UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

DOCKET NOS. 51-271, 72-59, 72-1014
EXEMPTION REQUEST FOR
ENTERGY NUCLEAR OPERATIONS, INC.'S
VERMONT YANKEE NUCLEAR POWER STATION
INDEPENDENT SPENT FUEL STORAGE INSTALLATION
IN VERNON, VERMONT

February 2, 2018

SUMMARY

By application dated May 16, 2017, (Entergy 2017a, BVY 17-006) and supplemented on September 7, 2017 (Entergy 2017b, BVY 17-031) and December 7, 2017 (Entergy 2017c, BVY 17-041), Entergy Nuclear Operations, Inc. (ENO) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) for an exemption, in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 72.7, from the requirements of 10 CFR 72.212(a)(2), 72.212(b)(3), 72.212(b)(5)(i), 72.214, and the portion of 72.212(b)(11) that requires compliance with the terms, conditions, and specifications of the Certificate of Compliance (CoC) No. 1014 for spent fuel storage at the Vermont Yankee Nuclear Power Station (VYNPS) Independent Spent Fuel Storage Installation (ISFSI).

In support of its exemption request, ENO points to Holtec's applications for Amendment Nos. 11 and 12 of CoC No. 1014 by letters dated January 29, 2016 (Holtec 2016a), and June 14, 2016 (Holtec 2016b), respectively. ENO also referenced supplemental information to Amendment No. 11 dated June 6, 2016 (Holtec 2016c) and to Amendment No. 12 dated July 22, 2016 (Holtec 2016d), November 4, 2016 (Holtec 2016e), and August 25, 2017 (Holtec 2017a). Both amendment applications are currently under NRC staff's (staff) review and staff's findings in this exemption are independent of the pending amendments. If granted, the exemption would:

1) Allow the use of a new regionalized quarter-symmetric head load (QSHL) pattern for the multipurpose canister (MPC)-68M as described in Figure 2.4-1 in BVY 17-006 Attachment 1 and in Section B.4 of this SER (also shown as Figure 2.4-1 in Holtec's Amendment No. 12 application, Appendix B)). The current allowed regionalized loading pattern for MPC-68M is shown in CoC No. 1014, Amendment No. 10, Appendix B, Figure 2.1-4. The new regionalized loading pattern would allow VYNPS to load hotter fuel from its final operating cycle with cooler fuel, as well as damaged fuel or fuel debris in a damaged fuel container (DFC), in an optimized manner. ENO would also limit the total aggregate heat load for each cask to 36.9 kilowatts (kW).

2) Allow the loading of fuel cooled for at least 2 years into the MPC-68M as described in Holtec's Amendment No. 12 application, Appendix B, Table 2.1-1, Section VI. The

current minimum cooling time is 3 years, as specified in CoC No. 1014, Amendment No. 10, Appendix B, Section 2.4.3 and Table 2.4-4, for calculating burnup limit, based on the specified range of minimum cooling times. This change would allow VYNPS to load fuel assemblies that have not been cooled for at least 3 years, as approved in the current CoC Amendment No. 10, but have been cooled for at least 2 years into MPC-68.

3) Allow the use of a per-cell maximum average burnup limit at less than or equal to 65,000 megawatt days per metric ton of uranium (MWD/MTU) as described in Holtec's Amendment No. 11 application, Appendix B, Table 2.1-1, Section VI. Currently, CoC No. 1014, Amendment No. 10, Appendix B, Section 2.4.3 describes the method and provides an equation to calculate maximum allowable fuel assembly average burnup based on fuel decay heat, enrichment, and cooling time. This is an accompanying change to the above two changes. Section 2.4.3 does not apply to the new regionalized pattern, and the equations and tables associated with Section 2.4.3 are specifically for fuel cooled for greater than or equal to 3 years.

This safety evaluation report (SER) documents the staff's review and evaluation of ENO's exemption request for VYNPS. The staff's evaluation is based on a review of ENO's application, as supplemented, and whether it meets the criteria for an exemption from the requirements of 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," (NRC 2017) for dry storage of spent nuclear fuel.

Section 72.7 of 10 CFR allows the Commission to grant exemptions from the requirements of 10 CFR Part 72 if the exemption is authorized by law and will not endanger life or property, or the common defense and security, and is otherwise in the public interest.

A. Authorized by Law

ENO stated that it plans to use Holtec's HI-STORM 100 cask system under CoC No. 1014, Amendment No. 10 (NRC 2016a), with exemption from certain requirements as noted, for the dry storage of spent nuclear fuel in MPC-68M canisters at VYNPS ISFSI. This exemption would allow VYNPS to 1) use a new 3-region QSHL pattern, as shown in Figure 2.4-1, to load hotter fuel from its final operating cycle with cooler fuel, as well as damaged fuel or fuel debris in a DFC, in an optimized manner; 2) load fuel that has been cooled for at least 2 years in MPC-68M; and 3) use a per-cell maximum average burnup limit at 65,000 MWD/MTU as described in BVY 17-006 Attachment 3. The provisions from which ENO is requesting the exemption require ENO to follow the conditions of CoC No. 1014, Amendment No. 10 (i.e., to use the regionalized loading pattern as shown in CoC Appendix B, Figure 2.1-4, to load fuel that has been cooled for at least 3 years in MPC-68M, and to use the equation in Appendix B, Section 2.4.3, to calculate maximum allowable fuel assembly average burnup based on fuel decay heat, enrichment, and cooling time).

As explained in this SER, the proposed exemption will not endanger life or property, or the common defense and security, and is otherwise in the public interest. Issuance of this exemption is consistent with the Atomic Energy Act of 1954, as amended, and not otherwise inconsistent with the NRC's regulations or other applicable laws. Therefore, issuance of the exemption is authorized by law.

B. Will Not Endanger Life or Property or the Common Defense and Security

The staff reviewed ENO's exemption request for VYNPS and concludes, as discussed below, that the proposed exemption from certain requirements of 10 CFR Part 72 will not cause the HI-STORM 100 MPC-68M to encounter conditions beyond those for which it has been evaluated and demonstrated to meet applicable safety and security requirements of 10 CFR Part 72. The staff followed the guidance of NUREG-1536 Revision 1, "Standard Review Plan for Spent Fuel Dry Cask Storage Systems at a General License Facility," July 2010 (NRC 2010). As explained below, the staff's evaluation includes only those areas of review that are relevant to ENO's requested exemption for VYNPS.

1.0 GENERAL INFORMATION

The proposed exemption would not alter the general description of the dry storage system, and thus no evaluation is necessary.

2.0 PRINCIPAL DESIGN CRITERIA EVALUATION

The proposed exemption would not alter the principal design of the dry storage system, and thus no evaluation is necessary.

3.0 STRUCTURAL EVALUATION

The objective of structural review is to ensure that the cask system will maintain confinement, subcriticality, radiation shielding, and retrievability or recovery of the fuel, as applicable, under all credible loads for normal and off-normal conditions, accidents, and natural phenomenon events.

In the exemption request, ENO requested to use the new 3-region QSHL pattern which allows for a higher overall heat load for the cask. However, in its supplement to the exemption request (BVY 17-031), ENO noted that, based on the fuels to be loaded at VYNPS, the maximum projected MPC-68M heat load will be 24.5 kW. This is well below the maximum heat load limit of 36.9 kW for MPC-68M approved in CoC No. 1014, Amendment No. 10 (NRC 2016a). Therefore, the proposed exemption is bounded by NRC's previous evaluation and would not alter the structural integrity of the dry storage system and no additional evaluation is necessary.

