Exelon Generation

200 Exelon Way
Kennett Square, PA 19348
www.exeloncorp.com

10 CFR 50.90

June 14, 2021

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Calvert Cliffs Nuclear Power Plant, Units 1 and 2
Renewed Facility Operating License Nos. DPR-53 and DPR-69
Docket Nos. 50-317 and 50-318

Subject: Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request

Reference: 1. Calvert Cliffs Nuclear Power Plant Spent Fuel Pool Cooling - Shutdown Cooling Licensing Design Basis License Amendment Request Pre-submittal Meeting, dated May 24, 2021 (ML21144A017)

In accordance with 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," Exelon Generation Company, LLC (Exelon) requests changes to the Licensing Design Basis for the Spent Fuel Pool Cooling (SFPC) System of the Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (CCNPP).

The proposed changes would revise the Updated Final Safety Analysis Report (UFSAR) Section 9.4, "Spent Fuel Pool Cooling System," design basis to allow for a full core offload without being supplemented with one train of the Shutdown Cooling (SDC) system. In addition, a new section to the Technical Requirements Manual (TRM) 15.9.5, "Full Core Offload," has been developed to provide for additional limits on operation based on number of fuel assemblies offloaded, time after shutdown, spent fuel pool cooling (SFPC) system service water temperature, number of operable trains of the SFPC System, and SDC system availability. These proposed changes were initially discussed in a pre-submittal meeting conducted on May 24, 2021 (Reference 1).

There are no regulatory commitments contained within this letter.

Attachment 1 provides a description and evaluation of the proposed change. Attachment 2 provides a markup of the affected Technical Requirements Manual (TRM) pages. Attachment 3 provides a Spent Fuel Pool Cooling System Simplified Diagram. Attachment 4 provides a markup of the affected Updated Final Safety Analysis Report (UFSAR) pages.

The proposed changes have been reviewed by the CCNPP Plant Operations Review Committee in accordance with the requirements of the Exelon Quality Assurance Program.

Exelon requests approval of the proposed license amendment by December 17, 2021. Once approved, the amendment shall be implemented prior to the start of the Unit 1 2022 Refueling Outage, for which this license amendment request is needed to support.

In accordance with 10 CFR 50.91, “Notice for public comment; State consultation,” paragraph (b), Exelon is notifying the State of Maryland of this application for license amendment by transmitting a copy of this letter and its attachments to the designated State Official.

Should you have any questions concerning this submittal, please contact Frank Mascitelli at (610) 765-5512.

I declare under penalty of perjury that the foregoing is true and correct. This statement was executed on the 14th day of June 2021.

Respectfully,

D. P. Helker

David P. Helker
Sr. Manager - Licensing and Regulatory Affairs
Exelon Generation Company, LLC

Attachments:
1. Evaluation of Proposed Change
2. Markup of Proposed Technical Requirements Manual Pages
3. Spent Fuel Pool Cooling System Simplified Diagram
4. Markup of the Proposed UFSAR Pages

cc: Regional Administrator, Region I, USNRC
USNRC Senior Resident Inspector, CCNPP
Project Manager [CCNPP] USNRC
S. Seaman, State of Maryland

ATTACHMENT 1

Evaluation of Proposed Change

Calvert Cliffs Nuclear Power Station, Units 1 and 2

Renewed Facility Operating License Nos. DPR-53 and DPR-69

Docket Nos. 50-317 and 50-318

Subject: **Spent Fuel Pool Cooling - Shutdown Cooling Systems Licensing Design Basis License Amendment Request**

1.0 SUMMARY DESCRIPTION

Exelon Generation Company, LLC (Exelon), proposes changes to the Spent Fuel Pool Cooling Licensing Design Basis of the Renewed Facility Operating License Nos. DPR-53 and DPR-69 for Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (CCNPP), respectively.

The proposed changes would revise the Updated Final Safety Analysis Report (UFSAR) Section 9.4, "Spent Fuel Pool Cooling System," design basis to allow for a full core offload without being supplemented with one train of the Shutdown Cooling (SDC) system. In addition, a new section to the Technical Requirements Manual (TRM) 15.9.5, "Full Core Offload," has been developed to provide for additional limits on operation based on number of fuel assemblies offloaded, time after shutdown, spent fuel pool cooling (SFPC) system service water temperature, number of operable trains of the SFPC System, and SDC system availability. These proposed changes were initially discussed in an NRC pre-submittal meeting conducted on May 24, 2021.

During the next 2022 Unit 1 Refueling Outage (CC1R26) which is planned to start early February 2022, a full core off load is scheduled to begin on or about Day 6 of the outage. One train of SDC is to be operable and in operation per TS 3.9.4, "Shutdown Cooling (SDC) and Coolant Circulation-High Water Level." The second SDC train will be out of service for scheduled outage work (ASME code required work). This course of action, without the additional heat removal capabilities of the supplemental train of SDC, may cause the spent fuel temperature to rise above the current licensing design bases limit of 130 °F. This License Amendment Request (LAR) will provide the justification for the licensing design bases temperature limit of the Spent Fuel Pool to change from 130 °F to 150 °F for a full core offload.

2.0 DETAILED DESCRIPTION

2.1 System Description

The primary purpose of the Spent Fuel Pool Cooling (SFPC) and Purification System is to remove decay heat from the spent fuel stored in the spent fuel pool. The SFPC system is classified as a non-safety related system. The SFPC system assists in the safety related function of the Spent Fuel Pool to keep the irradiated spent fuel adequately covered with water and to prevent the SFP from boiling.

The secondary purposes include:

- Provide cooling for refueling pools.
- Maintain clarity & activity levels in the spent fuel pool, refueling pools, & refueling water tanks.

- Transferring water to and from refueling water tanks as needed.

A simplified diagram of the SFPC System is shown in Attachment 3. The SFPC System is a closed-loop system consisting of two half-capacity pumps and two half-capacity heat exchangers in parallel, a bypass filter that removes insoluble particulates, and a bypass demineralizer that removes soluble ions. The SFPC heat exchangers are cooled by Service Water (SRW). The SRW heat exchangers are cooled by the Salt Water cooling system, with supply and return to the Chesapeake Bay.

Skimmers are provided in the SFP to remove accumulated dust from the pool. The clarity and purity of the water in the SFP, refueling pool, and the RWT are further maintained by passing a portion of the flow through the bypass filter and/or demineralizer. The SFP filter and demineralizer removes fission products from the cooling water in the event of a leaking fuel assembly.

Connections are provided for tie-in to the SDC system to provide for additional heat removal in the event that 1830 fuel assemblies are contained in the pool. When the pressure in the SDC system is greater than the design pressure of the SFPC system, the SFPC system is isolated from the SDC system via two manual isolation valves. Although not required by the design code, double valve isolation is provided at this system interface to meet the original FSAR design basis.

The entire SFPC system is tornado-protected and is located in a Seismic Category I structure. Borated makeup water comes from the Refuel Water Tank (RWT). Non-borated makeup water comes from the demineralized water system.

2.2 Detailed Licensing Bases Changes

<u>TRM Proposed Changes</u>

A new TRM Section 15.9.5 has been developed (see Attachment 2). Full core offloads will be conducted based on number of fuel assemblies offloaded, time after shutdown, SFPC System service water temperature, number of operable trains of the SFPC System, and SDC System availability. If limits are not met, movement of irradiated fuel assemblies will be immediately suspended, and actions will be immediately initiated to restore the plant to within limits.

<u>Updated Final Safety Analysis (UFSAR) Changes</u>

The following paragraphs in UFSAR Section 9.4, “Spent Fuel Pool Cooling System,” Section 9.4.1, “Design Basis,” are being changed (see Attachment 4):

From:
“The SFPC system is designed to remove the maximum decay heat expected from

1613 fuel assemblies, not including a full core off-load. The maximum pool temperature in this case is 120 °F. The system is also capable of being used in conjunction with the SDC system to remove the maximum expected decay heat load from 1830 fuel assemblies."

To:

"The SFPC system is designed to remove the maximum decay heat expected from 1613 fuel assemblies, not including a full core off-load. The maximum pool temperature in this case is 150 °F. The system is also capable of being used to remove the maximum expected decay heat load from 1830 fuel assemblies, including a full core discharge. The maximum SFP temperature in this case is 150 °F."

From:
"The maximum decay heat load expected from 1613 fuel assemblies, not including a full core off-load, is a function of decay time. For a limiting decay time of 3.5 days, which results in an initial core alteration time of 3.0 days after reactor shutdown, the decay heat load is 22.33×10^6 Btu/hr. The fuel is assumed to have undergone steady-state burnup at 2738 MWt for an average of 1562.4 days for an 100 assembly batch reload. The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from the two SFP heat exchangers as a function of SRW temperature to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature of 120 °F. A maximum SRW temperature of 65 °F is required to support a minimum decay time of 3.5 days. In the event that one SFP cooling loop is lost, the remaining loop can remove the heat load while maintaining the pool temperature at 155 °F."

And

To:
"The maximum decay heat load expected from 1613 fuel assemblies, not including a full core off-load, is a function of decay time. For a limiting decay time of 7 days, which results in an initial core alteration time of 6 days after reactor shutdown, the decay heat load is 34.4×10^6 Btu/hr. The 145 fuel assemblies are assumed to have undergone steady-state burnup at 2738 MWt for an average of 1498 days for a 101-assembly batch reload (note that 24 fuel assemblies of the oldest fuel assemblies in the SFP are assumed to be re-inserted into the core for the next cycle). The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from the two SFP heat exchangers as a function of SRW temperature to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature of 150 °F. A maximum SRW temperature of 50 °F is required to support a minimum decay time of 6 days. In the event that one SFP cooling loop is lost, the remaining loop can remove the heat load while maintaining the pool temperature at 150 °F."

And

From:
The maximum decay heat rate for 1830 fuel assemblies stored in the SFP is a function of decay time. For a limiting decay time of 4.5 days, which results in an initial core alteration time of 3.0 days after reactor shutdown, the decay heat load is 45.96×10^6 Btu/hr based upon the following hypothetical sequence of events:

1. Eighty-four fuel assemblies are removed from Unit 1 after an average of 1860 days of reactor operation at 2738 MWt, and are replaced with fresh fuel. Unit 1 is then returned to full power.
2. Three-hundred-sixty-five days after the Unit 1 refueling, 84 fuel assemblies are removed from Unit 2 after an average of 1860 days of irradiation and are replaced with fresh fuel. Unit 2 is then returned to full power.
3. Three-hundred-sixty-five days after the Unit 2 refueling, 84 fuel assemblies are removed from Unit 1 after an average of 1860 days of irradiation and are replaced with fresh fuel. Unit 1 is then returned to full power.
4. This refueling cycle continues until the pool contains 1613 fuel assemblies at the end of a Unit 2 refueling. It has been conservatively assumed that the 67 oldest assemblies have been removed from the pool to allow for complete filling of the racks with newer fuel.
5. Unit 1 is then shutdown 60 days after the previous Unit 2 shutdown and the entire core is offloaded after a minimum of 4.5 days of decay. At this point, it is conservatively assumed that the fuel has completed its current cycle, and is therefore at maximum irradiation.

