SSE, the cranes will not fail in such a manner as to reduce the functioning of any plant feature designated as seismic Category I by Regulatory Guide 1.29. The cranes are prevented from being dislodged off their rails during the SSE by mechanical anti-derailing devices. Figures 1.2-17 and 1.2-18 show the space envelope, boundaries and limits of hook travel of the cranes.

9.1.2 Spent Fuel Storage

The safety function of the spent fuel pool and storage racks is to maintain the spent fuel assemblies in a subcritical array during all credible storage conditions, and to provide a safe means for cask loading of the assemblies.

9.1.2.1 Design Bases

a. The spent fuel pool storage facility is designed in accordance with Regulatory Guide 1.13.

b. A total of 1236 fuel assemblies can be stored in the spent fuel pool. The spent fuel pool is able to accommodate 1236 spent fuel assemblies, based on sixteen (16) refuelings, one entire core, and thirteen (13) extra spent fuel assemblies. This number of accommodated spent fuel assemblies is based upon the following criteria:

   1. Six refuelings, each of which generates 65 spent fuel assemblies;

   2. Ten refuelings, each of which generates 64 spent fuel assemblies;

   3. One complete core unloading which generates 193 spent fuel assemblies;

   4. Thirteen spare locations if needed.

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(1)

c. Total fuel assembly storage capability is based on fuel storage cell geometry, center-to-center distance, lead-in angle requirements and poison thickness.

d. The spent fuel racks are designed for high density fuel storage, and contain neutron absorbing material to assure a $K_{eff} \leq 0.95$, even if the fuel is immersed in unborated water. 48

e. The design of the spent fuel pool storage racks is such that spent fuel assemblies cannot be inserted in other than designated locations, thereby preventing any possibility of accidental criticality.

f. A minimum of 10'-6" of water above the highest fuel element position is provided to permit fuel handling without exceeding a radiation dose of 2.5 mr/hr at the surface of the pool. The concrete walls provide adequate radiation protection from irradiated fuel assemblies.

g. The impact load for the design of the racks is based on a 17 x 17 fuel assembly, 8.426 inches square, 167 inches long, weighing 1467 pounds, and falling a distance of 18 inches to the racks at the worst possible orientation. 48 45

h. The facility and the building in which it is housed is capable of withstanding the effects of extreme natural phenomena, such as the SSE, tornadoes, hurricanes, missiles and floods.

i. The spent fuel storage racks have been designed to withstand an SSE, impact, handling loads, and dead load of the fuel assemblies, and meet ANSI N18.2 requirements. 48

j. The pool walls, fuel storage racks and other critical components whose failure could cause criticality, loss of cooling or physical damage to fuel, are classified as seismic Category I.

k. Failure of non-safety-related systems or structures located in the vicinity of the spent fuel storage facility which are not designed to seismic Category I requirements will not cause an increase in K_{eff} to exceed the maximum allowable.

l. The spent fuel pool bridge and hoist is designed to remain on its rails during an SSE and, therefore, cannot damage stored fuel.

m. The crane handling system is designed to prevent excessive forces from being applied to the spent fuel storage racks.

9.1.2.2 Facilities Description

The spent fuel storage and handling facility consists of four major areas: 1) the spent fuel pool, 2) the fuel transfer canal, 3) the spent fuel cask loading area and 4) a decontamination area. This arrangement is shown in Figures 1.2-15 through 1.2-21.

The spent fuel pool is a water-filled cavity designed to safely store irradiated fuel assemblies. This pool is constructed of reinforced concrete, with all interior surfaces lined with stainless steel.

The fuel storage area is protected against external tornado missiles by 2-foot thick reinforced concrete walls. The large roll-up door on the west wall of the fuel storage building is not designed for tornado missiles; 44 however, a missile wall is provided inside the building to prevent any missiles that could possibly penetrate the roll-up door from reaching the storage pool or cooling equipment.

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The elevation of the rail car loading area is 20'-6". Protection against flooding is assured since the pool operating floor level elevation is at 25'-0", which is above any postulated flooding conditions resulting from any potential ponding on the site due to extreme rain and wave overtopping.

The storage racks which hold the spent fuel assemblies are modular units, and each unit is free standing. 48

A portion of the pool will be reserved for inspection and testing of spent fuel assemblies.

The spent fuel pool is separated from the fuel transfer canal by a concrete shielding wall with a removable gate to facilitate the transfer of fuel assemblies. Location of the removable gate is shown on Figure 1.2-16. The fuel transfer canal contains the necessary equipment to transfer the fuel assemblies to and from the reactor containment. This equipment includes: 1) a fuel transfer system conveyor car; 2) fuel transfer valve; 3) fuel transfer system lifting frame equipment; 4) fuel transfer system control panel; and 5) new fuel elevator. The operation of this equipment is discussed in Subsection 9.1.4.