4.0 THERMAL EVALUATION

The objective of thermal review is to ensure that the cask and fuel material temperatures of the dry storage system will remain within the allowable values or criteria for normal, off-normal, and accident conditions. It includes confirmation that the temperatures of the fuel cladding (fission product barrier) will be maintained throughout the storage period to protect the cladding against degradation that could lead to gross rupture.

Based on Amendment No. 10 of CoC No. 1014, VYNPS is limited to loading fuel with a cooling time greater than 3 years. The requested exemption would allow VYNPS to 1) load selected fuel assemblies with shorter cooling times of at least 2 years and have a higher heat load than those currently approved for MPC-68M, and 2) use a QSHL pattern for the MPC-68M as described in Figures 2.4-1 in Attachment 1 of the

BVY 17-006 (shown below). In addition, ENO indicated that the actual total aggregated cask heat load would be limited to less than or equal to 36.9 kW.

4.1 Proposed Changes for MPC-68M

ENO proposed to add the QSHL pattern for MPC-68M as shown in Figure 2.4-1 at VYNPS. ENO stated that the QSHL pattern allows for storage of fuel assemblies with higher per-assembly heat loads in the MPC-68M. As shown in Figure 2.4-1, the maximum permissible heat load in each storage cell of the QSHL pattern is specific to its location within the quadrant and is limited to a unique prescribed value.

				1 0.5*	2 0.5*				
		3 0.5*	4 0.5	5 1.2	6 1.2	7 0.5	8 0.5*		
	9 0.5*	10 0.5	11 1.2	12 0.4	13 0.4	14 1.2	15 0.5	16 0.5*	
	17 0.5	18 1.2	19 0.4	20 0.4	21 0.4	22 0.4	23 1.2	24 0.5	
25 0.5*	26 1.2	27 0.4	28 0.4	29 0.4	30 0.4	31 0.4	32 0.4	33 1.2	34 0.5*
35 0.5*	36 1.2	37 0.4	38 0.4	39 0.4	40 0.4	41 0.4	42 0.4	43 1.2	44 0.5*
	45 0.5	46 1.2	47 0.4	48 0.4	49 0.4	50 0.4	51 1.2	52 0.5	
	53 0.5*	54 0.5	55 1.2	56 0.4	57 0.4	58 1.2	59 0.5	60 0.5*	
		61 0.5*	62 0.5	63 1.2	64 1.2	65 0.5	66 0.5*		
Cell ID Heat Load (kW)				67 0.5*	68 0.5*				

* Note: Allowable heat load is limited to 0.35 kW per cell when damaged fuel or fuel debris is stored in this location (in a damaged fuel container).

Figure 2.4-1 Per cell allowable heat loads (kW) – MPC-68M (QSHL pattern)

4.1.1 Normal Conditions of Storage

ENO referenced Holtec's thermal analyses (Holtec 2016b Section 4.III.4.2) to provide the normal storage conditions and presented the maximum fuel cladding and component temperatures of MPC-68M using the QSHL pattern under normal long-term storage in Table 4.III.3b (BVY 17-006 Attachment 2). Table 4.III.3b shows that the maximum fuel cladding temperature for QSHL pattern, with design heat load of 42.8 kW, is 708°F. Both the provisions of Spent Fuel Storage and Transportation (SFST)-Interim Staff Guidance (ISG)-11 Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel" (NRC 2003), and the design temperature in HI-STORM 100 final safety analysis report (FSAR) Revision 13 (Holtec 2016f) Table 2.2.3 provide maximum cladding temperature of 752°F under long-term normal condition.

The staff confirmed that the maximum cladding temperature of 708°F for QSHL pattern is well below the 752°F in the guidance and the component design temperature in Table 2.2.3, and provides sufficient margins under normal storage conditions for the purposes of this exemption for VYNPS. Per the proposed exemption, ENO would limit the actual total aggregated cask heat load at VYNPS to less than or equal to 36.9 kW, which is the current approved heat loading for CoC No. 1014 Amendment No. 10. Thus, the staff determines that the cladding temperature and component temperatures would be below the design temperature limits, and the staff finds ENO's reported cladding and component temperatures at normal conditions acceptable.

4.1.2 Storage of Fuel Debris

In addition to the current uniform loading pattern for DFCs, ENO proposed to store the damaged fuel or fuel debris in DFCs in a regionalized pattern which allows VYNPS to load the canister with better radiation protection strategies. As provided in the analysis referenced by ENO (Holtec 2016b Section 4.III.4.4), the damaged fuel is placed in up to 16 DFCs before long-term storage, and then the DFCs are placed for storage in basket peripheral locations within MPC, as shown in Figure 2.4-1.

As provided in ENO's referenced thermal analysis (Holtec 2016b Sections 4.III.4.4 and 4.4.4.1), since the DFCs are placed in the cold peripheral locations, they do not control the peak cladding temperature (PCT); as a substantial fraction of basket cells are occupied by intact fuel, the overall effect of DFC fuel storage on the heat dissipation from the basket is small. ENO presented the calculated results in Table 4.III.11 (BVY 17-006 Attachment 2).

The staff reviewed ENO's provided thermal analysis and the resulting PCT and component temperatures tabulated in Table 4.III.11. The staff finds that the reported PCT of 687°F under fuel debris is below 752°F, consistent with the provisions of SFST-ISG-11 Revision 3 and the design basis component temperature in HI-STORM 100 FSAR Table 2.2.3 (Holtec 2016f). The staff finds ENO reported temperatures acceptable because the actual total aggregated cask heat load at VYNPS would be less than or equal to 36.9 kW, the PCT and component temperatures would be below the design temperature limits.

4.1.3 Off-Normal Conditions of Storage

ENO referred to Holtec's thermal analyses (Holtec 2016b Section 4.III.6.1) for off-normal conditions of (a) elevated ambient air temperature and (b) partial blockage (50%) of air inlets. ENO provided the PCT and maximum component temperatures, and the maximum cavity pressures of MPC-68M (QSHL pattern, 42.8 kW heat load) in Table 4.III.15 (BVY 17-006 Attachment 2).

The staff reviewed Table 4.III.15 (BVY 17-006 Attachment 2) and ENO referenced thermal analysis (Holtec 2016b Section 4.III.6.1) , and considered the maximum total aggregated cask heat load at VYNPS at Amendment No. 10 design basis heat load of 36.9 kW. The staff confirmed that for off-normal conditions, the PCTs would be below 752°F limit, consistent with the provisions in SFST-ISG-11 Revision 3; the maximum component temperatures would be below the allowable design temperature limits in HI-STORM 100 FSAR Table 2.2.3 (Holtec 2016f); and the maximum MPC pressures

would be below the allowable design limit of 110 pounds per square inch gauge (psig) in HI-STORM 100 FSAR Table 2.2.1 (Holtec 2016f). Thus, the staff finds ENO's reported temperatures and pressures acceptable.

4.1.4 Accident Conditions of Storage

HI-STAR Fire

As provided in ENO's referenced thermal analysis (Holtec 2016b Section 4.III.6.2(a)(ii)) evaluating MPC-68M (with QSHL pattern, 42.8 kW heat load) under the HI-TRAC fire, the rate of temperature rise of the HI-TRAC depends on the thermal inertia of the cask, the cask initial conditions, the decay heat load, and the fire heat flux. The analysis used lower-bound thermal inertia, steady state maximum cask temperatures, and a design heat load of 42.8 kW and calculated a temperature rise of 24.9°F and a pressure increase of 2.9 psig during a fire period of 4.775 minutes. Table 4.III.9 (BVY 17-006 Attachment 2) shows the calculated MPC internal pressure of 103.4 psig. The staff reviewed the above information and determined ENO reported pressures acceptable for this exemption as the resulted MPC internal pressure of 103.4 psig is below the accident design limit of 200 psig in HI-STORM FSAR Table 2.2.1 (Holtec 2016f).