Upon completion of the last operation, the pool will contain 1830 fuel assemblies, with each discharge subjected to different periods of irradiation and decay, in accordance with the table below assuming the minimum decay time of 4.5 days:

Number of Assemblies	Irradiation Period (Days)	Decay Period (Days)
17	1860	6964.5
84	1860	6599.5
84	1860	6234.5
84	1860	5869.5
84	1860	5504.5
84	1860	5139.5
84	1860	4774.5
84	1860	4409.5
84	1860	4044.5
84	1860	3679.5
84	1860	3314.5
84	1860	2949.5
84	1860	2584.5
84	1860	2219.5

84	1860	1854.5
84	1860	1489.5
84	1860	1124.5
84	1860	759.5
84	1860	394.5
84	1860	64.5
217	1860	4.5

The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from both loops of SFPC as a function of SRW temperature, supplemented with one loop of SDC to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature at 130 °F. A maximum SRW temperature of 75 °F is required to support a minimum decay time of 4.5 days.

To:

"The maximum decay heat rate for 1830 fuel assemblies stored in the SFP is a function of decay time. For a limiting decay time of 4.5 days, which results in an initial core alternation time of 3 days after reactor shutdown, the decay heat load is 53.1 x10^6 Btu/hr based upon the simplification of the following hypothetical sequence of events:

1. *125 fuel assemblies are removed from Unit 1 after an average of 1498 days of reactor operation at 2738 MWt and are replaced with 101 fresh fuel assemblies and 24 oldest spent fuel assemblies from the SFP. Unit 1 is then returned to full power.*
2. *365 days after the Unit 1 refueling, 125 fuel assemblies are removed from Unit 2 after an average of 1498 days of irradiation and are replaced with 101 fresh fuel assemblies and 24 oldest spent fuel assemblies from the SFP. Unit 2 is then returned to full power.*
3. *365 days after the Unit 2 refueling, 125 fuel assemblies are removed from Unit 1 after an average of 1498 days of irradiation and are replaced with 101 fresh fuel assemblies and 24 oldest spent fuel assemblies from the SFP. Unit 1 is then returned to full power.*
4. *This refueling cycle continues until the pool contains 1613 fuel assemblies at the end of a Unit 2 refueling. It has been conservatively assumed that the 12 oldest fuel assemblies have been removed from the pool to allow for complete filling of the racks with newer fuel.*
5. *Unit 1 is then shutdown 60 days after the previous Unit 2 shutdown and the entire core is offloaded after a minimum of 4.5 days. At this point, it is conservatively assumed that the fuel has completed its current cycle and is therefore at maximum irradiation.*

Upon completion of the last operation, the pool will contain 1830 fuel assemblies, with each discharge subjected to different periods of irradiation and decay, in accordance with the table below assuming the minimum decay time of 4.5 days:

	Number of Assemblies	*Irradiation Period (Days)*	*Decay Period (Days)*
a.	*113*	*1498*	*4409.5*
b.	*125*	*1498*	*4044.5*
c.	*125*	*1498*	*3679.5*
d.	*125*	*1498*	*3314.5*
e.	*125*	*1498*	*2949.5*
f.	*125*	*1498*	*2584.5*
g.	*125*	*1498*	*2219.5*
h.	*125*	*1498*	*1854.5*
i.	*125*	*1498*	*1489.5*
j.	*125*	*1498*	*1124.5*
k.	*125*	*1498*	*759.5*
l.	*125*	*1498*	*394.5*
m.	*125*	*1498*	*64.5*
n.	*217*	*1498*	*4.5*

The simplified approach, which is also more conservative, assumes the age of 1488 stored fuel assemblies in the SFP are 2 years and the last 125 stored fuel assemblies have 330 days of age.

The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from both loops of SFPC as a function of SRW temperature, to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature at 150 °F. A maximum SRW temperature of 50 °F is required to support a minimum decay time of 4.5 days."

The following paragraph in UFSAR Section 9.4, "Spent Fuel Pool Cooling System," Section 9.4.4, "System Operation and Reliability," is being changed (see Attachment 4):

From:
"In the normal case (i.e., with no full-core off load), if one SFPC loop is lost, the remaining loop can remove decay heat while maintaining the pool temperature at 155 °F. In the case of total loss of SFPC with 1613 fuel assemblies in the pool, it would take more than 8 hours to raise the pool temperature from 155 °F to 210 °F.

To:
"In the normal case (i.e., with no full core off load), if one SFPC loop is lost, the remaining loop can remove the decay heat while maintaining the pool temperature at 150 °F. In the case of total loss of SFPC with 1613 fuel assemblies in the pool, it would take slightly more than 8 hours to raise the pool temperature from loss of both cooling loops at time of full core offload to 210 °F."

3.0 TECHNICAL EVALUATION

3.1 Reason for Evaluation:

This activity is for the upcoming 2022 Refueling Outage (RFO) and future outages. For the 2022 Refueling Outage (CC1R26), Unit 1 full core offload, this activity develops a new methodology to obtain margin in heat removal capability by raising the maximum allowable SFP water temperature from 130 °F to 150 °F. The current UFSAR (Reference 1) assumes the SFP cooling system is supplemented with one Shutdown Cooling Heat Exchanger (SDCHX) from the offload unit. However, during a refueling outage, one loop of SDC will be required to be operable per TS 3.9.4, "Shutdown Cooling (SDC) and Coolant Circulation-High Water Level". The second SDC loop will be out of service for scheduled outage work (ASME code required work). Thus, no SDC loop will be available as a supplemental to cool the SFP. The methodology developed by this activity instead will credit the time it takes for the bulk SFP water to heat up to 150 °F.

In this activity, for normal operations (incore shuffle), the maximum allowable will be 145 discharged fuel assemblies into the spent fuel pool. During normal operations the two Spent Fuel Pool Heat Exchangers (SFPHXs) would cool down the SFP. The total decay heat of the spent fuel assemblies in the SFP is expected to increase due to the larger number of discharged fuel assemblies. However, by crediting higher SFP water temperature and/or lower SRW water temperature, the SFP cooling capacity will be increased.

The proposed changes would revise the Updated Final Safety Analysis Report (UFSAR) Section 9.4, "Spent Fuel Pool Cooling System," design basis (Reference 1) to allow for a full core offload without being supplemented with one loop of the SDC system. In addition, the Technical Requirements Manual (TRM) 15.9, "Refueling Operations," will be revised with a new section, 15.9.5, "Full Core Offload," to provide for additional limits on operation based on number of fuel assemblies offloaded, time after shutdown, spent fuel pool cooling system service water temperature (SRW), number of SFPC trains in operation and no availability of SDC to assist with SFP cooling.

The results of SAS2H/ORIGEN-S sequence of the SCALE 4.4 code system has been utilized to calculate decay heat loads. Manual computations are performed in Excel Spreadsheet to calculate decay heat loads for various scenarios. Heat balance calculations are also performed between the SFP decay heat loads as a function of decay time and the heat removal capacities for both normal and abnormal operations.

There is an ongoing action for further SFP thermal analysis by modeling and calculation of different scenarios including single loop failure. This additional analysis may result in further changes to TRM 15.9.5 and will use the same methodology as described in this license amendment request.

3.2 Detailed Evaluation of Problem/Changes:

Despite the existing potential to exceed the heat removal capability of the SFP cooling system, CCNPP existing licensing basis does not give credit to the time it takes the SFP water content to heat up to gain additional margin in the decay heat removal of the SFP. Giving credit to the time of heat up of SFP water requires a change to the methodology applied in the UFSAR. The methodology change in this activity requires a License Amendment Request (LAR).

Note that for non-refueling outage winter conditions, if a forced maintenance outage arose where a full core offload was required, it is expected that two trains of SDC system would be available and that one train would be used to assist the SFPC system in keeping the SFP bulk temperature below the 150 °F limit.

3.3 Spent Fuel Pool Cooling System:

The SFPC system (Figure 1) is a closed-loop system consisting of two half capacity pumps and two half capacity heat exchangers in parallel, a bypass filter that removes insoluble particles, and a bypass demineralizer that removes soluble ions. The SFPC heat exchangers are cooled by Service Water (SRW). Connections are provided for tie-in to the SDC system to provide for additional heat removal in some events. When the pressure in the SDC system is greater than the design pressure of the SFPC system, the SFPC system is isolated from the SDC system via two manual isolation valves.

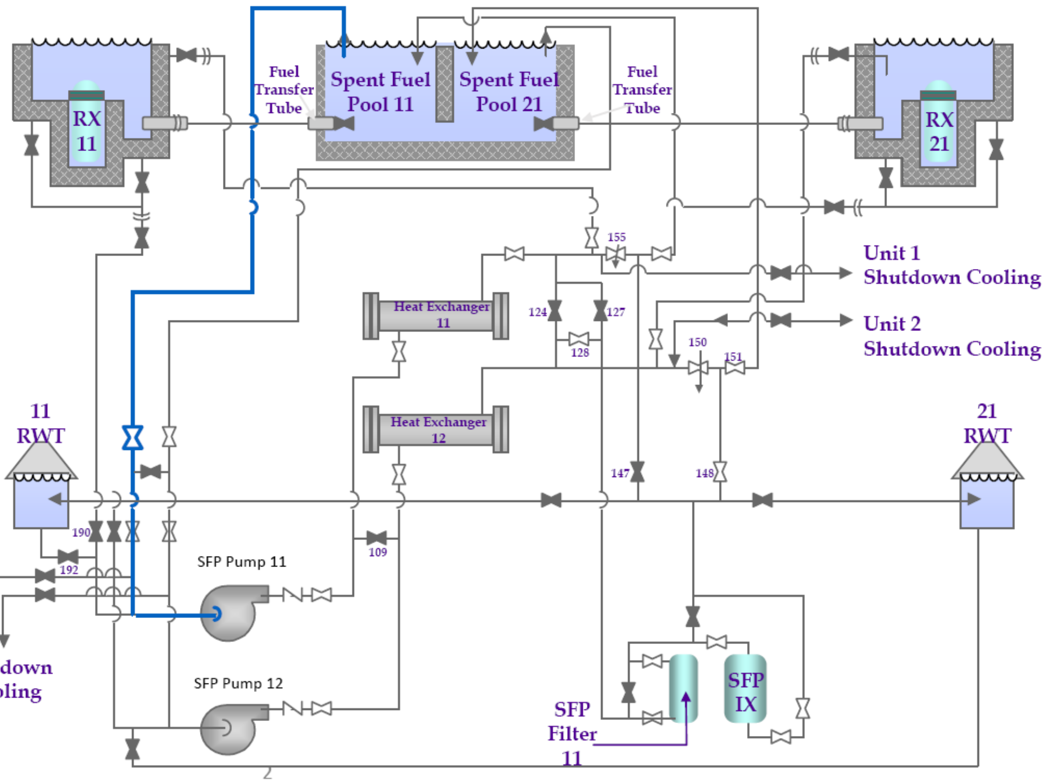


Figure - 1 Spent Fuel Pool Cooling System

3.4 Spent Fuel Pool Heat-up Analysis (Reference 2):

The purpose of this analysis is to determine the amount of delay time, after shutdown, required before starting the fuel discharge to the SFP. To determine the required time delay, a time dependent heat transfer model using Microsoft Excel has been generated to illustrate the maximum spent fuel temperature for given inputs. This evaluation focuses on the development of the SFP temperature model and the results associated with typical conditions during February, as this is when the Spring 2022 RFO will begin.