Isolation of the fuel transfer canal from the spent fuel pool by the removable gate provides a means for dry maintenance of the refueling equipment.

The cask loading pit is located next to the fuel transfer canal. This provides for submerged loading of spent fuel. The location eliminates the need to move heavy cask components over either new or spent fuel storage areas. The cask-handling crane is located so that its path of travel does not pass over the spent fuel pool. The cask is lowered in two steps: from the operating floor level of 25' to a shelf at elevation 4'-5½", and then to the loading position on the bottom of the pool at elevation (-) 23'-10½". This arrangement prevents submersion of the crane hook and cables in the pool water and eliminates contamination of the crane.

The spent fuel assemblies are handled by a long-handled tool suspended from an overhead hoist and manipulated by an operator standing on the movable bridge over the pool. A minimum of 10'-6" of water exists during fuel handling operations to provide radiation protection to the operator.

The hoist on the spent fuel pool bridge is equipped with a load cell to advise the operator if the fuel assembly is caught in the storage rack. This load cell has adequate sensitivity to detect an abnormal binding condition and thus prevent the movement of the entire rack. If the load exceeds a preset limit of 2,500 lbs, the hoist control circuit is interrupted and the brakes set.

The spent fuel cask decontamination area is used for the storage, maintenance, cleaning, and decontamination of spent fuel shipping casks. This area can also be used for the temporary storage of other contaminated components. The area is sized to permit the storage of a shipping cask head, shipping cask, cask lifting beam and a cask head lifting device.

Decontamination and maintenance procedures may require the use of portable scaffolds or elevated platforms to gain access to the upper parts of the cask. The decontamination area is provided with electricity, plant air, fresh water, demineralized water, steam and adequate drainage for the decontamination washdown water. This area is located between the transport vehicle loading area and the cask loading pool.

The spent fuel pool is monitored for leakage by a series of leak detection channels located adjacent to each liner seam weld. The leak monitor system has three channels which will gravity drain to a sump located in the fuel storage building. This zoning arrangement can be used to aid in establishing the location of the leakage. By monitoring the leakage rate, any change in the integrity of the liner can be established.

9.1.2.3 Safety Evaluation

The required margin of subcriticality of the fuel storage array is assured by neutron absorber material built into the storage structure of the rack.

The fuel pool and storage racks are designed so that normal loads, when combined with the forces resulting from the SSE, will not result in failure. The spent fuel pool, fuel transfer canal and cask loading pit are designed to meet the requirements of ACI 318-71. Seismic design considerations of these areas are discussed in detail in Section 3.7 and Subsection 3.8.4.

The spent fuel pool cooling pump suction penetration is located approximately two feet below the water level elevation, and the return line is a minimum of 16 feet above the top of the spent fuel assemblies. The failure of piping external to these penetrations will not result in lowering of the pool water below this elevation. The amount of water remaining above the top of the fuel assemblies is approximately 16 feet, and this will result in a pool surface radiation level of less than 2.5 mr/hr.

The cask loading pool and the spent fuel pool are separate pools. A loss of spent fuel pool water from a cask drop accident is prevented by an isolation gate, protected from the cask by concrete walls, which is installed between the spent fuel pool and the transfer canal during cask handling operations. See Figure 1.2-17 for the limits of travel of the cask. The crane cannot

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be passed over the spent fuel storage area; hence the fuel shipping cask cannot be transported over this area. Hence, dropping of a heavy cask will not breach the integrity of the spent fuel storage area nor damage stored fuel. The cask travels over the cask handling dry storage area as it travels from the receiving area to the cask loading pool. The spent fuel cask cannot travel over any safety-related equipment.

Protection against the effects of tornado and wind loadings is discussed in Section 3.3. Protection against the dynamic effects associated with postulated pipe ruptures is discussed in Section 3.6. Radiation monitoring is discussed in Section 12.3.

9.1.3 Spent Fuel Pool Cooling and Cleanup System

9.1.3.1 Design Bases

The functions of the spent fuel pool cooling and cleanup system are to:

a. Continuously remove decay heat generated by fuel elements stored in the pool,

b. Continuously maintain a minimum of 10 feet of water over the spent fuel elements to shield personnel, and 44

c. Continuously maintain the chemical parameters and optical clarity of the spent fuel pool water, and the water in the reactor cavity and refueling canal during refueling operations. 44

Each of the two units has an independent spent fuel pool cooling and purification system, and no interconnections exist between the two units.