Burial under Debris

The analysis (Holtec 2016b Section 4.6.2.5) referenced by ENO used the same approach that NRC previously approved for burial under debris evaluation to determine the burial time and MPC cavity pressure for MPC-68M (QSHL pattern, 42.8 kW heat load). ENO presented the evaluation results in Table 4.III.16 (BVY 17-006 Attachment 2), which shows that it takes 30.7 hours for the PCT to reach the 1,058°F limit, and the maximum MPC cavity pressure of 133.3 psig remains below the accident limit of 200 psig in HI-STORM 100 FSAR Table 2.2.1 (Holtec 2016f).

The staff reviewed Table 4.III.16 and confirmed that the maximum pressure for burial under debris is below the permissible limit of 200 psig and the time-period of 30.7 hours for the PCT to reach the accident limit of 1,058°F is bounded by technical specifications (TS), surveillance requirement (SR) 3.1.2 in Appendix A, that requires cask users to verify all overpack inlets and outlets are free of blockage from solid debris every 24 hours. Thus, the staff finds ENO reported analysis results acceptable.

100% Inlet Duct Blockage

ENO referenced the thermal analysis in Section 4.III.6.2(d) (Holtec 2016b) for MPC-68M (with QSHL pattern, 42.8 kW heat load) under 100% blockage of air inlet ducts event for 32 hours, and in Table 4.III.7 (BVY 17-041), presented the maximum component temperatures and pressure. ENO stated the calculated PCT of 722°F was based on heat load limit of 36.9 kW and a maximum per-storage decay heat of 710 watts. For the cask to be loaded at VYNPS, the highest heat load is approximately 24.5 kW and the highest decay heat in any cell location is 912 watts. Since the total heat load would have more effect on the cladding temperature, ENO concluded that the maximum cladding temperature for any cask loaded at VYNPS would be below 722°F. The staff reviewed the above information and noted that only 16 cell locations in the QSHL pattern would have decay heat between 500 watts and 912 watts (others have lower decay heat) and the total heat load would be the major contributor to cladding temperature.

Therefore, the staff determined ENO's conclusion is reasonable in that the highest heat load of 24.5 kW at VYNPS is much lower than the 36.9 kW used for the calculation. The staff also confirmed that the calculated PCT of 722°F is below 1,058°F, consistent with SFST-ISG-11 Revision 3; the maximum cask component temperatures would be below the allowable design temperature limits in HI-STORM 100 FSAR Table 2.2.3 (Holtec 2016f); and the calculated maximum MPC-68M pressure of 116.3 psig is below the accident limit of 200 psig in HI-STORM 100 FSAR Table 2.2.1 (Holtec 2016f). Thus, the staff finds ENO reported analysis results acceptable.

<u>100% Fuel Rod Rupture</u>

ENO referenced analysis in Section 4.III.6.2(f) (Holtec 2016b), which evaluated 100% rod rupture event assuming the release of 100% of the fill gases and fission gas, which is consistent with NUREG-1536 release fractions. ENO presented the maximum pressures for the MPC-68M (QSHL pattern, 42.8 kW heat load) in Table 4.III.4 (BVY 17-031 Attachment 2).

The staff reviewed the above information and determined ENO's reported analysis results are acceptable by confirming that the calculated maximum MPC-68M pressure of 152 psig is below the accident limit of 200 psig in HI-STORM 100 FSAR Table 2.2.1 (Holtec 2016f).

<u>Time to Boil in Wet Transfer</u>

ENO referenced analysis in Section 4.III.5.2 (Holtec 2016b), which calculated the time to boil for QSHL pattern using the methodology described in HI-STORM 100 FSAR Section 4.5.2 (Holtec 2016f), and using the thermal inertia of the constituent components in Table 4.III.13 (BVY 17-006 Attachment 2). ENO presented the results in Table 4.III.14 (BVY 17-006 Attachment 2).

The staff reviewed the thermal model of the QSHL pattern and relevant information and determined that the time-to-boil limits provided in Table 4.III.14 are acceptable because the time-to-boil limits are calculated using the same methodology which was approved by NRC in CoC No. 1014, Amendment No. 9 (NRC 2016b).

<u>Jacket Water Loss</u>

ENO references analysis in Section 4.III.6.2(g) (Holtec 2016b), which indicated that the jacket water loss will cause a temperature increment in the stored fuel from the baseline conditions when MPC is in the HI-TRAC. ENO presented the MPC-68M temperatures, using the QSHL pattern and 42.8 kW heat load, in Table 4.III.6 (BVY 17-006 Attachment 2).

The staff reviewed Table 4.III.6, information in BVY 17-006, and the analysis referenced by ENO, and confirmed that the calculated PCT of 709°F is below the accident limit of 1,058°F, consistent with SFST-ISG-11 Revision 3, and the maximum cask component temperatures is below the design limits in HI-STORM 100 FSAR Table 2.2.3 (Holtec 2016f). The calculated maximum MPC-68M cavity pressure of 100.5 psig is also below the accident limit of 200 psig in HI-STORM 100 FSAR Table 2.2.1 (Holtec 2016f). Therefore, the staff finds ENO reported analysis results for this exemption request acceptable.

Extreme Ambient Temperature

As provided in ENO's referenced analysis (Holtec 2016b Section 4.III.6.2(e)), the thermal evaluation was performed for MPC-68M with the QSHL pattern and a design decay heat of 42.8 kW under the extreme ambient temperature of 125°F. ENO presented the PCT, maximum component temperatures, and maximum MPC-68M pressure in Table 4.III.17 (BVY 17-006 Attachment 2).

The staff reviewed Table 4.III.17, information in BVY 17-006, and analysis referenced by ENO, and confirmed that the calculated PCT of 753°F is below the accident limit of 1,058°F, consistent with SFST-ISG-11 Revision 3; and the maximum cask component temperatures are below the allowable design temperature limits in HI-STORM 100 FSAR Table 2.2.3 (Holtec 2016f). The calculated maximum MPC-68M cavity pressure of 103.9 psig is also below the accident limit of 200 psig in HI-STORM 100 FSAR Table 2.2.1 (Holtec 2016f). Therefore, the staff finds ENO's reported analysis results acceptable.

4.2 Proposed Changes in Appendix A, Technical Specifications, and Appendix B, Approved Contents and Design Features, of CoC No. 1014, Amendment No. 10

Surveillance Requirement (SR) 3.1.2 in CoC Appendix A

ENO revised SR 3.1.2 in CoC Appendix A to add a limit of less or equal to 164°F on the difference between the average overpack air outlet temperature and the ISFSI ambient temperature to reflect the proposed addition of the QSHL pattern with maximum heat load of 42.8 kW.

The staff reviewed Table 4.III.3b (BVY 17-006 Attachment 2) and accepts a limit of less than 164°F for the difference between the average overpack air outlet temperature and the ISFSI ambient temperature. This is consistent with the difference between the area-averaged air outlet temperature of 244°F shown in Table 4.III.3b and the ISFSI ambient temperature of 80°F under normal long-term storage.