Design Inputs

The analysis is based on the following inputs:

- The maximum temperature of the Spent Fuel Pool is 150 °F.
- The full core decay heat as a function of time since shutdown is taken from Table D8-11 of Reference 3.
- The cooling capacities (heat removal capacity) are taken from Reference 4.
- The maximum capacity of the spent fuel pool storage tray is 1830 assemblies (Reference 3).
- There are 217 fuel assemblies in a full core load per Reference 3.

- The spent fuel pool temperature for February is taken to be 92 °F, the maximum temperature logged for February of 2021 from plant data.
- The rate of fuel movement to the SFP is taken to be six fuel assemblies per hour.

Assumptions

- The water level in the Spent Fuel pool is assumed to be constant, such that the volume is constant at 79,000 cf. This is conservative as the model takes no credit for the addition of cool water to maintain level lost to evaporation or for the cooling associated with evaporation.
- The fuel assemblies stored in the spent fuel pool are all assumed to be the bounding case Westinghouse VAP fuel from Reference 3.
- The SFP contains 1830 fuel assemblies with each fuel assembly subjected to different periods of irradiation and decay as shown in Table E7-9 of Reference 3. However, the heat load associated with the stored fuel in the SFP is assumed to be constant, not decaying. This is conservative as there will still be a slight decay over time, however it is nearly constant over the time frame of the recent spent fuel discharge.
- Assume no thermal cross communication between the reactor cavity and the spent fuel pool.
- For simplicity, the bounding average age of the fuel assemblies in the pool is assumed as follows: For Cases 1 and 2, 125 fuel assemblies are assumed to be 60 days old and the remaining stored fuel assemblies are assumed to be two years old. Case 3 and 7 assume 125 fuel assemblies are 330 days old, and the remaining 1488 stored fuel assemblies in the SFP are 2 years old. For Cases 4, 5, and 6 it is assumed that all stored fuel in the SFP is two years old. Using this assumption, the decay heat for the stored fuel is summarized as follows:

Table-1 Decay Heat Stored Fuel

Age of Stored Fuel Assemblies	Decay Heat of Stored Fuel, Q_{stored} (btu/hr)
125 @ 60 Days 1488 @ 2 years	2.02×10^7
125 @ 330 Days 1488 @ 2 Years	1.60×10^7
1613 @ 2 years	1.49×10^7

- The Service Water (SRW) is assumed to be 5 °F warmer than the bay temperature of 42 °F. This is based on historical data from the plant and a design temperature difference of 5 °F on the Service Water heat exchangers. Therefore, in this analysis at February conditions, the SRW temperature is taken to be 47 °F.
- According to Reference 5 the Chesapeake Bay high water temperature is 90°F.

Methodology:

The calculation of pool temperature rise starts with the following equation:

$$Q = mc_p\Delta T \qquad \text{Equation 1}$$

Where m is the mass (lbm) of the water in the pool, cp is the specific heat (1 btu/lbm-°F), ΔT is the temperature rise (°F), and Q is the net energy input in the spent fuel pool calculated as follows:

$$Q = Q_{Stored} + \left(\frac{N}{217}\right) Q_{Reactor} - Q_{Cooling} \qquad \text{Equation 2}$$

Q_{Stored} is the heat associated with the existing fuel stored in the SFP. The spent fuel pool has the capacity to hold 1830 fuel assemblies. The maximum amount of fuel assemblies stored in the SFP, allowing room for a full core off-load, is 1830 – 217 = 1613 fuel assemblies. The heat load associated with the stored fuel will be taken to be constant (not decaying). This is conservative, as the heat output will be reduced over time, however the decay rate is greatly reduced over time. N is the number of assemblies moved from the reactor into the spent fuel pool during unloading. $Q_{Reactor}$ is the heat load per full core of spent fuel (217 fuel assemblies). As the heat load output from the core is decaying, $Q_{Reactor}$ is dependent on the time elapsed since the shutdown. The decay heat table is given in Reference 3.

The fuel assemblies are moved into the spent fuel pool at a rate of six fuel assemblies per hour or one fuel assembly every 10 minutes. This is simplified in the analysis as the heat load associated with one fuel assembly is instantaneously applied at the beginning of the time step, and that complete heat load is applied over the entire time step. The heat associated with one additional fuel assembly is added every 10 minutes until the entire quantity of fuel assemblies have been moved to the SFP (either a partial load or full core off-load of 217 fuel assemblies).

For this analysis, the cooling capacity associated with 50 °F Service Water is used. This is conservative, as the cooling capacity would be improved at a lower SRW temperature. The net heat load calculated is multiplied by the time step to provide the heat (Btu) input, and Equation 1 is solved for temperature change in the spent fuel pool. Time since shutdown is adjusted in the model until the maximum SFP temperature is 150 °F. The result is an earliest possible time since shutdown to begin moving fuel into the SFP (at a rate of six assemblies per hour) such that the temperature in the SFP does not exceed 150 °F.

The spent fuel pool temperature would be at a steady equilibrium when the net heat load in the pool is zero, the point in which the cooling capacity is equal to the heat load in the pool. In this analysis, the spent fuel pool is taken to be a fixed volume of water, the heat load associated with the stored fuel is considered constant (not decaying). To find this equilibrium SFP temperature, the relevant cooling capacity equation is set equal to the stored fuel heat load and then the equation is solved for SFP temperature, T_{SFP}.

To provide a bounding operator reaction time, a case study is performed for a full core offload, where both cooling loops are lost at the time of fuel discharge completion (217 new spent fuel assemblies have been added to the spent fuel pool). This time to boil calculation is based on a given starting time of 5 days based on a review of past refueling practices. When all fuel assemblies have been added (6.5 days after shutdown) the spent fuel pool cooling is set to zero, and the water temperature will rise due to the total decay heat in the pool. The time to boil is provided as follows:

$$Time\ to\ Boil = tboil - tdischarge\ completion \qquad \text{Equation 3}$$

Where t_{boil} is the time at which the temperature reaches 212°F, and $t_{discharge\ completion}$ is the time in which the last fuel assembly was discharged to the spent fuel pool.

Cases Analyzed:

All of the following cases use a Service Water temperature of 50 °F, and an initial spent fuel pool temperature of 92 °F, as described in the inputs and assumptions.
Case 1: This is a bounding scenario in which a full core offload occurs while there is also a partial offload of 125 fuel assemblies in the pool that is 60 days old, and the rest of the stored fuel is assumed to be two years old. This was based on a bounding case presented in Reference 3, postulating that an inspection and partial discharge of fuel had occurred 60 days before this full core offload.
Case 2: This is the same as Case 1, but with a single cooling loop in operation.
Case 3: This case is a repeat of Case 1 with the removal of conservatism associated with the stored fuel assemblies in the SFP. Two cooling loops are in operation and the stored fuel in the SFP includes 125 assemblies at 330 days old and 1488 fuel assemblies at two years old.
Case 4: This case is provided to illustrate a full core offload, and all stored fuel assemblies in the spent fuel pool are assumed to be two years old.
Case 5: This case illustrates a partial discharge of 145 fuel assemblies into the SFP, and all stored fuel in the SFP is assumed to be two years old.
Case 6: This is the same as Case 5, but with single loop SFP cooling capacity used.
Case 7: This is the time to boil calculation and is set to a start time of five days after shutdown. The stored fuel in the pool is taken to be the same as Case 3, with 125 assemblies that are 330 days old, and the remaining stored fuel is taken to be two years old. The loss of both cooling loops occurs immediately after the last fuel assembly is discharged to the SFP (time of 6.5 days after shutdown).

The Heat-up Analysis Results:

These results are produced by inputting a maximum SFP temperature of 150 °F and solving for an initial time (time since shutdown) to begin fuel discharge to the SFP.

Case 1 illustrates a full core offload, and a conservatively high initial decay heat load due to the stored fuel in the SFP. For this bounding case, beginning the fuel discharge to the SFP at 4.36 days after shutdown, the SFP temperature does not exceed 150 °F. Based on these same conservative heat loads in the pool, a full core offload is not feasible with a single cooling loop, as shown by Case 2. Case 3 represents the most realistic scenario for the Spring 2022 RFO with a full core offload and two cooling loops in operations. Case 3 also considers a reasonable stored fuel decay heat estimate of 125 fuel assemblies that are 330 days old, with the rest conservatively assumed to be two years old. Case 3 illustrates that a full core offload with two cooling loops in service could begin as early as 2.98 days. To provide further guidance for Case 3, the SFP Temperature vs. Time Since Shutdown is plotted in Figure 2 with a fuel discharge starting time of 5 days. Case 4 illustrates a full core discharge, two cooling loops in service, and all stored fuel in the spent fuel pool is taken to two years old. The resulting required decay time is 2.74 days. Case 5 illustrates that the cooling system can easily maintain the SFP temperature below 150 °F for decay heat associated with a partial offload, even at very early start times. The start time in this scenario would not be limited by required decay time, but more likely by the time required to remove the head from the reactor vessel. Case 6 illustrates that with a cooling loop out of service, even a partial offload of 145 fuel assemblies is not feasible. The bulk temperature in the spent fuel pool would exceed 150 °F unless the decay time after shutdown is greater than 20 days.

