Thermal Evaluation for Amendment 10 of NUHOMS® System 61BTH and 32PTH1

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Thermal Evaluation for 61BTH and 32PTH1 Systems

- *Heat Loads and DSC Types*
- *Analyzed Cases*
- *Methodology and Computational Tools*
- *Summary*

Thermal Evaluation 61BTH and 32PTH1

- **61BTH**
  - ***Various Heat Load Configurations Based on Basket Type***
  - ***Maximum Total Heat Load 31.2 kW***
  - ***Maximum Heat per Fuel Assembly 0.54 kW***

- **32PTH1**
  - ***Various Heat Load Configurations Based on Basket Type***
  - ***Maximum Total Heat Load 40.8 kW***
  - ***Maximum Heat per Fuel Assembly 1.30 kW***

Thermal Evaluation – Heat Loads and DSC Types

To Bound Thermal Evaluations:

- ***For 61BTH***
  - ***Maximum heat loads with borated aluminum neutron absorber are considered for basket plates to provide bounding maximum temperatures***
- ***For 32PTH1***
  - ***The bounding DSC length is considered for all analyses to maximize the heat flux***
  - ***The lowest conductivity for neutron absorber plates is used in all models***

Thermal Evaluation – Analyzed Cases

Analyzed Cases are the same as those considered for 24PTH

- **Storage in HSM or HSM-H Module**
  - **Normal Conditions (Steady State)**
    - 0 to 100°F ambient for 61BTH, 0 to 106°F ambient for 32PTH1
    - Insolance from 10CFR71 for hot conditions
  - **Off-Normal Conditions (Steady State)**
    - -40 to 117°F ambient
    - Insolance from 10CFR71 for hot conditions
  - **Hot Accident Conditions (Steady State) Only for 32PTH1**
    - 133°F ambient
    - Insolance from 10CFR71 for hot conditions
  - **Blocked Vent Accident Conditions (Transient)**
    - Initial conditions at 117°F ambient with Insolance

Thermal Evaluation – Analyzed Cases

Analyzed Cases are the same as those considered for 24PTH

- ***Transfer in OS197/OS197H or OS197FC-B for 61BTH***
  - ***Operations within Handling Building (Transient)***
    - ***Cask in vertical or horizontal orientation***
    - ***Ambient temperature at 120°F***
    - ***Determines time limit for transfer operations***
  - ***Normal and Off-Normal Conditions***
    - ***0 to 100°F ambient for normal conditions with Insolance***
    - ***-40 to 117°F ambient for off-normal conditions***
    - ***Steady state evaluation for heat loads ≤ 22.0 kW***
    - ***Transient evaluation for heat loads ≤ 31.2 kW for type 2 basket which determines time limit for transfer operations***

Thermal Evaluation – Analyzed Cases

Analyzed Cases are same as those considered for 24PTH

- ***Transfer in OS200 / OS200FC for 32PTH1***
  - ***Operations within Handling Building (Transient)***
    - *Cask in vertical or horizontal orientation*
    - *Ambient temperature at 120°F and 140°F*
    - *Determines time limit for transfer operations*
  - ***Normal and Off-Normal Conditions***
    - *0 to 106°F ambient for normal conditions with Insolance*
    - *-40 to 117°F ambient for off-normal conditions*
    - *Steady state evaluation for heat loads $\leq$ 24.0 kW*
    - *Steady state evaluation for heat loads $\leq$ 31.2 kW for type 1 basket*
    - *Transient evaluation for heat loads $\leq$ 31.2 kW for type 2 basket &*
    - *Transient evaluation for heat loads $\leq$ 40.8 kW for type 1 basket which determine time limit for transfer operations*

Thermal Evaluation – Analyzed Cases

Analyzed Cases are the same as those considered for 24PTH

- ***Transfer for 61BTH and 32PTH1 – continued***
  - ***Accident Conditions***
    - ***Accidental Cask Drop***
      - ***Loss of neutron shield***
      - ***Loss of shade if used***
      - ***Loss of air circulation if used***
    - ***Engulfing Fire***
    - ***Hot Accident Conditions for 133°F – only for 32PTH1***

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Thermal Evaluation – Analyzed Cases

- **Loading and Unloading Conditions**
  - ***Vacuum Drying (Steady State)***
    - ***Helium is used for blow-down***
    - ***Annulus between DSC and Transfer Cask is filled with water***
  - ***Reflooding***
    - ***Pool water is used to re-flood the DSC***
    - ***Controlling of re-flood flow rate maintains the DSC cavity pressure below 20 psig***

Thermal Design Criteria for 61BTH and 32PTH1 systems are the same as those for 24PTH and NUHOMS® HD systems

Thermal Evaluation – Methodology & Tools

Analysis	Methodology	Previously Reviewed and Accepted by NRC
Exit / Bulk Air Temperature	Loss Coefficient Calculation Verified by Thermal Test	Standardized NUHOMS® UFSAR Appendix P, Section P.4.4.3 NUHOMS® HD SAR, Section 4.13
Storage Module HSM for 61BTH type 1 with ≤ 22.0kW	ANSYS 2-D Models of HSM with 24.0 kW	Standardized NUHOMS® UFSAR, Section 8.1.3.1
Storage Module HSM-H	ANSYS 3-D Models of HSM-H Verified by Thermal Test	Standardized NUHOMS® UFSAR Appendix P, Section P.4.4.4 NUHOMS® HD SAR, Section 4.3.1.2 and 4.4.1.2
Transfer Cask OS197, OS197H, and OS197FC	SINDA/FLUINT™ and Thermal Desktop® 3-D Models	Standardized NUHOMS® UFSAR Appendix P, Section P.4.5.1 and P.4.5.2
Transfer Cask OS200 and OS200FC	SINDA/FLUINT™ and Thermal Desktop® 3-D Models	Standardized NUHOMS® UFSAR Appendix P, Section P.4.5.2 NUHOMS® HD SAR, Section 4.9 for Liquid Shield Convection Coefficients

Thermal Evaluation – Methodology & Tools

Analysis	Methodology	Previously Reviewed and Accepted by NRC
Intact Fuel Properties	2-D model of Cross Section for Transverse Conductivity Cladding Area for Axial Conductivity Mass and Volume Average of Cladding and Pellets Materials for Specific Heat and Density	Standardized NUHOMS® UFSAR Appendix K, Section K.4.2 for BWR Fuel Assemblies Standardized NUHOMS® UFSAR Appendix P, Section P.4.8.1 and NUHOMS® HD SAR, Section 4.8 for PWR Fuel Assemblies
Damaged Fuel Properties	Reduction of Transverse and Axial Conductivity based on Configuration	Standardized NUHOMS® UFSAR Appendix K, Section K.4.8.1 for BWR Fuel Assemblies NUHOMS® HD SAR, Section 4.14.3 for PWR Fuel Assemblies

Thermal Evaluation – Summary

- ***The methodologies to evaluate the thermal performance of 61BTH and 32PTH1 systems were reviewed by NRC in previous applications for amendment 8 (24PTH system) and NUHOMS® HD system***