Table 3-1 in CoC Appendix A

ENO revised Table 3-1 in CoC Appendix A for the proposed QSHL pattern to specify that forced helium dehydration (FHD) is the method of moisture removal for VYNPS when loading fuel to MPC-68M containing at least one assembly with burnup greater than 45,000 MWD/MTU.

The staff finds ENO's revisions in Table 3-1 acceptable because FHD is a drying method appropriate for moisture removal of a canister loaded with fuel burnup greater than 45,000 MWD/MTU in one or more fuel assemblies, as approved in HI-STORM 100 Amendment No. 2 (NRC 2005).

Table 3-2 and Table 3-3 in CoC Appendix A

ENO revised Table 3-2 in CoC Appendix A to specify MPC helium backfill limits (≥ 43.5 psig and ≤ 46.5 psig) for MPC-68M with QSHL pattern and heat load limit of 42.8 kW as shown in the BVY 17-006. ENO also revised Table 3-3 in CoC Appendix A to clarify that the heat load limits for MPC-68/69F/68-EF as provided are also applicable to MPC-68M, but not applicable to MPC-68M with QSHL pattern as shown in Figure 2.4-1.

The staff finds that ENO's revisions in Table 3-2 on MPC helium backfill limits for MPC-68M with QSHL pattern and Table 3-3 on regionalized storage cell heat load limits for MPC-68M are acceptable because they conform to the proposed QSHL pattern shown in Figure 2.4-1.

Section 2.4.2 in CoC Appendix B

ENO revised Section 2.4.2 of CoC Appendix B in four areas.

The first change deletes the restriction that only "intact or undamaged fuel" is loaded in a regionalized manner because the proposed 3-region QSHL pattern as shown in Figure 2.4-1 allows for the loading of damaged fuel in regionalized manner.

The second change identifies that when loading fuel in accordance with the existing 2-region method shown in Table 2.4-2 of CoC Appendix B, the exemption request does not alter the requirement that all fuel assemblies be intact.

The third change introduces an optional 3-region QSHL pattern for the MPC-68M as shown in Figure 2.4-1. When loading fuel according to Figure 2.4-1, it allows VYNPS to store a selected number of fuel assemblies with higher per-assembly heat loads and a minimum cooling time of 2 years in the MPC-68M. The proposed change also allows for the storage of damaged fuel or fuel debris in a DFC in specified locations as shown in Figure 2.4-1.

ENO stated that the proposed optional regionalized loading pattern, as specified in Figure 2.4-1, was thermally evaluated for MPC-68M with all undamaged fuel assemblies and for MPC-68M with damaged fuel and/or fuel debris stored in the peripheral locations. ENO concluded that the fuel and cask component temperatures are maintained below the required limits.

The fourth change directs the actual heat load value for each assembly of the MPC-68M to be calculated utilizing SCALE 4.3, based on the assembly burnup, enrichment, cooling time, the operating parameters in HI-STORM 100 FSAR Section 5.2 and the fuel parameters from CoC Appendix B Table 2.1-1. ENO calculates assembly heat load and then compares to the maximum allowable decay heat for the assembly storage location that is determined by calculation using the existing 2-region loading in CoC Appendix B Table 2.4-2, or taken directly from the proposed regionalized loading pattern shown in Figure 2.4-1.

Therefore, staff concludes that the four changes in Section 2.4.2 in CoC Appendix B are consistent with and conform to ENO proposed changes.

<u>Note 1 in Table 3.4-2 in CoC Appendix B</u>

ENO added Note 1 to CoC Appendix B, Table 2.4-2 for an optional regionalized pattern for MPC-68M.

The staff reviewed Note 1 in Table 2.4-2 and confirmed that this is a consistency change associated with changes in Section 2.4.2 of CoC Appendix B (see above) and reflects a proposed addition of an optional regionalized loading pattern, Figure 2.4-1 of CoC Appendix B.

<u>Figure 2.4-1 of CoC Appendix B</u>

ENO added Figure 2.4-1 to CoC Appendix B as an optional regionalized loading pattern which allows for the storage of fuel assemblies with higher per-assembly heat loads in an MPC-68M. The staff reviewed Figure 2.4-1 and confirmed that the loading pattern is consistent with the proposed QSHL pattern for MPC-68M loaded with intact fuel or damaged fuel/fuel debris.

4.3 Evaluation Findings

The staff verified that the calculated fuel cladding temperatures fall below the allowable limits of 400°C (752°F) for normal conditions and 570°C (1,058°F) for off-normal and accident conditions, consistent with SFST-ISG-11 Revision 3. The staff also verified that other cask component temperatures are below the allowable design temperature limits in HI-STORM 100 FSAR Table 2.2.3 for normal, off-normal, and accident conditions of storage at VYNPS ISFSI. The staff confirmed that the heat removal capability of the MPC-68M, using QSHL pattern and actual total aggregated cask heat load of 36.9 kW, loaded with all undamaged fuel assemblies or loaded with damaged fuel and/or fuel debris at VYNPS ISFSI remains acceptable and meets the requirements of 10 CFR 72.122(h)(1) and 72.236(f).

5.0 CONFINEMENT EVALUATION

The proposed exemption would not alter the confinement boundary of the dry storage system, and thus no evaluation is necessary.

6.0 SHIELDING EVALUATION

The objective of a shielding review is to ensure that, with the requested exemption, the design of the HI-STORM 100 cask system continues to provide adequate protection against direct radiation to the onsite operating workers and members of the public, and that the ISFSI continues to satisfy the regulatory requirements during normal operating, off-normal, and design-basis accident conditions. Specifically, the review seeks to ensure the shielding design would continue to meet the operational dose requirements of 10 CFR Part 20 and 10 CFR 72.104 and 72.106 in accordance with 10 CFR 72.236(d).

ENO's exemption request would allow VYNPS to use the new 3-region QSHL pattern and loading irradiated fuel cooled for at least 2 years in the HI-STORM 100 MPC-68M using Amendment No. 10 of Holtec HI-STORM 100 CoC No. 1014.

Evaluation of the 3-Region QSHL Pattern

All MPC baskets in the HI-STORM 100 system, except MPC-68F, allows for two loading strategies, namely the uniform fuel loading and the 2-region loading. ENO references analysis in Supplement 5.III (Holtec 2016b), which evaluated an optional 3-region QSHL pattern, shown in Figure 2.4-1, to determine its acceptability as approved contents in the MPC-68M only. The staff found this new QSHL pattern acceptable for this exemption since it is bounded by the previously NRC-approved uniform pattern as discussed below.

As provided in ENO's referenced analysis (Holtec 2016b Supplement 5.III, Holtec 2016e), the proposed QSHL pattern was evaluated for the MPC-68M and compared it with the design basis uniform loading pattern (Holtec 2016b Table 5.III.2). The dose rates on the surface and at distances near the 100-ton HI-TRAC with a 9.5-inch thick MPC lid were calculated. It is important to calculate dose rates near to the surface because it helps to determine the distance and length of time that the radiation workers can work around the cask. The analysis used GE 7x7 assembly for the boiling-water reactor (BWR) fuel assembly and assumed that the occupancy factor for the controlled area boundary calculations is 8,760 hours per year, which is the full occupancy for the entire year. GE 7x7 assembly is the design basis fuel assembly used for the HI-STORM 100 Cask System in previous amendments, and it bounds all 8x8, 9x9, and 10x10 assembly types used at VYNPS.