Table-2 Fuel Discharge to SFP Starting Time Results

	Number of Cooling Loops	Number of New Fuel Assemblies Discharged into SFP	Age of Stored Fuel Assemblies	Time After Shutdown to Begin Fuel Discharge	Time After Shutdown for Fuel Discharge Completion	Time to Reach SFP Temp of 150°F (after discharge begins)
Case 1	2	217	125 @ 60 Days 1488 @ 2 Years	4.36 Days	5.86 Days	2.34 Days
Case 2	1	217	125 @ 60 Days 1488 @ 2 Years	Not Feasible (Greater than 100 Days)	N/A	N/A
Case 3	2	217	125 @ 330 Days 1488 @ 2 Years	2.98 Days	4.48 Days	2.20 Days
Case 4	2	217	2 Years	2.74 Days	4.24	2.21 Days
Case 5	2	145	2 Years	0.42 Days	1.42	1.65 Days
Case 6	1	145	2 Years	21.79 Days	22.79	4.14 Days

Table 3 Time to Boil After Loss of Cooling Results

	Cooling Loops	Number of New Fuel Assemblies Discharged into SFP	Age of Stored Fuel Assemblies	Time After Shutdown to Begin Fuel Discharge	Time to Boil
Case 7	Loss of Both Cooling Loops at Time of Fuel Discharge Completion	217	125 @ 330 days 1488 @ 2 Years	5 Days	8.67 hours

Case 7 provides a time to boil if both cooling loops are lost after all fuel has been discharged to the spent fuel pool. Given a discharge start time of 5 days after shutdown and loss of cooling at 6.5 days, the time to boil will be 8.67 hours as shown in Table 3.

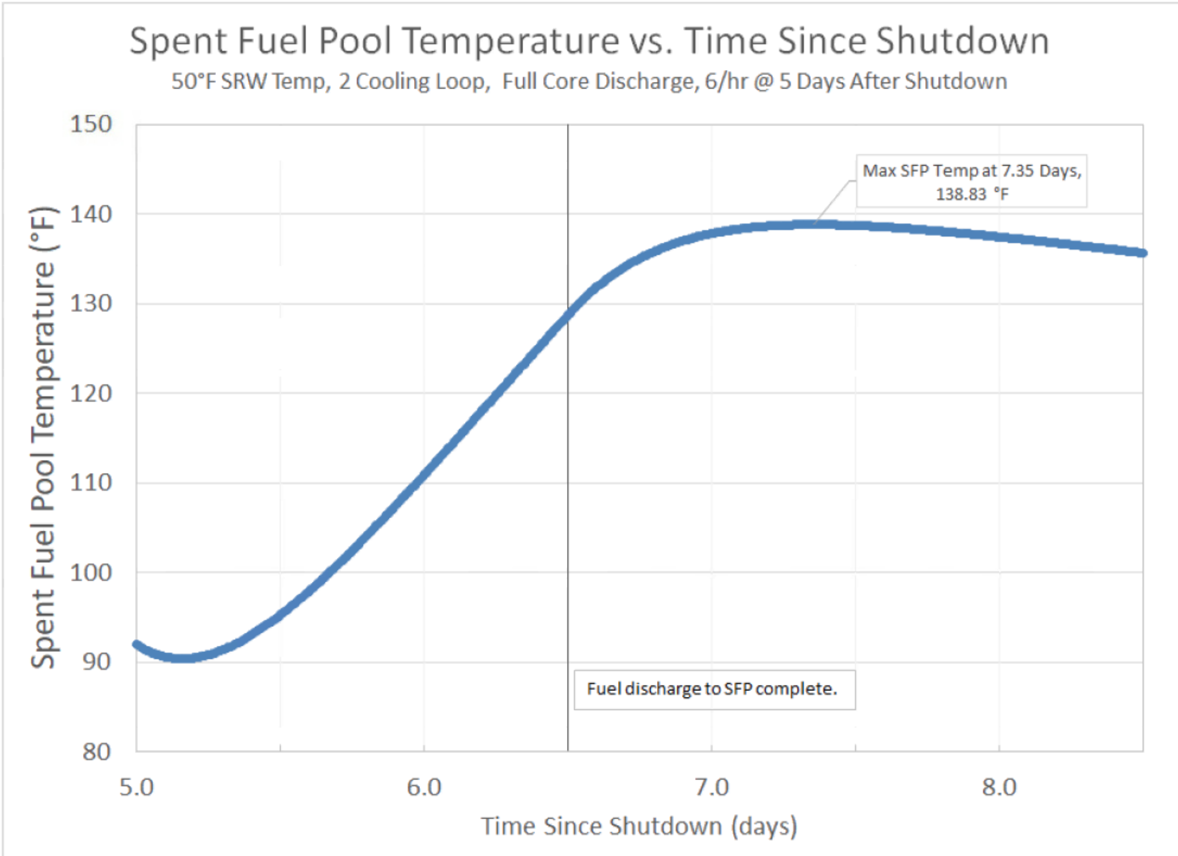


Figure 2 Spent Fuel Pool Temperature for a Full Core Offload Beginning 5 Days After Shutdown

Assuming SFP cooling is lost at the time of fuel discharge completion, the time to boil is 8.67 hours (Case 7, Table 3). The maximum boil-off rate for this condition is 93.9 gallons per minute (gpm) **(Attachment 2, Note: Attachments in Section 3.0 of this LAR refer to Attachments in ECP 21-000209, "Modify Spent Fuel Pool Decay Heat Analysis for Full Core Offload," Reference 16).** Makeup water can be supplied indefinitely to the SFP at a rate of at least 150 gpm. It can be supplied at a greater rate for a period of many days. The makeup water flow path is as follows (Reference1):

a. Source - Well water,
b. Potable makeup Demineralizers
   - Typical capacity 150 gpm or more
c. Demineralized water storage tank
   - Storage capacity 350,000 gallons
d. Four reactor coolant makeup pumps (Normally run one per unit)
   - Capacity 165 gpm each, less than amount required for each coolant makeup
e. Two RWTs
   - Storage capacity 420,000 gallons

  - Required to have 400,000 gallons during operation
  - During refueling this water has been transferred to the refueling pool where it is also available for pumping if conditions permit

f. Two Spent Fuel Cooling Pumps (one per RWT)
  - Capacity 1390 gpm each

g. Spent Fuel Pool

Items a, b, c and d are Non-Safety-Related and items e, f and g are Safety-Related (per References 6 to 9).

3.5 Structural Integrity of the Spent Fuel Pool:

According to Reference 10, the structural analysis for the SFP does not require a change as long as the maximum bulk SFP water temperature remains below 150 °F. It also states that the maximum temperature of 212 °F was considered for the Refueling Outage and the concrete and rebar stresses still remain within allowable limits. Therefore, the current licensing basis for the SFP structural analysis accommodates the increased SFP allowable maximum temperature of 150 °F.

3.6 Impact on the SFP Cooling System/Purification System:

The major SFP cooling components that may be impacted by SFP temperature raising from 130 °F to 150 °F are the pumps, heat exchangers, fuel pool filter, fuel pool demineralizer, piping, fittings, and valves. Per M-0212 Specification, “Fuel Pool Cooling Pumps,” the SFP pumps will circulate borated spent fuel pool water at a maximum temperature of 150 °F. The shell and tube side of the heat exchangers have design temperatures of 200 °F. This will not be challenged with the SFP temperature increase. The fuel pool filter and demineralizer both have design temperatures of 250 °F which is well above the 150 °F change. The SFP piping, fittings, and valves are all designed to withstand temperatures up to 150 °F (Attachment 3).

3.7 Impact of SFP temperature rise on the criticality:

The subject of this activity is to change the SFP bulk temperature. The SFP bulk temperature change might impact the fuel reactivity in the SFP. The criticality analyses for both Units’ SFPs cover the SFP bulk temperature range from 40 °F and 155 °F (References 11 to 14). The Unit 1 pool has higher reactivity at 40 °F while the Unit 2 pool has higher reactivity at 155 °F. Since the SFP bulk temperature change in this activity, for both cases, is still within the range from 40 °F and 155 °F, there is no impact on the SFP criticality analyses (Attachment 4).

3.8 Radiological consequences during a Fuel Handling Incident including control room operator dose:

For radiological consequences during a Fuel Handling Incident, FHI, Reference 15 has been reviewed. In the Reference, SFP temperature is not an input to the calculation, "Validation of Calvert Cliffs FHA for Increased Fuel Rod Pressure of 1400 psig," and there is no impact on the FHA analysis (Attachment 5).

3.9 Risk Assessment:

There is no SFPC model in the CCNPP Probabilistic Risk Assessment (PRA) as it does not have any impact on core damage. SFPC has been considered from a defense-in-depth perspective and the decision tree associated with it can be seen below.

Although spent fuel pool cooling is not considered in the PRA as it does not provide core damage mitigation, risk can be assessed from a defense-in-depth perspective. Three aspects are considered when assessing defense in depth:

- Heat load in the pool
- SFP Cooling loops available
- Alternate inventory control sources available

The pool is considered to be under a high heat load when the unit is defueled, the pool temperature is above 200 °F, or the time for the pool to reach 200°F is less than 72 hours. Alternate inventory control sources include the 2 trains from each of the demineralized water transfer pumps and 2 trains (1 apiece) from each RWT.

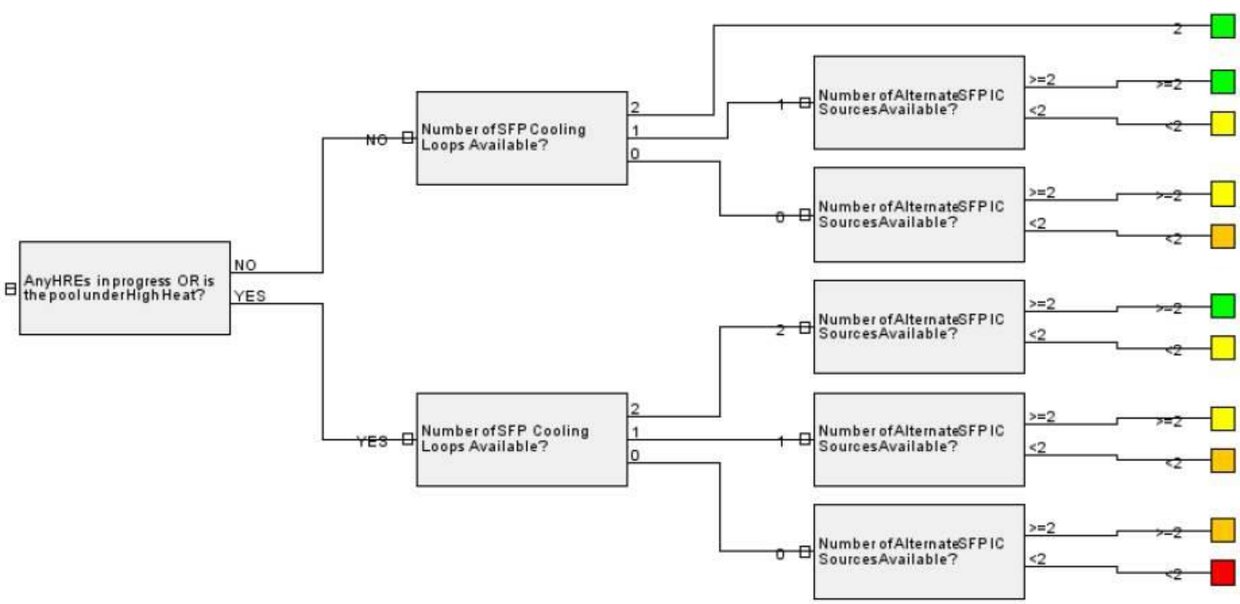


Figure 2 Decision tree associated with SFPC

GREEN: Based on the combination of available pathways and activity types a failure or error could be easily mitigated without presenting a significant challenge in that Key Safety Function. This represents optimal defense-in-depth with all or nearly all mitigation equipment available.