All portions of the spent fuel pool cooling loop are designated Safety Class 3, and are designed and constructed to meet seismic Category I requirements. Those portions of the cleanup system not designed to these requirements are normally isolated from the cooling loop.

A leak detection system is provided (refer to Subsection 9.1.2).

All safety-related portions of the spent fuel pool cooling system are housed in structures capable of withstanding seismic and flood conditions, as well as tornado generated missiles. Refer to Section 3.5 for a discussion of internally-generated missiles and jet impingement. Protection against dynamic effects associated with postulated pipe ruptures is discussed in Section 3.6.

A seismic Category I normal makeup and a backup supply capable of being connected to an alternate seismic Category I source are provided.

The spent fuel pool cooling system is designed to assure adequate cooling to stored fuel, assuming a single failure of an active component coincident with a loss of offsite power.

The spent fuel pool cooling and cleanup system design temperature is 200°F, with a design pressure of 150 psig.

The system design has been evaluated using the NRC Branch Technical Position ASB 9-2. The basic assumptions used in this analysis are as follows:

1) The reactor core heat output is 3411 MWT.

2) Full power operation is assumed for the entire year between annual refueling.

3) The fuel is unloaded annually with approximately one-third of a core transferred to the spent fuel pool for 16 refueling cycles as depicted in Subsection 9.1.2.1b. The spent fuel pool inventory considers a full core to be placed in the spent fuel pool 36 days after the 16th refueling.

4) The irradiation time for the first cycle refueling batch is 365 days; for the second cycle 730 days, and for the equilibrium cycles 1095 days. An average fuel assembly power of 17.67 MWT is used for all irradiation times. For the full core unload, 36 days after the 16th refueling, one-third of the core was irradiated for 36 days, one-third has been irradiated 401 days, and one-third has been irradiated for 766 days.

5) The time sequence used for full core unload is 150 hours to prepare for refueling the reactor and the full core unload.

The analysis using the above assumptions, and the computer code DEHEX(1) yields the following maximum decay heat loads in the spent fuel pool.

Refueling Cycle	Spent Fuel Pool - Maximum Decay Heat-BTU/HR At End of Refueling
1	11.51×10^6
2	12.92×10^6
3	13.78×10^6
4	14.33×10^6
5	14.75×10^6
6	15.11×10^6
7	15.45×10^6
8	15.78×10^6
9	16.09×10^6
10	16.40×10^6
11	16.69×10^6
12	16.98×10^6
13	17.27×10^6

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14	17.54×10^6
15	17.81×10^6
16	18.08×10^6
Full Core 36 days after 16th refueling	42.6×10^6

Presently, the system thermal design provides for the removal of 18.1×10^6 BTU/HR of decay heat while maintaining a pool water temperature of 122°F if 16 refuelings of 1/3 core each are to be accommodated. In addition, the present design allows the removal of 42.6×10^6 BTU/HR of decay heat and a pool water temperature of 141°F if the heat load is produced from 16 refuelings and an entire irradiated core. The values of 122°F and 141°F are valid only if all of the spent fuel heat exchangers and pumps are operating during the heat removal process (refer to Table 9.1-3).

The computer code BUTRES(2) is used to calculate the transient temperature response in the spent fuel pool. See Table 9.1-3 for additional system thermal design conditions.

The final storage capacity of the spent fuel rack will be 1236 fuel elements. This accepts the 1223 spent fuel elements from the 16 refuelings plus a full core reload. The remaining 13 cells could be used for storage of fuel elements that may be removed from the reactor between cycles because of cladding defects, etc. As the heat load to the spent fuel pool is based upon the normal cycles and irradiation, the impact of partial spent fuel cells in the 13 additional cells is inherent in the total heat load calculation.

System component design data, together with the safety and code class requirements, are presented in Table 9.1-1.

9.1.3.2 System Description

The flow diagrams for this system are shown in Figures 9.1-1 and 9.1-2.

Each spent fuel pool cooling and cleanup system is comprised of three subsystems:

Spent fuel pool cooling subsystem

Spent fuel pool cleanup subsystem

Reactor cavity and canal cleanup subsystem

The overall system is comprised of the following major components:

Two spent fuel pool cooling pumps

Two spent fuel pool cooling heat exchangers

One inlet strainer

One pre-filter

One demineralizer

One post filter

One skimmer pump

Five spent fuel pool skimmer intakes

One reactor cavity cleanup pump

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a. **Spent Fuel Pool Cooling Subsystem**

The spent fuel cooling pumps take suction from the pool and circulate water through the heat exchangers which are cooled by the primary component cooling water system. Pool water enters the suction line through a strainer near one wall of the pool at a point thirteen feet higher than the return line terminations. The return lines are located at a sufficient distance from the suction line to assure adequate circulation and uniform pool water temperatures.