The enrichment of the fresh fuel assembly of 3.4 wt.% uranium (U)-235 is used to calculate the material compositions for U-235 and U-238 in the active fuel region using Monte Carlo N-Particle (MCNP) code. The staff found this assumption conservative because the actual spent fuel to be stored in a storage cask has fewer amounts of fissile isotopes due to burnup as compared to fresh fuel. Fission products in the burned fuel, which decrease the neutron multiplication factor, are conservatively not considered. The cobalt-59 impurity level is assumed to be 1.0 g/kg for the hardware above and below the active fuel region and for the grid spacers. The back-row factor of the casks in the second row is calculated. Back-row factor means that casks located in a second row will have lower dose rates because it uses the first row as a shielding barrier. The analysis referenced by ENO used an updated version of SCALE (SCALE 5.1) for source terms and dose rates calculations which is consistent with other NRC-approved similar applications. Comparison of the dose rates of the 3-region QSHL pattern and uniform loading pattern showed that uniform loading bounds the 3-region QSHL pattern by a margin of approximately 17%.

Evaluation of Fuels Cooled for 2 Years

The staff performed confirmatory analyses on source terms calculations based on the data provided in ENO's referenced analysis (Holtec 2016b Supplement 5.III, Holtec 2016e) for fuels with 2-year cooling time in QSHL pattern. The staff concluded that the confirmatory source term calculations showed that the uniform loading content with fuels of 3-year cooling bounds the 3-region QSHL pattern with fuels of 2-year cooling.

Evaluation of Burnup Limit

ENO has established that it will use 65,000 MWD/MTU maximum burnup limit as specified in Table 2.1-1 (BVY 17-006 Attachment 3) in lieu of calculating individual burnup limits as specified in CoC Appendix B, Section 2.4.3. The NRC staff found this

burnup limit to be acceptable since the maximum average burnup for any fuel assembly to be stored under this exemption request is 52,000 MWD/MTU, the difference between the 65,000 MWD/MTU maximum burnup limit and the actual site-specific maximum value of 52,000 MWD/MTU is at least 20%. This margin is substantially greater than the 5% conservatism built into the equations in CoC Appendix B, Section 2.4.3 and accompanying tables.

6.1 Evaluation Findings

Based on the assumptions stated above for the MPC-68M, and the results of the source terms and dose rates calculations discussed above, the staff finds that the 3-region QSHL pattern to be used at the VYNPS in the exemption request is acceptable because the 3-region QSHL pattern is bounded by the design basis loading pattern and will allow the MPC-68M to maintain the dose rates below the applicable regulatory limits in 10 CFR Part 20 and 10 CFR 72.104 and 72.106. In addition, the use of the maximum average burnup limit of 65,000 MWD/MTU is acceptable for the purposes of this exemption as it provides sufficient conservatism.

7.0 CRITICALITY EVALUATION

The proposed exemption would not alter the criticality design and analyses related to the dry storage system, and thus no evaluation is necessary.

8.0 MATERIALS EVALUATION

The objective of this review is to ensure adequate material performance of components important to safety of the spent fuel storage system under normal, off-normal, and accident conditions.

The staff reviewed the information provided by ENO including additional consistency, or complementary, changes to Appendix A and Appendix B of CoC No. 1014, Amendment No. 10 and evaluated the three changes requested in ENO's exemption request:

1) Introduction of an optional regionalized loading pattern for the MPC-68M.
2) Allowance for fuel cooled for at least 2 years to be loaded into the MPC-68M compared to minimum cooling time of 3 years as specified in CoC No. 1014, Amendment No. 10, Appendix B.
3) The establishment of a per-cell maximum average burnup limit at 65,000 MWD/MTU.

The staff reviewed the Appendix A, TS, changes associated with the ENO's exemption request:

- SR 3.1.2: Changes to the spent fuel storage cask (SFSC) heat removal system and the maximum temperature difference between the overpack air outlet temperature and the ISFSI ambient temperature for the MPC-68M.
- Table 3-1: MPC cavity drying limits for all MPC types with additional heat load limits for the MPC-68M depending on fuel burnup and method of moisture removal.
- Tables 3-2 and 3-3: MPC helium backfill limits for loading an MPC-68M.

Changes to Appendix B, Approved Contents and Design Features, associated with ENO's exemption request include:

- Section 2.1: Regionalized fuel loading to allow for the storage of damaged fuel or fuel debris in a DFC in specified locations in the MPC-68M.
- Table 2.1-1: Fuel assembly limits for the MPC-68M including revision of the cooling time to ≥ 2 years, an increase in the average burnup to ≤ 65,000 MWD/MTU and revised per assembly decay heat specifications.
- Section 2.4.2: Addition of an optional regionalized loading pattern for MPC-68M that allows for the loading of damaged fuel, allowing increased heat loads for fuel that has been cooled for greater than 2 years, and changes to the calculation of the assembly heat load.
- Figure 2.4-1: Per-cell allowable heat loads (kW) for the MPC-68M for the optional regionalized loading pattern allows for the storage of fuel assemblies with higher per assembly heat loads.

8.1 Applicable Codes and Standards for System Design and Materials

ENO did not propose any changes that affect the staff's principal design criteria evaluation provided in previous safety evaluations for CoC No. 1014, Amendments Nos. 0 through 10. Therefore, the staff determined that a new evaluation was not required.

8.2 Environmental Conditions

ENO provided the operational environment for the components of the HI-STORM 100 Cask system in the exemption request. As a result of loading fuel with less cooling time (at least 2 years instead of 3 years), ENO's exemption request includes higher temperatures for some structures, systems, and components (SSCs) for the MPC-68M, including subcomponents of the MPC, HI-TRAC Transfer cask, and the HI-STORM overpack. The thermal evaluation is presented in Section B.4 of this SER. The staff reviewed the environmental description to verify its accuracy, such as the material evaluations under normal, off normal, and accident conditions.

Other than the higher temperatures associated with loading fuel with at least 2 years of cooling, all other operational environments are identical to previously approved HI-STORM 100 amendments and are not reevaluated in this SER.

ENO provided peak fuel cladding temperatures for different loading configurations in Table 4.III.3a (BVY 17-006 Attachment 2). ENO indicated that the highest peak cladding temperature was obtained for the QSHL pattern. As such, the QSHL pattern was used for all licensing basis evaluations for fuel storage in the MPC-68M.

ENO provided maximum temperatures for the MPC under normal long-term storage or on-site transfer in Table 4.III.3b (BVY 17-006 Attachment 2). It indicates that the MPC shell may reach 499°F, the basket may reach temperatures as high as 674°F, and the aluminum alloy basket shims may reach temperatures of 563°F. The maximum temperature for the HI-STORM overpack inner steel shell is 358°F in Table 4.III.3b. Maximum concrete temperatures are 257°F for the overpack lid and 252°F for the overpack body.

ENO provided maximum steady state temperatures and pressures during on-site transfer operations in Table 4.III.6 (BVY 17-006 Attachment 2). The staff reviewed the maximum temperatures for each component and compared the values listed in Table 4.III.6 to the design temperatures in HI-STORM 100 FSAR Table 2.2.3 (Holtec 2016f) for the component materials. The maximum temperatures of all components of the HI-TRAC Transfer cask remain below the allowable temperature limits for the materials of construction. The maximum temperature for all components of the fuel cladding and the MPC, including the MPC shell and the MPC basket shims, remain below the respective allowable temperature limits for the materials of construction. ENO reported that while the peak temperature in the basket shim is 563°F, the cross-sectional average temperature of the shim at the peak temperature location is about 500°F and the volumetric average temperature of the shim is less than 450°F. ENO provided an analysis (BVY 17-031) to show that the maximum stress of the MPC basket shims is significantly smaller than the yield strength of the material after exposure at 550°F for 10,000 hours. The analysis provided by ENO demonstrates that the basket shims have adequate material properties at the calculated maximum temperature.