YELLOW: Based on the combination of available pathways and activity types a failure or error can still be mitigated but might present a challenge in that Key Safety Function. This represents lowered defense-in-depth with more than the minimum pathways available.

ORANGE: Based on the combination of available pathways and activity types a failure or error would potentially lead to the loss of the Key Safety Function. This represents no defense-in-depth with the minimum pathways available.

RED: Based on the combination of available pathways and activity types the Key Safety Function is potentially not maintained. This represents a condition in which the safety function is not supported relative to its success criteria.

Optimal defense-in-depth is considered to be the key safety function, in this case SFPC, plus 2 additional success pathways (B=N+2). If the pool is not under a high heat load, then some loss of redundancy is acceptable among the SFP cooling loops and alternate inventory control sources. If the pool is under a high heat load, a loss of one SFPC loop is considered to be nominal defense-in-depth (B=N+1) as long as two or more alternate inventory control sources are available. If both SFPC loops are lost, redundancy is lost, and it is considered marginal defense-in-depth (B=N). It should be noted that from past experiences there have been no Maintenance Rule Functional Failures or Condition Monitoring Events since 2002 to present (Attachment 6).

3.10 Single Failure Analysis:

In a refueling outage if one train of SFPC is lost while the other train of SDC is still out of service for maintenance, the SFP temperature would be monitored and appropriate actions would be taken per alarm manual 1C13 if a SFP high temperature alarm would be received. One of the actions in the alarm manual directs operators to AOP-06F, “Spent Fuel Pool Cooling System Malfunctions,” (Reference 17) which provides guidance to consider aligning SDC if the unit is defueled per OI-03B-1(2), “Shutdown Cooling,” (Reference18). Section 6.13 of OI-03B-1(2) addresses aligning the SDC to the SFP (Attachment 7). This alignment can occur relatively quickly with the spool piping connections preinstalled prior to offloading the core.

As mentioned previously, there is an ongoing action for further SFP thermal analysis by modeling and calculation of different scenarios including single loop failure. Additional studies are in progress for scenarios for one SFPC loop failure at different steps of fuel assembly discharge from the core to the SFP, and then aligning an SDC loop after losing one train of SFPC loop This additional analysis may result in further changes to TRM 15.9.5 and will use the same methodology as described in this License Amendment Request.

3.11 Conclusion/Findings:

- Based on the results for normal operations (i.e., in-core shuffle with 145 to-be-discharged assemblies) a limiting decay time of 0.42 days is needed to begin fuel discharge after shutdown with two SFPHXs given a maximum SRW temperature of 50 °F to remove the SFP decay heat load of 55.2×10^6 Btu/hr (Attachment 8). Considering the rate of fuel movement to the SFP is taken to be 6 fuel assemblies per hour, the time after shutdown for fuel discharge completion would be 1.42 days. It takes 2.07 days after shutdown, for SFP water to reach the maximum temperature of 150 °F at this condition.

- The maximum decay heat load expected from 1613 fuel assemblies, not including a full core off-load, is a function of decay time. For a limiting decay time of 7 days, which results in an initial core alteration time of 6 days after reactor shutdown, the decay heat load is 34.4×10^6 Btu/hr. The 145 fuel assemblies are assumed to have undergone steady-state burnup at 2738 MWt for an average of 1498 days for a 101-assembly batch reload (note that 24 fuel assemblies of the oldest fuel assemblies in the SFP are assumed to be re-inserted into the core for the next cycle). The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from the two SFP heat exchangers as a function of SRW temperature to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature of 150 °F. A maximum SRW temperature of 50 °F is required to support a minimum decay time of 6 days.

- For in-core shuffle with 145 to-be discharged fuel assemblies, a decay time of 22.79 days is needed to maintain the SFP at a temperature of 150 °F with one SFPHX given a maximum SRW temperature of 50 °F to remove the SFP decay heat load.

- Based on the results for abnormal operation (i.e., a full core offload) a limiting decay time of 2.98 days is needed to begin fuel discharge after shutdown with two SFPHXs given a maximum SRW temperature of 50 °F to remove the SFP decay heat load of 53.1×10^6 Btu/hr (Attachment 8). Considering the rate of fuel movement to the SFP is taken to be 6 fuel assemblies per hour, the time after shutdown for fuel discharge completion would be 4.48 days. It takes 2.2 days after shutdown, for SFP water to reach the maximum temperature of 150 °F at this condition.

- For full core offload, a decay time of more than 100 days is needed to maintain the SFP at a temperature of 150 °F with one SFPHX given a maximum SRW temperature of 50 °F to remove the SFP decay heat load.

- In the case of total loss of two SFPHXs with 1613 fuel assemblies in the pool, it would take more than 8 hours to raise the SFP temperature from 150 °F to 212 °F. The maximum boil-off rate for this condition is 93.9 gallons per minute (gpm). The time to heat up the bulk water to boiling provides sufficient time to establish an alternate means of cooling, and the makeup rate exceeds the rate of water loss due to boil-off.

Per Reference 1, makeup water can be supplied indefinitely to the SFP at a rate of at least 150 gpm.

- The analysis shows that the SFP water will remain subcooled and the effects of changes in this activity on the local SFP water temperature are acceptable. There is no adverse impact on cooling/purification system, structural integrity, criticality, and radiological consequences during a fuel handling incident including control room operator dose, due to SFP maximum water temperature rise from 130 °F to 150 °F.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements/Criteria

The proposed changes have been evaluated to determine whether applicable regulations and requirements continue to be met. Exelon has determined that the proposed changes do not require any exemptions or relief from regulatory requirements from the following current applicable regulations and regulatory requirements, which were reviewed in making this determination:

<u>10 CFR 50.36, Technical Specifications</u>

10 CFR 50.36(c) provides that TS will include Limiting Conditions for Operation (LCOs) which are “the lowest functional capability or performance levels of equipment required for safe operation of the facility. When a limiting condition for operation of a nuclear reactor is not met, the licensee will shut down the reactor or follow any remedial action permitted by the technical specifications until the condition can be met.” The proposed changes do not involve or require TS LCOs for the SFPC System.

<u>General Design Criterion 44, Cooling Water</u>

GDC Criterion 44 states in part: "A system to transfer heat from structures, systems, and components important to safety, to an ultimate heat sink shall be provided. The system safety function shall be to transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions. Suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available)”.

There is not a direct correlation for GDC Criterion 44 to pre-GDC Criteria. There is a similar correlation for pre-GDC 44 concerning ECCS cooling, which states in part, “At least two emergency core cooling systems, preferably of different design principles, each with a capability for accomplishing abundant emergency core cooling, shall be provided. Each emergency core cooling system and the core shall be designed to prevent fuel and clad damage that would interfere with the emergency core cooling function and to limit the clad metal-water reaction to negligible amounts…” The SFPC system provides two trains designed to keep the spent fuel adequately cooled.

The proposed changes do not affect CCNPP's compliance with the intent of GDC 44. The CCNPP SFPC system was not originally licensed to single failure criteria and is not safety related. A single failure of one of the SFPC trains was analyzed for two cases (midway in full core off load and immediately after full core off load) and the results indicated there is sufficient time to restore and align a SDC train to maintain the SFP bulk temperature at or below the 150 °F limit. The proposed changes do not affect CCNPP's compliance with the intent of GDC 44.

<u>10 CFR 50 Appendix A, General Design Criterion (GDC) 61, Fuel Storage and Handling and Radioactivity Control (For CCNPP, this correlates to pre-GDC criterion 67)</u>

GDC 61 requires that fuel storage and handling systems be designed to ensure adequate safety under anticipated operating and accident conditions. Specifically, GDC 61 requires (1) periodic inspections; (2) suitable radiation shielding; (3) appropriate containment, confinement, and filtering systems; (4) residual heat removal capability consistent with its importance to safety; and (5) prevention of significant reduction in fuel storage inventory under accident conditions. Pre-GDC Criterion 67, Fuel and Waste Storage Decay Heat, states that reliable decay heat removal systems shall be designed to prevent damage to the fuel in storage facilities that could result in radioactivity release to plant operating areas or the public environs. The proposed changes do not affect CCNPP's compliance with the intent of GDC 61.

<u>Regulatory Guide (RG) 1.13 Rev 2, Spent Fuel Pool Storage Facility Design Basis.</u>

NRC issued this regulatory guide to provide current guidance regarding the design basis for spent fuel storage facilities. This regulatory guide endorses (with certain additions, clarifications, and exceptions) "Design Objectives for Light-Water Spent Fuel Storage Facilities at Nuclear Power Plants," which the American National Standards Institute/American Nuclear Society issued as ANSI Standard N210-1976/ANS-57.2-1983.

RG exceptions state in part that the ANSI/ANS-57.2-1983 states that spent fuel pool water should be maintained below 66 °C (150 °F) during normal operating conditions. By contrast, this regulatory guide specifies that pool water should be maintained below 60 °C (140 °F) for all heat load conditions, including full-core offloads during refueling.

The proposed changes have been evaluated in accordance with RG 1.13 and have been found to be acceptable per the revised SFP Heat-up Analysis to maximum SFP temperature of 150 °F.

<u>NUREG 0800, Standard Review Plan (SRP) 9.1.3 Spent Fuel Pool Cooling and Cleanup System</u>

All nuclear reactor plants include a spent fuel pool for the wet storage of spent fuel assemblies. The methods used to provide cooling for the removal of decay heat from the stored assemblies vary from plant to plant, depending upon the individual design. The safety function to be performed by the system in all cases remains the same; that is, the spent fuel assemblies must be cooled and must remain covered with water during all storage conditions. Other functions performed by the system but not related to safety include water cleanup for the spent fuel pool, refueling canal, refueling water storage tank, and other equipment storage pools; means for filling and draining the refueling canal and other storage pools; and surface skimming to provide clear water in the storage pool.