All system connections to the fuel pool penetrate at elevations sufficiently above the top of the fuel (10 ft.) to maintain adequate shielding in the event the water level drains to the penetration level. Piping arrangement precludes syphoning below this level.

All components in contact with the spent fuel cooling water are stainless steel.

The spent fuel pool pump motors are Class 1E motors and are supplied from separate emergency busses.

b. **Spent Fuel Pool Cleanup Subsystem**

Spent fuel pool water quality is maintained by a pool skimmer loop which filters and demineralizes the circulated water. The pool skimmer loop consists of five pool surface skimmers, a skimmer pump, two filters and a demineralizer. This system is utilized to maintain the pool surface free from floating particles and other materials and to remove radioactive materials in the water. The system is sized to process approximately 120 gpm, which means that 1/2 of the pool volume is processed in a day. All spent fuel pool cooling and cleanup system equipment is located in the fuel storage building, except the filters and demineralizer which are located in the demineralizer area of the primary auxiliary building.

The skimmer pump motor is not Class 1E, and is supplied from a local control center.

c. **Reactor Cavity and Canal Cleanup System**

The reactor cavity cleanup portion of the system is designed to purify the reactor cavity during refueling operations to improve the optical clarity of the water. A composite drawing showing this function is shown in Figure 9.1-2. The system consists of five surface skimmers at the water surface of the refueling cavity and refueling canal, all piped to the suction of the reactor cavity cleanup system. The cavity water is pumped through the chemical and volume control system mixed bed demineralizer and filters to the suction of the residual heat removal pumps where it is returned to a cold leg through a residual heat removal heat exchanger. Suction can also be taken from any of the cavity drains and final cavity cleanup effected by pumping the cavity water through a portable cleanup filter.

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The reactor cavity cleanup pump motor is not Class 1E, and is supplied from a motor control center in the control building.

9.1.3.3 Safety Evaluation

Normally, more than 25 feet of water is maintained over the spent fuel. During fuel handling operations, the operator is protected from direct shine emanating from the spent fuel by at least 10 feet of water. The purification provided by the cleanup system, in addition to the water levels maintained above the spent fuel, result in a pool surface radiation level of less than 2.5 mr/hr, which allows unlimited operator access to the surface of the pool and cooling system components. However, the filters and the demineralizer in the cleanup system and expected to collect particulate and ionic radioactive materials, and thus have restrictive access. These components are located in the primary auxiliary building behind shield walls. A radiological evaluation of the purification loop is presented in Chapters 11 and 12. 44

Each spent fuel pool pump is capable of circulating pool water through either spent fuel pool heat exchanger. If one spent fuel pool pump becomes inoperable for any reason, the remaining pump supplying half flow to each heat exchanger can maintain pool water temperatures at 135°F, with sixteen spent core regions stored in the pool.

If only one spent fuel pool pump and heat exchanger are operable, the pool water temperature can be maintained below 157°F with 16 spent core regions in the pool (refer to Table 9.1-3). 48

The thermal capacity of the spent fuel pool cooling system equals the physical storage capacity of the spent fuel pool. Thus, actual water temperatures will be no greater than those indicated in Table 9.1-3.

The spent fuel pool cooling and cleanup system is designed so that the pool level will not be inadvertently drained below a point approximately 10 feet above the top of the spent fuel assemblies. The spent fuel pool suction line penetration and the return line terminations are located at elevations such that the failure of piping external to these penetrations will not result in lowering the pool water level below this elevation.

Each spent fuel pool heat exchanger is supplied cooling water from a separate primary component cooling water loop (see Section 9.2.2). In the unlikely event that all forced circulation cooling flow to the pool is lost, the large volume of pool water (approximately 280,000 gallons) provides a heat sink which allows time for maintenance. The minimum time for the pool water to reach the saturation temperature is 2-3/4 hours for the 16 spent core region storage condition. 48

Spent fuel pool makeup water can be obtained from either the refueling water storage tank, or the condensate storage tank, if necessary. The refueling water storage tank and its piping to the pool is seismic Category I. A hose connection is provided in the emergency feedwater pump suction piping from the seismic Category I condensate storage tank. The connection is

TABLE 9.1-1
(Sheet 1 of 2)

SPENT FUEL COOLING AND CLEANUP SYSTEM DESIGN DATA

SYSTEM DESIGN DATA

System Cooling Capacity, Btu/hr	
a. Normal (16 spent core regions at maximum pool water temperature of 122°F)	18.1×10^6
b. Maximum (16 spent core regions plus full core at maximum pool water temperature of 141°F)	42.6×10^6
System Design Pressure, psig	150
System Design Temperature, °F	200
Nominal Boron Concentration, ppm	2,000