ENO provided the maximum temperatures and pressures for the HI-STORM 100 storage system under a 32-hour 100% air inlet blockage accident in Table 4.III.7 (BVY 17-041). ENO stated that the actual maximum heat load for any future loading at VYNPS would be approximately 24.5 kW which is well below the maximum heat load of 36.9 kW approved for HI-STORM 100, Amendment No. 10 systems (NRC 2016a) used at VYNPS. Using a maximum heat load of 36.9 kW, the maximum cladding temperature for a 32-hour 100% air inlet blockage accident is 722°F. ENO stated that because future loadings at VYNPS are well below the maximum allowable cask heat load, the maximum cladding temperature would be bounded by the limits approved for Amendment No. 10 for a 32-hour 100% air inlet blockage accident. Under these conditions, the fuel cladding would not exceed the long-term normal temperature limit of 752°F. The temperatures of the austenitic stainless steel MPC shell and MPC lid do not exceed the American Society of Mechanical Engineers (ASME) code limits for these materials. The temperature of the MPC basket is well below the off-normal and accident temperature limits for short-term events. The temperature of the overpack inner shell is below the off-normal and accident temperature limit for the steel components of the overpack steel structure. For concrete temperatures, ENO referenced the concrete temperature limits in the approved CoC No. 1014, Amendment No. 10 (NRC 2016a) which is based on the guidance on temperature limits for concrete in American Concrete Institute (ACI)-349 (ACI 1985). ENO also noted that for the fuel to be loaded at VYNPS, the maximum projected MPC-68M heat load will be approximately 24.5 kW which is well below the MPC-68M heat maximum load limit of 36.9 kW approved in CoC No. 1014, Amendment No. 10 (NRC 2016a).

The staff reviewed ENO's description of the operating environments for the spent fuel to be stored, MPC, HI-TRAC transfer cask, and the HI-STORM overpack. The staff reviewed the calculated maximum temperatures for the fuel cladding, MPC, HI-TRAC transfer cask, and the HI-STORM overpack and compared the calculated temperatures to the ASME Boiler & Pressure Vessel (B&PV) code allowable temperatures. The staff determined that the fuel cladding temperatures for the spent fuel to be stored under normal, off-normal, and accident conditions are acceptable because the temperatures under these conditions are consistent with the regulatory guidance described in NUREG-1536 Revision 1, Section 8.4.17. The staff determined that for the ASME B&PV

code materials, the calculated temperatures were acceptable because they were below the allowable temperatures specified by the ASME B&PV code.

The staff also reviewed ENO's descriptions of the operating procedures described in the exemption request. The staff determined the calculated temperatures for the MPC basket shims were acceptable because ENO provided adequate material properties strength at the calculated maximum temperature as required by the ASME B&PV code (ASME 1997). The staff determined that the maximum concrete temperatures are below the approved values in CoC No. 1014, Amendment No. 10 for normal, off-normal, and accident conditions because the maximum heat load of the MPC-68M systems to be loaded at VYNPS are well below the approved maximum heat load limits. The staff determined that the maximum concrete temperatures under normal, off-normal, and accident conditions are acceptable because the allowable temperature limits are based on the guidance for concrete in ACI-349 (ACI 1985). Based on the staff's verification of the information provided by ENO, the staff determined that ENO's description of the operating environments is accurate and acceptable. The staff finds that the descriptions of the operating environments use of consensus codes and standards and the materials evaluation are consistent with the guidance in NUREG-1536 Revision 1.

8.3 Engineering Drawings

ENO did not propose any changes that affect the staff's principal design criteria evaluation provided in previous safety evaluations for CoC No. 1014, Amendments No. 0 through 10. No new drawings were included as part of the ENO's exemption request. Therefore, the staff determined that a new evaluation was not required.

8.4 Material Selection (Structural)

The staff reviewed the structural calculation package (Holtec 2016d) referenced by ENO, including the revision provided in the supplement to the exemption request, to determine whether the selected materials are acceptable for their structural applications.

Materials used in the MPC confinement boundary are identical to the materials specified in previously approved HI-STORM 100 amendments. This includes materials used in the MPC basket, the HI-TRAC transfer cask, and the HI-STORM overpack. ENO provided updated fracture toughness values of the Metamic-HT basket materials in the supplement (Holtec 2017a). The updated fracture toughness values are based on laboratory measurements using standardized test methods and were used in the revised structural calculation package used to support the application.

The staff reviewed the revised structural calculation package on the fracture toughness testing method and the results of the fracture toughness measurements. The staff determined that the fracture toughness measurements were adequate because ENO used an appropriate standardized test method. As noted in Section B.3.0 of the SER, since the proposed exemption would not alter the structural integrity of the storage system approved in CoC No. 1014, Amendment No. 10 (NRC 2016a), no additional evaluation is necessary. The staff determined that the fracture analysis provided by ENO was acceptable because ENO used a fracture toughness values that was below the minimum measured value and considered a flaw equal to the minimum detectable flaw size.

8.4.1 Multipurpose Canister Confinement

The exemption request did not include material changes to the MPC materials. Since the MPC materials have previously been approved, no additional review was conducted on the MPC materials.

8.5 Material Properties

The materials for the ENO's exemption request are identical to the materials specified in previously approved HI-STORM 100 amendments. This includes materials used in the MPC basket, the HI-TRAC transfer cask, and the HI-STORM overpack. Since the HI-STORM 100 system used in the exemption request uses materials that have previously been approved, no additional review was conducted on the HI-STORM 100 system materials.

8.6 Weld Design and Specification

The exemption request did not include changes to the weld design and specifications or changes to the MPC materials. Since the MPC weld design and specifications or materials have previously been approved, no additional review was conducted.

8.7 Fuel Cladding

8.7.1 Fuel Cladding Temperature Limits

As provided in ENO's referenced thermal analysis (Holtec 2016b Supplement 4.III), MPC-68M was evaluated to address regionalized loading and identified fuel cladding temperatures under both normal, off normal, and accident conditions. BVY 17-006 Table 4.III.3a shows the fuel loading pattern screening evaluations. ENO showed that the new QSHL pattern resulted in the highest PCT. Therefore, ENO based the revised analysis on the QSHL pattern for all the licensing basis evaluations of fuel to support its exemption request.

BVY 17-006 Table 4.III.3b provides the maximum temperatures under normal long-term storage. ENO showed that the maximum cladding temperature was below the 400°C (752°F) identified in NUREG-1536 Revision 1 for normal conditions of storage and short-term loading operations.

BVY 17-006 Table 4.III.6 shows the maximum steady state HI-TRAC temperatures and pressures during on-site transfer operations. ENO showed that the maximum cladding temperature was below the 400°C (752°F) identified in NUREG-1536 Revision 1.

BVY 17-041 Table 4.III.7 shows the maximum temperatures and pressures under a 32-hour 100% air inlets blockage accident. ENO stated that the maximum cladding temperature is consistent with the guidance in NUREG-1536 Revision 1 which states that for off-normal and accident conditions, the maximum cladding temperature should not exceed 570°C (1,058°F).

BVY 17-006 Table 4.III.11 shows the HI-STORM temperatures under fuel debris storage. ENO stated that the maximum cladding temperature was below the 400°C (752°F) identified in NUREG-1536 Revision 1.