SRP 9.1.3 III, Review Procedures, Section1.D states in part:

The minimum heat removal capacity with the forced-circulation cooling system in operation, the pool at the design temperature of the structure, and the heat sink at its maximum design temperature is greater than 0.3 percent of the reactor rated thermal power. The cooling system retains at least half of its full heat removal capacity assuming a single active failure. This capacity provides reasonable assurance that the pool temperature will remain within design bounds for the structure during full core discharges to the spent fuel pool when the forced-circulation cooling system is in operation, and ensures that significant heat removal capacity will remain available when an active component is unavailable due to a single failure or maintenance. The forced cooling capacity remaining following a single failure is adequate due to the low probability that the single failure would occur coincident with maximum decay heat load and the maximum heat sink temperature.

The proposed changes do not affect CCNPP's compliance with the intent of SRP 9.1.3 requirements for the heat removal capability of the SFPC system and the requirements to maintain sufficient water in the spent fuel pool.

4.2 Precedent

Turkey Point Units 3 and 4 – Issuance of Amendments Regarding Reduction in Decay Time from 100 to 72 hours (TAC NOS. MB6549 AND MB6550), dated March 4, 2003 (ML0306207460) provides relevant insights and review criteria as the reduction in decay time resulted in an increase in heat load to the SFPC system and SFP bulk temperature.

The subject of Turkey Point (TP) LAR was reduction in minimum decay heat time for reactor subcriticality prior to removing irradiated fuel from the reactor vessel from 100 hr to 72 hr. TP demonstrated that the bulk water temperature in the SFP remains below the design bulk SFP water temperature for planned offloads, and below the boiling (212 °F) for unplanned offloads, the time to heat up the bulk water to boiling provides sufficient time to establish an alternate means of cooling, and the make-up rate exceeds the rate of water loss due to boil-off. TP used the same methodology in their UFSAR allowing to vary the actual offload start time, average offload rate, and actual cooling water average temperature. The actual heat load in the SFP was used, rather than assuming the heat load from a full SFP. The calculation methodology was accepted in predicting the maximum bulk SFP temperature for planned offloads to maintain the bulk SFP temperature below the design temperature.

Assuming SFP cooling is lost at the time of peak pool temperature, the time to boil, the maximum boil-off rate, and make-up rate for this condition were evaluated. It was shown that during time to boil there is sufficient time to establish make-up to the SFP. The analysis showed that the SFP water will remain subcooled and the effects of reduced decay time on the local SFP water temperature are acceptable. TP evaluated the impact of the proposed amendment in the SFP cooling system including structural integrity of the SFP, radiological consequences, and control room habitability.

Calvert Cliffs Units 1 and 2 TS Amendment Nos. 47 and 30, respectively, to increase the spent fuel storage capability up to a maximum of 1760 fuel assemblies in the spent fuel pool through the use of high density borated spent fuel racks, dated September 19, 1980 (ML003773029). Section 3.2 (Spent Fuel Cooling) of the Safety Evaluation Report provides relevant insights and review criteria for original licensing design bases for the SFPC System.

4.3 No Significant Hazards Consideration

Pursuant to 10 CFR 50.90, “Application for amendment of license or construction permit,” Exelon Generation Company, LLC (Exelon), proposes a permanent change to the Licensing Design Bases of the Spent Fuel Pool Cooling System (SFPC) system of Renewed Facility Operating License Nos. DPR-53 and DPR-69 for Calvert Cliffs Nuclear Power Plant Units 1 and 2 (CCNPP).

The proposed permanent change to the SFPC system licensing design basis would allow for a full core offload without being supplemented with one train of the Shutdown Cooling (SDC) system. The licensing design basis change involves the development of a new methodology to obtain margin in heat removal capability by raising the maximum allowable spent fuel pool (SFP) water temperature from 130 °F to 150 °F. The current Updated Final Safety Analysis (UFSAR) assumes the SFP cooling system is supplemented with one Shutdown Cooling Heat Exchanger (SDCHX) from the offload unit in order to keep the bulk temperature below 130 °F. However, during refueling outage, one loop of SDC will be required to be operable per TS 3.9.4,”Shutdown Cooling (SDC) and Coolant Circulation-High Water Level”. The second SDC loop will be out of service for scheduled outage work (ASME code required work). Thus, no SDC loop will be available as a supplemental to cool the SFP. The methodology developed by this activity instead will credit the time it takes for the bulk SFP water to heat up to 150 °F.

Exelon has evaluated whether a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, “Issuance of amendment,” as discussed below:

1. Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No.

The accident of concern related to the proposed changes is the Fuel Handling Incident (FHI). This accident assumes a dropped fuel assembly. For radiological consequences the bounding analysis has been reviewed for an FHI. In the bounding analysis, SFP temperature is not an input to the calculation, "Validation of Calvert Cliffs FHA for Increased Fuel Rod Pressure of 1400 psig," and therefore, there is no impact on the consequences of an FHI analysis. The proposed changes do not involve any physical alterations, or new or different types of equipment, or new system operating procedures or revisions. Therefore, the probability of the FHI has not increased.

Regarding impact to reactivity of the spent fuel in the SFP, the criticality bounding analysis has been reviewed for the impact of a rise in the SFP bulk temperature. The criticality analyses for both Units' SFPs cover the SFP bulk temperature range from 40 °F and 155 °F. The Unit 1 SFP has higher reactivity at 40°F while the Unit 2 pool has higher reactivity at 155 °F. Since the SFP bulk temperature change in this activity, for both cases, is still within the range from 40°F and 155°F of the criticality bounding analysis, there is no impact on the SFP criticality.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

The impact of the proposed change is limited to fuel handling operations and spent fuel pool cooling. No physical plant changes to existing systems or procedures are proposed to accommodate allowing the spent fuel pool bulk temperature to heat up from 130 °F to 150 °F. The same water makeup systems are available for makeup to the spent fuel pool. Hence, no new failure modes are created that would cause a new or different kind of accident from any accident previously evaluated. The supporting analysis for allowing the spent fuel pool to heat up to 150 °F demonstrates that the associated increase in water temperature heat load will not cause any spent fuel pool (SFP) component or structure to operate outside design limits. Adequate margins to safety are maintained with respect to SFP water temperature and structural loading.

With the new additional Technical Requirements Manual (TRM) changes of time after shutdown for fuel moves for decay heat; requirement for two operating SFPC trains; and lower Service Water (SWR) temperature requirements; the time to boil in the SFP (8.67 hours) should a complete loss of SFPC occur for a full core off load, is approximately the same as the original licensing design basis (more than 8 hours) for a partial core offload.

Assuming SFP cooling is lost at the time of peak SFP temperature, the time to boil, the maximum boil-off rate, and make-up rate for this condition were evaluated. It was shown that during time to boil there is sufficient time to establish make-up to the SFP with existing systems and procedures. The analysis showed that the SFP water will remain subcooled and the effects of the elevated SFP bulk temperature are acceptable.

Therefore, the proposed change does not create the possibility of a new or different kind of accident from any previously evaluated.

3. Does the proposed change involve a significant reduction in a margin of safety?

Response: No.

The proposed change in plant operation does not significantly reduce the margin of safety because of the additional operating constraints imposed by changes in the Technical Requirements Manual. Although there is a very small reduction in the margin of safety by allowing the SFP bulk temperature limit to change from 130 °F to 150 °F, it has been shown that this temperature rise is bounded by the existing analyses. These analyses include: SFP Heat-up Analysis, structural analysis, dose consequence analysis of the Fuel Handling Incident, and spent fuel thermal hydraulic analysis. Adequate margins are maintained by the actions and changes proposed by this License Amendment Request.

Therefore, the proposed change does not involve a significant reduction in a margin of safety.

Based on the above, Exelon concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of no significant hazards consideration is justified.

4.4 Conclusions

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

The proposed change would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed change does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed change meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed change.

6.0 REFERENCES

1. Updated Final Safety Analysis Report, UFSAR, Rev 51 Chapter 9.4 "Spent Fuel Pool Cooling System"

2. ILD Calculation, "CCNPP Spent Fuel Pool Heat-up Analysis"

3 CA06535 Rev. 0002, "SFP Decay Heat for 24-M VAP and Framatome Core with App. K Power Uprate"

4. CA03959 Rev. 0002, "Spent Fuel Pool Heat Removal Capability"

5 Updated Final Safety Analysis Report, UFSAR, Rev 51 Chapter 9.5.2.3, "Saltwater System"

6. DWG 60730SH0001, "Chemical and Volume Control System"

7. DWG 60731SH0001, "Safety Injection & Containment Spray System"

8. DWG 60716, "Spent Fuel Pool Cooling Pool Fill & Drain System"

9. DWG 60706SH0002, "Service Water Cooling System"

10. CA09085, "Spent Fuel Pool"

11.. CA06011, "Unit 1 Spent Fuel Pool Enrichment Limit With Soluble Boron Credit"

12. CA06015, "Unit 2 Spent Fuel Pool Criticality Analysis With Soluble Boron Credit But Without Boraflex Credit"

13. CA07456, "Unit 1 Spent Fuel Pool Enrichment Limit With Soluble Boron Credit For Areva Fuel"

14. CA07142, "Unit 2 Spent Fuel Pool Criticality Analysis With Soluble Boron And Burnup Credit For Areva Fuel"

15. CA06067, "Validation Of Calvert Cliffs Fuel Handling Accident For Increased Fuel Rod Pressure Of 1400 PSIG"

16. ECP 21-000209, "Modify Spent Fuel Pool Decay Heat Analysis for Full Core Offload"

17. AOP-6F, "Spent Fuel Pool Cooling System Malfunctions," Revision 00701

18. OI-03B-1(2), "Shutdown Cooling," Revisions 03400(03100)

ATTACHMENT 2

Calvert Cliffs Nuclear Power Station, Units 1 and 2

Renewed Facility Operating License Nos. DPR-53 and DPR-69

Markup of Proposed Technical Requirements Manual Pages

TRM Pages

75
76
77

15.9.5 Full Core Offload

NORMAL CONDITION

TNC 15.9.5

During the removal of all irradiated fuel assemblies from the reactor to the spent fuel pool (SFP).

a. The SFP water temperature shall be $> 50°F$ and $< 150°F$;

b. Two SFP Cooling Systems shall be OPERABLE, and in operation, and

c. The combination of the following Service Water (T_{SRW}) and time after shutdown shall be met:

--------------------------- NOTE ----------------------------

1. One SFPC loop may be replaced by one shutdown cooling loop provided it is lined up to provide cooling flow to the Spent Fuel Pool.

APPLICABILITY

During the complete removal of irradiated fuel assemblies from the reactor to the SFP, and until the reactor has been refueled.