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SAFETY CLASS
COMPONENT DESIGN DATA

Components	Design Data	ANSI N18.2 Safety Class	Code
Spent Fuel Pool Cooling Pump		3	ASME III Class 3
Quantity/Unit	2		
Type	Horizontal, centrifugal		
Material	Stainless steel		
Flow (each), gpm	1100		
Head (each), ft.	43		
Design pressure, psig	150		
Design temperature, °F	225		
Motor horsepower	20		
Spent Fuel Pool Cooling Heat Exchanger (worst case which considers 16 refuelings and one full core unloading)		3	ASME III Class 3
Quantity/Unit	2		
Type	Counter flow		
Installation	Horizontal		
Design heat transfer rate, Btu/hr.	21.3×10^6		
Effective heat transfer area, ft^2	3037		

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TABLE 9.1-1
(Sheet 2 of 2)

Components	Design Data	ANSI N18.2 Safety Class	Code
Shell side - design			
Design pressure, psig	150		
Design temperature, °F	200		
Primary component cooling flow rate, gpm	3000		
Primary component cooling water temperature (in), °F	85		
Primary component cooling water temperature (out), °F	99		
Fouling factor, hr-ft^2 - F/Btu	0.0005		
Material	Carbon steel	3	ASME III Class 3
Tube side - design			
Design pressure, psig	150		
Design temperature, °F	200		
Spent fuel pool water flow rate, gpm	1100		
Spent fuel pool water temperature (in), °F	141		
Spent fuel pool water temperature (out), °F	103		
Fouling factor, hr-ft^2 - F/Btu	0.0005		
Material	Austenitic stainless steel		
Piping and Valves Associated With Fuel Pool Cooling			
Material	Stainless steel	3	ASME III Class 3
Design pressure, psig	150		
Design temperature, °F	200		

TABLE 9.1-2

SPENT FUEL POOL COOLING AND CLEANUP SYSTEM

MALFUNCTION ANALYSIS

Component	Malfunction	Comments and Consequences
1. Spent Fuel Pool Cooling Pump	Rupture of a pump casing	Pumps can be isolated. With only one of the two pumps operating, adequate heat removal can be obtained.
2. Spent Fuel Pool Cooling Heat Exchanger	Tube or shell rupture	Rupture is considered unlikely. Heat exchanger can be isolated for maintenance. The second heat exchanger can provide adequate heat removal under all design conditions. 48
3. Spent Fuel Pool Skimmer	Component failure	Spent fuel continues to be cooled by fuel pool cooling pumps and heat exchangers. Optical clarity of pool water may be decreased. Adequate time is available for restoration before unacceptable clarity is reached. Part of cooling flow can be diverted to cleanup loop. 48
4. Spent Fuel Pool Purification Loop	Component failure	Loop is isolated from fuel pool cooling loop. Spent fuel continues to be cooled by the fuel pool cooling pumps and heat exchanger. Purity of pool water may be decreased until loop is restored. 48 Adequate time is available for restoration before unacceptable impurity level is reached. A bypass loop is also provided to divert flow to the demineralizer if required.
5. Spent Fuel Pool Cooling Loop	Pipe rupture	Fuel pool cannot be drained below a level that provides adequate shielding. Sufficient time is available for restoration of cooling. Assured pool makeup water is provided by reactor makeup water system or refueling water storage tank. 48

TABLE 9.1-3

SPENT FUEL POOL COOLING AND CLEANUP SYSTEM

DESIGN CONDITIONS

NORMAL OPERATING CONDITIONS

Each Operating SFPHX	Sixteen 1/3 cores stored; both SFPHX's and pumps operating	Full Core Plus sixteen 1/3 cores stored; both SFPHX's and pumps operating
Heat Load, 10^6 Btu/hr	9	21.3
SF Pump Flow, gpm	1100	1100
PCCW Flow, gpm	810	3000(1)
Pool Temperature, °F (max.)	122	141

ABNORMAL OPERATING CONDITIONS

Each Operating SFPHX	(1) Normal Power sixteen 1/3 cores stored; both SFPHX's and one pump operating	Normal Power sixteen 1/3 cores stored; one SFPHX and one pump operating
Heat Load, 10^6 Btu/hr	9	18.1
SF Pump Flow, gpm	550	1100
PCCW Flow, gpm	810	810(1)
Pool Temperature, °F (max.)	135	157

Note:

(1) Increased PCCW is available under this condition.

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