BVY 17-006 Table 4.III.15 shows the off-normal condition maximum HI-STORM temperatures and MPC cavity pressures. ENO stated that the maximum cladding temperature was below the 400°C (752°F) identified in NUREG 1536 Revision 1.

BVY 17-006 Table 4.III.17 shows the extreme environmental accident condition maximum HI-STORM temperatures and MPC cavity pressure. ENO shows that the maximum cladding temperature is consistent with the guidance in NUREG-1536 Revision 1 which states that for off-normal and accident conditions, the maximum cladding temperature should not exceed 570°C (1,058°F).

The staff reviewed ENO's calculated cladding temperatures to confirm that there is reasonable assurance that creep will not cause gross rupture of the cladding and that hydride reorientation will not degrade the mechanical properties of the cladding. The guidance in NUREG-1536 Revision 1 establishes a maximum fuel cladding temperature limit of 400°C for normal storage conditions and short-term loading operations and 570°C for off-normal and accident conditions. The staff reviewed the thermal analyses and confirmed that ENO's calculated temperatures are below these maximum temperature limits.

8.8 Evaluation Findings

F.8.1 The exemption request adequately describes the materials that are used for SSCs important to safety and the suitability of those materials for their intended functions in sufficient detail to evaluate their effectiveness.

F8.2 The exemption request has met the requirements of 10 CFR 72.122(a). The material properties of SSCs important to safety conform to quality standards commensurate with their safety function.

F8.3 The exemption request has met the requirements of 10 CFR 72.104(a), 10 CFR 72.106(b), and 10 CFR 72.124. Materials used for criticality control and shielding are adequately designed and specified to perform their intended function.

F8.4 The exemption request has met the requirements of 10 CFR 72.122(h)(1) and 10 CFR 72.236(h). The design of the HI-STORM 100 storage system and the selection of materials adequately protect the spent nuclear fuel (SNF) cladding against degradation that might otherwise lead to damaged fuel.

F8.5 The exemption request has met the requirements of 10 CFR 72.236(h) and 10 CFR 72.236(m). The material properties of SSCs important to safety will be maintained during normal, off-normal, and accident conditions of operation so that the SNF can be readily retrieved without posing operational safety problems.

F8.6 The exemption request has met the requirements of 10 CFR 72.236(g). The material properties of SSCs important to safety will be maintained during all conditions of operation so that the SNF can be safely stored for the minimum required years and maintenance can be conducted as required.

The staff concludes that the material properties of the SSCs of the HI-STORM 100 storage system in the ENO's exemption request are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the material properties provides reasonable assurance that the HI-STORM 100 in the ENO's exemption request will allow for the safe storage of SNF for a licensed (certified) life of 20 years. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

9.0 OPERATING PROCEDURES EVALUATION

The proposed exemption would not alter the operating procedures, and thus no evaluation is necessary.

10.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM EVALUATION

The proposed exemption would not alter the acceptance tests and maintenance program, and thus no evaluation is necessary.

11.0 RADIATION PROTECTION EVALUATION

The objective of the radiation protection evaluation is to determine whether the design features and operations meet the regulatory requirements.

VYNPS currently has spent BWR fuel assemblies stored at its ISFSI in thirteen (13) HI-STORM 100 casks under CoC No. 1014, Amendment No. 2. ENO plans to load the remaining spent fuel assemblies in a total of 45 MPC-68/68M canisters by the end of 2018. ENO presented in Holtec proprietary Report No. HI-2146076 (BVY 17-006 Attachment 6) the dose versus distance calculations and results for the ISFSI loaded with the total of 58 casks. The fuel assemblies at VYNPS have the same parameters (i.e., burnup, initial U-235 enrichment, and cooling time) as Case 1 and Case 2 patterns used in the dose calculations in Report No. HI-2146076. Case 1 and Case 2 casks have the following characteristics:

Case 1 casks represent all casks to be loaded in 2017/2018 campaign. All 68 fuel assemblies have:
- a burnup of 50,500 MWD/MTU
- an initial U-235 enrichment of 3.6 wt.%
- a cooling time of 5 years

Case 2 casks represent casks that are already in the ISFSI and were loaded prior to 2016. All 68 fuel assemblies have:
- a burnup of 53,000 MWD/MTU
- an initial U- 235 enrichment of 3.6 wt.%
- a cooling time of 13 years

The dose rates at several distances from the HI-STORM 100 cask were calculated based on the actual fuel loading plan and ENO had submitted the information as supplemental information to the previous exemption request dated January 9, 2017 (ENO 2017e). The dose rates from the actual fuel loading plan for each cask at the VYNPS ISFSI are lower than the dose rates from casks loaded with the Case 1 and

Case 2 fuel assembly parameters. Thus, the dose rates from the actual fuel loading at VYNPS ISFSI are bounded by NRC previously approved loading.

As demonstrated in previous HI-STORM 100 amendments, there are no accidents which would significantly affect shielding effectiveness of the HI-STORM 100 system. The design basis accidents analyzed may affect the shielding materials, more specifically the water jacket shell, of the HI-TRAC transfer casks. The accident consequence analyses assumed that the water (neutron shield) is completely lost from the water jacket and replaced by a void, and demonstrated that the requirements of 10 CFR 72.106 were met by the HI-STORM 100 system (HI-STORM and HI-TRAC) at 100 meters (328 feet). For the ISFSI at VYNPS, the controlled area boundary is located further than 100 meters from the ISFSI.

The staff evaluates the source terms through confirmatory analysis using SCALE 6.1 and verified that the source terms for Case 1 bounds the source terms for Case 2. The staff also reviewed ENO provided calculated dose rates for normal, off-normal, and accident conditions (BVY 17-006 Attachment 6) and found it acceptable because it demonstrates that dose rates and annual dose, at 100 meters to 800 meters from the ISFSI, are in compliance with the dose limits specified in 10 CFR Part 20 and 10 CFR 72.104 and 72.106.

11.1 Evaluation Findings

The staff concludes that there is reasonable assurance the VYNPS ISFSI continues to satisfy the requirements for the dose limits as specified in 10 CFR Part 20 and 10 CFR 72.104 and 72.106. The staff reached this finding on the basis of an application review and consideration of the regulation in 10 CFR Part 72 and accepted practices.

12.0 ACCIDENT ANALYSES EVALUATION

The staff evaluates ENO's identification and analysis of hazards as well as the summary analysis of system responses to both off-normal and accident or design-basis events to ensure that ENO has conducted thorough accident analyses. The detailed evaluations are provided in Sections B.4.1, B.8, and B.11.0 of this SER.

The staff concludes that ENO's thermal analyses for accident conditions of storage is acceptable as described in Section B.4.1.4 of this SER. The calculated maximum fuel cladding and cask component temperatures under accident conditions of HI-STAR fire, burial under debris, 100% inlet duct blockage, 100% fuel rod rupture, time to boil in wet transfer, jacket water loss, and extreme hot ambient are below the allowable limits provided in Table 2.2.3 (Holtec 2016f).

As described in Section B.8 of this SER, the staff also concludes that ENO has met the requirements of 10 CFR 72.236(h) and 10 CFR 72.236(m) in that the material properties of SSCs important to safety will be maintained during normal, off normal, and accident conditions of operation so that the SNF can be readily retrieved without posing operational safety problems.