TABLE 1 - Full Core Offload (Discharge of 217 Fuel assemblies) using 2 SFP cooling loops

Time to Start Discharge (days)	Time to Complete Discharge (days)	T_{SRW} [°F]
3	4.5	≤ 50

TABLE 1 - Full Core Offload (Discharge of 217 Fuel assemblies) using 2 SFP loops

CONTINGENCY MEASURES

Nonconformance		Contingency Measures		Completion Time
A.	SFP temperature not within limit.	A.1	Suspend movement of irradiated fuel assemblies from the reactor to the SFP.	Immediately
		<u>AND</u>		
		A.2	Initiate action to restore SFP temperature to within limit.	Immediately
B.	One required SFP Cooling System inoperable.	B.1	Suspend movement of irradiated fuel assemblies from the reactor to the SFP.	Immediately
		<u>AND</u>		
		B.2	Initiate action to restore a second SFP Cooling Loop to OPERABLE status.	Immediately
		<u>AND</u>		
		B.3.	Restore second SFP Cooling Loop.	3 Hours
C.	Combination of Service Water temperature (T_{SRW}) and minimum time after shutdown not met.	C.1	Suspend movement of irradiated fuel assemblies from the reactor to the SFP.	Immediately
D.	Contingency measures and associated restoration times of Nonconformance A, B or C are not met.	C.1	See Section 15.0.3	Immediately

VERIFICATION REQUIREMENTS

TVR	Verification	Frequency
15.9.5.1	Verify SFP temperature is within limit.	12 Hours
15.9.5.2	Verify two SFP Cooling Systems are OPERABLE, each commensurate with the SFP heat load associated with the full core offload.	Once prior to moving irradiated fuel assemblies from the reactor to the SFP and every 12 hours thereafter
15.9.5.3	Verify combination of the Service Water temperature (T_{SRW}) and minimum time after shutdown met.	Once prior to moving irradiated fuel assemblies from the reactor to the SFP and every 24 hours thereafter

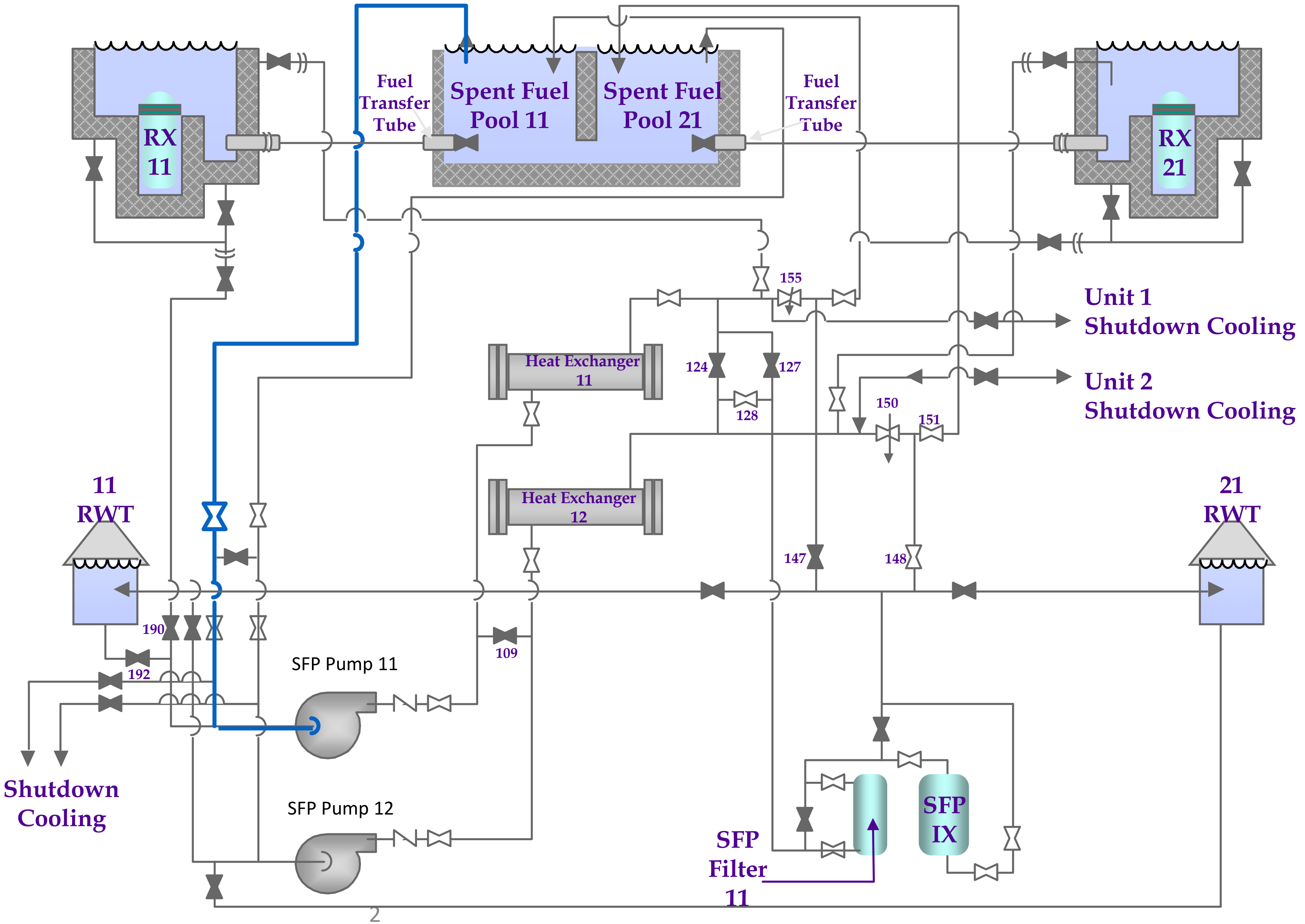
ATTACHMENT 3

Calvert Cliffs Nuclear Power Station, Units 1 and 2

Renewed Facility Operating License Nos. DPR-53 and DPR-69

Spent Fuel Pool Cooing System Simplified Diagram

Spent Fuel Pool Cooling & Purification



ATTACHMENT 4

Calvert Cliffs Nuclear Power Station, Units 1 and 2

Renewed Facility Operating License Nos. DPR-53 and DPR-69

Markup of the Proposed UFSAR Pages

9.4-1
9.4-2
9.4-3

9.4-4, 9.4-5, and 9.4-6 are included for completeness.

9.4 SPENT FUEL POOL COOLING SYSTEM

9.4.1 DESIGN BASIS

The SFPC system is common to both units. The pool contains water with the proper dissolved concentration of boron and has the capacity to store 1830 fuel assemblies.

Insert 1

The SFPC system is designed to remove the maximum decay heat expected from 1613 fuel assemblies, not including a full core off-load. The maximum pool temperature in this case is 120°F. The system is also capable of being used in conjunction with the SDC system to remove the maximum expected decay heat load from 1830 fuel assemblies, including a full core discharge. The maximum SFP temperature in this case is 130°F.

Insert 2

The maximum decay heat load expected from 1613 fuel assemblies, not including a full core off-load, is a function of decay time. For a limiting decay time of 3.5 days, which results in an initial core alteration time of 3.0 days after reactor shutdown, the decay heat load is 22.33×10^6 Btu/hr. The fuel is assumed to have undergone steady-state burnup at 2738 MWt for an average of 1562.4 days for an 100 assembly batch reload. The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from the two SFP heat exchangers as a function of SRW temperature to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature of 120°F. A maximum SRW temperature of 65°F is required to support a minimum decay time of 3.5 days. In the event that one SFP cooling loop is lost, the remaining loop can remove the heat load while maintaining the pool temperature at 155°F.

Insert 3

The maximum decay heat rate for 1830 fuel assemblies stored in the SFP is a function of decay time. For a limiting decay time of 4.5 days, which results in an initial core alteration time of 3.0 days after reactor shutdown, the decay heat load is 45.96×10^6 Btu/hr based upon the following hypothetical sequence of events:

1. Eighty-four fuel assemblies are removed from Unit 1 after an average of 1860 days of reactor operation at 2738 MWt, and are replaced with fresh fuel. Unit 1 is then returned to full power.
2. Three-hundred-sixty-five days after the Unit 1 refueling, 84 fuel assemblies are removed from Unit 2 after an average of 1860 days of irradiation and are replaced with fresh fuel. Unit 2 is then returned to full power.
3. Three-hundred-sixty-five days after the Unit 2 refueling, 84 fuel assemblies are removed from Unit 1 after an average of 1860 days of irradiation and are replaced with fresh fuel. Unit 1 is then returned to full power.
4. This refueling cycle continues until the pool contains 1613 fuel assemblies at the end of a Unit 2 refueling. It has been conservatively assumed that the 67 oldest assemblies have been removed from the pool to allow for complete filling of the racks with newer fuel.
5. Unit 1 is then shutdown 60 days after the previous Unit 2 shutdown and the entire core is offloaded after a minimum of 4.5 days of decay. At this point, it is conservatively assumed that the fuel has completed its current cycle, and is therefore at maximum irradiation.

Upon completion of the last operation, the pool will contain 1830 fuel assemblies, with each discharge subjected to different periods of irradiation and decay, in accordance with the table below assuming the minimum decay time of 4.5 days:

	Number of Assemblies	Irradiation Period (Days)	Decay Period (Days)
a.	17	1860	6964.5
b.	84	1860	6599.5
c.	84	1860	6234.5
d.	84	1860	5869.5
e.	84	1860	5504.5
f.	84	1860	5139.5
g.	84	1860	4774.5
h.	84	1860	4409.5
i.	84	1860	4044.5
j.	84	1860	3679.5
k.	84	1860	3314.5
l.	84	1860	2949.5
m.	84	1860	2584.5
n.	84	1860	2219.5
o.	84	1860	1854.5
p.	84	1860	1489.5
q.	84	1860	1124.5
r.	84	1860	759.5
s.	84	1860	394.5
t.	84	1860	64.5
u.	217	1860	4.5

The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from both loops of SFPC as a function of SRW temperature, supplemented with one loop of SDC to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature at 130°F. A maximum SRW temperature of 75°F is required to support a minimum decay time of 4.5 days.

9.4.2 SYSTEM DESCRIPTION

The SFPC System shown in Table 9-16 and Figure 9-7 is a closed-loop system consisting of two half-capacity pumps and two half-capacity heat exchangers in parallel, a bypass filter that removes insoluble particulates, and a bypass demineralizer that removes soluble ions. The SFPC heat exchangers are cooled by service water (SRW).

Skimmers are provided in the SFP to remove accumulated dust from the pool. The clarity and purity of the water in the SFP, refueling pool, and the RWT are further maintained by passing a portion of the flow through the bypass filter and/or demineralizer. The SFP filter and demineralizer removes fission products from the cooling water in the event of a leaking fuel assembly.

Connections are provided for tie-in to the SDC system to provide for additional heat removal in the event that 1830 fuel assemblies are contained in the pool. When the pressure in the SDC system is greater than the design pressure of the SFPC system, the SFPC system is isolated from the SDC system via two manual isolation valves. Although not required by the design code, double valve isolation is provided at this system interface to meet the original FSAR design basis (FCR 90-87).

The entire SFPC system is tornado-protected and is located in a Seismic Category I structure. Borated makeup water comes from the RWT. Non-borated makeup water comes from the demineralized water system.

9.4.3 COMPONENTS

9.4.3.1 Functional Description

A description for the spent fuel pool cooling system is contained in Table 9-16.

9.4.3.2 Codes and Standards

The following codes and standards were used in the design of the SFPC System components:

Pump	Standards of: ASME (III, VIII, IX, PTC8.2), ASTM, NEMA, ANSI
Heat Exchanger	Standards of: Tubular Exchanger Manufacturers Association (TEMA), ASME (III, VIII, IX), ASTM, ANSI
Filter	ASME III C and ASME VIII paragraph UW-2(a)
Ion Exchanger	ASME III C and ASME VIII paragraph UW-2(a)
Valves, Piping, Fittings	ANSI B31.7 Class III

9.4.3.3 Tests and Inspections

Each component is cleaned and inspected before installation and the assembled systems flushed with demineralized water. The flow paths, flow capacity and mechanical operability are tested by operation. The head and capacity of the pumps are also tested.

Instruments are calibrated prior to tests. Alarm functions are checked for operability and limits during preoperational testing. During normal operation, periodic tests will be made to confirm design criteria.

9.4.4 SYSTEM OPERATION AND RELIABILITY

Insert 4

In the normal case (i.e., with no full-core off load), if one SFPC loop is lost, the remaining loop can remove decay heat while maintaining the pool temperature at 155°F. In the case of total loss of SFPC with 1613 fuel assemblies in the pool, it would take more than 8 hours to raise the pool temperature from 155°F to 210°F. The case of total loss of SFP cooling is only discussed to demonstrate the time available to take appropriate action in such an event to preclude boiling, and the resulting loss in pool water level. The design of the SFPC System and pool structural components (e.g., pool liner plate, SFPC piping and pumps) for total loss of cooling is not part of the system's design basis.

The most serious failure to the system is the loss of SFP water. This is avoided by routing all SFP piping connections above the water level and providing them with siphon breakers to prevent gravity drainage.

The SFP is designed to preclude the loss of structural integrity. Section 5.6.1 describes the analysis made to verify that the structural integrity cannot be impaired. Additional design and quality control requirements for the SFP are given in Section 6.3.5.1. However, if a leak from the SFP is postulated, the capabilities for controlling the leak are as follows:

Makeup water can be supplied indefinitely to the SFP at a rate of at least 150 gpm. It can usually be supplied at a greater rate for a period of many days, but this depends upon plant conditions. The makeup water flow path is as follows:

a. Source - Well water

b. Portable Makeup Demineralizers

   - Typical capacity 150 gpm or more

c. Demineralized Water Storage Tank

   - Storage capacity 350,000 gallons

d. Four Reactor Coolant Makeup Pumps (Normally run one per unit)

   - Capacity 165 gpm each, less the amount required for reactor coolant makeup

e. Two RWTs (One per unit)

   - Storage capacity 420,000 gallons
   - Required to have 400,000 gallons during operation
   - During refueling this water has been transferred to the refueling pool where it is also available for pumping if conditions permit

f. Two Spent Fuel Cooling Pumps (One per RWT)

   - Capacity 1390 gpm each

g. Spent Fuel Pool

The two halves of the SFP can be isolated from each other and 830 fuel assemblies, as a minimum, can be stored in the non-leaking half.

The four Emergency Core Cooling System (ECCS) equipment rooms on the lowest level of the Auxiliary Building (Figure 1-5) can be prevented from flooding by shutting their watertight doors. In addition, each ECCS pump room is also drained by an 80 gpm sump pump. The remainder of this level is drained by two sump pumps at a rate of 160 gpm. The sump pumps discharge to the Miscellaneous Waste Processing System (MWPS), which has storage capacity of 8000 gallons and can process 128 gpm.

TABLE 9-16

SPENT FUEL POOL COOLING SYSTEM COMPONENT DESCRIPTION

Pump	
Type	Horizontal, centrifugal with mechanical seals
Number	2
Capacity (each)	1390 gpm
TDH	200 feet
Materials	
Casing	American Society for Testing and Materials (ASTM) A296, Gr CA-15 or ASTM A217, Gr CA-15
Stuffing Box Extension Assy. (Backhead)	ASTM A296, Gr CA-15, ASTM A217, Gr CA-15, ASTM A487 Gr CA-15, or ASTM A487 Gr CA6NM Class A
Motor	100 hp, 460 Volt, 60 Hz, 3 phase, 3550 RPM
Heat Exchanger	
Type	Horizontal counter flow Straight tube rolled and seal welded into tube sheets
Number	2 in parallel
Heat Transfer area (each)	1920 ft^2
Materials	
Shells	C.S. SA-285-C
Tubes	SS-304, SA-213
Tube Sheets	SS-304, SA-240
Shell side relief valve setpoint	150 psig
Fuel Pool Filter	
Type	Cartridge
Number	1
Design/Operating Flow	128/120 gpm
Design Pressure	175 psig
Design Temperature	250°F
Material	ASTM SA240, Type 304
Fuel Pool Demineralizer	
Type	Mixed bed, non-regenerable
Number	1
Design/Operating Flow	128/120 gpm
Design Pressure	200 psig
Design Temperature	250°F
Resin	Mixed (anion, cation)
Materials	ASTM SA240, Type 304

TABLE 9-16

SPENT FUEL POOL COOLING SYSTEM COMPONENT DESCRIPTION

<u>SFP Piping, Fittings, Valves</u>

Material	Stainless Steel 304
Design Pressure	160 psig
Design Temperature	150°F/155°F[a]
Joints 2-1/2" and Larger	Butt-welded except at flanged equipment
Joints 2" and Smaller	Socket weld except at flanged equipment
Valves 2-1/2" and Larger	Stainless steel, butt weld-ends, 150 psi
Valves 2" and smaller	Stainless steel, socket weld ends, 150 psi
Relief valve setpoint	150 psig (on tube side of spent fuel pool cooling heat exchanger)
Butterflies 3" and larger	Rubber seated carbon steel lug type, 150 psi

[a] Portions of the SFP Cooling System are designed for a maximum postulated temperature of 155°F [Section 9.4.4, Doc. No. 92-769(M601)].

Inserts for CCNPP UFSAR Chapter 9.4 Markup

Insert 1:

The SFPC system is designed to remove the maximum decay heat expected from 1613 fuel assemblies, not including a full core off-load. The maximum pool temperature in this case is 150 °F. The system is also capable of being used to remove the maximum expected decay heat load from 1830 fuel assemblies, including a full core discharge. The maximum SFP temperature in this case is 150°F.

Insert 2:

The maximum decay heat load expected from 1613 fuel assemblies, not including a full core off-load, is a function of decay time. For a limiting decay time of 7 days, which results in an initial core alteration time of 6 days after reactor shutdown, the decay heat load is $34.4x10^6$ Btu/hr. The 145 fuel assemblies are assumed to have undergone steady-state burnup at 2738 MWt for an average of 1498 days for a 101-assembly batch reload (note that 24 fuel assemblies of the oldest fuel assemblies in the SFP are assumed to be re-inserted into the core for the next cycle). The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from the two SFP heat exchangers as a function of SRW temperature to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature of 150 °F. A maximum SRW temperature of 50 °F is required to support a minimum decay time of 6 days. In the event that one SFP cooling loop is lost, the remaining loop can remove the heat load while maintaining the pool temperature at 150 °F.

Insert 3:

The maximum decay heat rate for 1830 fuel assemblies stored in the SFP is a function of decay time. For a limiting decay time of 4.5 days, which results in an initial core alternation time of 3 days after reactor shutdown, the decay heat load is 53.1 $x10^6$ Btu/hr based upon the simplification of the following hypothetical sequence of events:

1. 125 fuel assemblies are removed from Unit 1 after an average of 1498 days of reactor operation at 2738 MWt, and are replaced with 101 fresh fuel assemblies and 24 oldest spent fuel assemblies from the SFP. Unit 1 is then returned to full power.
2. 365 days after the Unit 1 refueling, 125 fuel assemblies are removed from Unit 2 after an average of 1498 days of irradiation and are replaced with 101 fresh fuel assemblies and 24 oldest spent fuel assemblies from the SFP. Unit 2 is then returned to full power.
3. 365 days after the Unit 2 refueling, 125 fuel assemblies are removed from Unit 1 after an average of 1498 days of irradiation and are replaced with 101 fresh fuel assemblies and 24 oldest spent fuel assemblies from the SFP. Unit 1 is then returned to full power.
4. This refueling cycle continues until the pool contains 1613 fuel assemblies at the end of a Unit 2 refueling. It has been conservatively assumed that the 12 oldest fuel assemblies have been removed from the pool to allow for complete filling of the racks with newer fuel.

5. Unit 1 is then shutdown 60 days after the previous Unit 2 shutdown and the entire core is offloaded after a minimum of 4.5 days. At this point, it is conservatively assumed that the fuel has completed its current cycle and is therefore at maximum irradiation.

Upon completion of the last operation, the pool will contain 1830 fuel assemblies, with each discharge subjected to different periods of irradiation and decay, in accordance with the table below assuming the minimum decay time of 4.5 days:

	Number of Assemblies	Irradiation Period (Days)	Decay Period (Days)
a.	113	1498	4409.5
b.	125	1498	4044.5
c.	125	1498	3679.5
d.	125	1498	3314.5
e.	125	1498	2949.5
f.	125	1498	2584.5
g.	125	1498	2219.5
h.	125	1498	1854.5
i.	125	1498	1489.5
j.	125	1498	1124.5
k.	125	1498	759.5
l.	125	1498	394.5
m.	125	1498	64.5
n.	217	1498	4.5

The simplified approach, which is also more conservative, assumes the age of 1488 stored fuel assemblies in the SFP are 2 years and the last 125 stored fuel assemblies has 330 days of age.

The total SFP decay heat load as a function of decay time is compared to the heat removal capacity from both loops of SFPC as a function of SRW temperature, to show what time after shutdown is acceptable for each SRW temperature condition to maintain the pool at a temperature at 150 °F. A maximum SRW temperature of 50 °F is required to support a minimum decay time of 4.5 days.

Insert 4:

In the normal case (i.e., with no full core off load), if one SFPC loop is lost, the remaining loop can remove the decay heat while maintaining the pool temperature at 150 °F. In the case of total loss of SFPC with 1613 fuel assemblies in the pool, it would take slightly more than 8 hours to raise the pool temperature from loss of both cooling at time of full core offload to 210 °F.