In addition, as described in Sections B.6 and B.11 of this SER, the staff finds ENO has demonstrated that dose rates and annual dose at the site boundary are in compliance with the dose limits specified in 10 CFR Part 20 and 10 CFR 72.104 and 72.106.

13.0 TECHNICAL SPECIFICATIONS AND OPERATING CONTROLS AND LIMITS

The review of the TS and its operating controls and limits ensures that the operating controls and limits of the TS, including their bases and justification, meet the requirements of 10 CFR Part 72.

The staff reviewed ENO's proposed TS revisions against the proposed changes and documented the evaluation in Sections B.4.2 and B.8 of this SER, and determined that it is consistent and accurately reflect the proposed changes.

The staff concludes that the limiting condition for operation and SRs of TS for use of the HI-STORM 100 system continue to satisfy 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The TS provides reasonable assurance that the system will continue to provide for safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices.

14.0 QUALITY ASSURANCE EVALUATION

The proposed exemption would not alter the quality assurance program, and thus no evaluation is necessary.

Based on these evaluations, the staff has concluded that granting this exemption will be consistent with the requirements of 10 CFR Part 72 and will not endanger life or property.

ENO's exemption request is not related to any security or common defense aspect of the VYNPS ISFSI. Therefore, granting the exemption would not result in any potential impacts to common defense and security.

C. Otherwise in the Public Interest

In determining whether granting the exemption is in the public interest, the staff considered the no-action alternative of denying the exemption request. Denial of the exemption request would require ENO to load and store spent fuel in accordance with the current conditions of Amendment No. 10 of CoC No. 1014, which uses the regionalized loading pattern shown in CoC Appendix B, Figure 2.1-4, requires fuel to be cooled for at least 3 years, and requires the use of the equation in Appendix B, Section 2.4.3, to calculate maximum allowable fuel assembly average burnup based on fuel decay heat, enrichment, and cooling time.

ENO's proposed exemption would allow VYNPS to use a new regionalized QSHL pattern as described in Figure 2.4-1; load fuel that has been cooled for at least 2 years in MPC-68M; and use a per-cell maximum average burnup limit at 65,000 MWD/MTU as described in Holtec's Amendment No. 11 application, Appendix B, Table 2.1-1, Section VI. With this exemption, VYNPS would be able to use a more optimized loading pattern for MPC-68M, so that VYNPS could store hotter fuel from its final operating cycle, as well as for storing damaged fuel or fuel debris in a DFC, with cooler fuel in the same cask. By loading higher-burned, shorter-cooled assemblies into the inner regions of the cask and low-burned, longer-cooled assemblies on the periphery of the cask, the longer-cooled assemblies on the periphery of the cask acts as shielding and blocks the radiation from the shorter-cooled fuel assemblies stored in the inner region of the cask. ENO noted that this loading pattern would significantly reduce dose rates to

onsite workers and at site boundary. As discussed in Section B.6 of this SER, this exemption would result in a reduction in dose rate, and the site-specific loading plan also demonstrates that the dose rates at site boundary remains below NRC's regulatory limits.

ENO noted that the approval of the exemption request will facilitate a continuous loading campaign without interruption to wait for the fuel to meet the heat loading requirement for individual cell location. ENO also noted that this could avoid potential higher personal exposure and human errors due to loss of experienced workers.

ENO indicated that by using this exemption, VYNPS would be able to complete the transfer of irradiated fuel to the ISFSI within a shorter time period (completed by 2018 instead of 2020). It would permit the spent fuel pool-related SSCs to be removed from service earlier, and allow for staffing reductions to a level commensurate with dry fuel storage only operations. ENO also noted that this would reduce VYNPS's costs associated with the maintenance of SSCs for wet fuel storage. ENO estimated the savings to the Decommissioning Trust Fund would be on the order of $64 million dollars. The staff determined, based on its review of ENO's cost avoidance analysis (BVY 17-006 Attachment 4) and Decommissioning Funding Status Reports dated March 30, 2016 (Entergy 2016) and March 31, 2017 (Entergy 2017d), that there would be savings to the Decommissioning Trust Fund if the transfer of irradiated fuel to the ISFSI is completed in a shorter time.

The staff also notes the Entergy Nuclear Vermont Yankee, LLC. Master Decommissioning Trust Agreement for Vermont Yankee Nuclear Power Station, Exhibit D (Entergy 2002), states that the excess funds remaining in the Decommissioning Trust Fund shall be distributed for the benefit of electric consumers in pro rata shares. Therefore, the savings to the Decommission Trust Fund could financially benefit the electric consumers.

The staff has reviewed the information provided by ENO and based upon the above stated information, concludes that granting the requested exemption continues to provide adequate protection of public health and safety and is otherwise in the public interest.

CONCLUSION

The staff performed a comprehensive review of the exemption request. Based on the statements and representations provided by ENO in its exemption request, as supplemented, the staff concludes that the proposed actions (i.e., the use of the new regionalized QSHL pattern as described in Figure 2.4-1; loading fuel that has been cooled for at least 2 years; and using a per-cell maximum average burnup limit at 65,000 MWD/MTU as described in Holtec's Amendment No. 11 application, Appendix B, Table 2.1-1, Section VI), does not affect the ability of the HI-STORM 100 cask system to meet the requirements of 10 CFR Part 72.

This exemption request should be approved.

REFERENCES

ACI 1985. American Concrete Institute, "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary," ACI 349-85, 1985.

ASME 1997. American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code," Section II, "Materials," 1995 Edition with 1997 Addenda.

Entergy 2002. Entergy Nuclear Vermont Yankee, LLC. Master Decommissioning Trust Agreement for Vermont Yankee Nuclear Power Station. July 31, 2002. Agencywide Document Access and Management System (ADAMS) Accession No. ML15111A086.

Entergy 2016. Letter from Entergy Nuclear Operations, Inc. to NRC, "Decommissioning Funding Status Report per 10 CFR §50.75(f)(1) and 10 CFR 50.82(a)(8)(v) – Entergy Nuclear Operations, Inc." March 30, 2016. ADAMS Accession No. ML16090A355.

Entergy 2017a, BVY 17-006. Letter from Entergy Nuclear Operations, Inc. to NRC, "Exemption Request from Certain Requirements of 10 CFR 72.212 and 10 CFR 72.214 to Support the Dry Fuel Loading Campaign, Vermont Yankee Nuclear Power Station, License No. DPR-28, Docket Nos. 50-271, 72-59 and 72-1014." May 16, 2017. This package contains six attachments, and Attachment 6 is *Proprietary Information and Not Publicly Available.* ADAMS Accession No. ML17142A354.

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SUBJECT: SAFETY EVALUATION REPORT, DOCKET NOS. 51-271, 72-59, 72-1014, EXEMPTION REQUEST FOR ENTERGY NUCLEAR OPERATIONS, INC.'S VERMONT YANKEE NUCLEAR POWER STATION INDEPENDENT SPENT FUEL STORAGE INSTALLATION IN VERNON, VERMONT, DOCUMENT DATE: FEBRUARY 2, 2018

ADAMS Accession No. ML17298A135

OFC	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM
NAME	YChen	WWheatley	JChang	DDunn	DTang	ASotomayor-Rivera
DATE	10/19/2017	10/25/2017	10/20/2017	10/23/2017	10/20/2017	10/24/2017
OFC	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM	OGC NLO	NMSS/DSFM	
NAME	YDiaz-Sanabria	MRahimi	TTate	MWoods	MRahimi	
DATE	12/19/2017	12/15/2017	11/2/2017	2/1/2018	2/2/2018	

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