Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Direct tel: (412) 374-5093

e-mail: harperzs@westinghouse.com

LTR-NRC-19-73 Revision 1

December 2, 2019

Subject: SENTRY™ Dry Fuel Storage System Pre-Submittal Presentation Materials

Enclosed are the public meeting presentation materials as well as proprietary and non-proprietary versions of **SENTRY** Dry Fuel Storage System Pre-Submittal Meeting. These materials are updated from those previously submitted. They were used during the discussion in the meetings held on November 21, 2019.

This submittal contains proprietary information of Westinghouse Electric Company LLC ("Westinghouse"). In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Nuclear Regulatory Commission's ("Commission's") regulations, we are enclosing with this submittal an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of this submittal or the Westinghouse Affidavit should reference AW-19-4976 and should be addressed to Camille T. Zozula, Manager, Infrastructure & Facilities Licensing, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 1, Suite 165, Cranberry Township, PA 16066.

Zachary S. Harper, Manager
Licensing Engineering

cc: John McKirgan (NRC)
Nishka Devaser (NRC)

Enclosures:
1. Affidavit AW-19-4976
2. Proprietary Information Notice and Copyright Notice
3. **SENTRY**™ Dry Fuel Storage System Pre-Submittal Meeting: Public Meeting (Non-Proprietary)
4. **SENTRY**™ Dry Fuel Storage System Pre-Submittal Meeting - Proprietary Closed Meeting
5. **SENTRY**™ Dry Fuel Storage System Pre-Submittal Meeting - Non-Proprietary Closed Meeting

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:
COUNTY OF BUTLER:

(1) I, Zachary S. Harper, have been specifically delegated and authorized to apply for withholding and execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse).

(2) I am requesting the proprietary portions of LTR-NRC-19-73 Revision 1 be withheld from public disclosure under 10 CFR 2.390.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged, or as confidential commercial or financial information.

(4) Pursuant to 10 CFR 2.390, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse and is not customarily disclosed to the public.

(ii) Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

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(5) Westinghouse has policies in place to identify proprietary information. Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage (e.g., by optimization or improved marketability).

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(6) The attached documents are bracketed and marked to indicate the bases for withholding. The justification for withholding is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters

AFFIDAVIT

refer to the types of information Westinghouse customarily holds in confidence identified in Sections (5)(a) through (f) of this Affidavit.

I declare that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 12/2/2019

Zachary S. Harper, Manager
Licensing Engineering

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of a document, furnished to the NRC in connection with requests for generic review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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Enclosure 3

SENTRY™ Dry Fuel Storage System Pre-Submittal Meeting: Public Meeting (Non-Proprietary)

November 2019

SENTRY™ Dry Fuel Storage System Pre-Submittal Meeting: Public Meeting

Robert Quinn, Director
Global Spent Fuel Storage and Disposal

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Introduction

- Pre-submittal meeting in advance supporting of Westinghouse’s planned submittal of an amendment request to CoC 72-1026
- Submittal will be in the form of a the Safety Analysis Report (SAR) for the **SENTRY** Dry Fuel Storage System (DSS)
- Planned submittal in late December 2019
- Transportation SAR submittal anticipated in mid-2020

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Background

- Westinghouse innovation project over the last two years to develop two new spent nuclear fuel (SNF) canister designs:
  - Minimum Cooling Time Canister (W21H) that would support safe, expedited transfer of SNF from SFPs to dry storage
  - High Capacity Canister (W37) that supports economical dry storage of most SNF fuel
- **SENTRY** DSS is an updated design of certified *FuelSolutions*™ (FS) DSS
  - Westinghouse acquired all IP to the FS CoC in 2019 (NRC notification letter on September 13th, 2019, ML19260C962).

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SENTRY DSS Components & Key Features

The main system components are:

- **SENTRY** W37 canister – high-capacity canister
- **SENTRY** W21H canister - enhanced heat transfer capability (~65 kW)
- **SENTRY** W180 storage cask – higher thermal capacity & enhanced heat removal
- **SENTRY** W110 transfer cask – accommodates both the W21H and W37

Design and Regulatory Basis

- Regulatory basis and SAR development performed following the draft guidance of NUREG-2215
- Canister designs in accordance with ASME Section III, Division 3
- All design work performed under the NRC-approved Westinghouse Quality Management System (QMS)

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Application Approach

- Plan to submit an amendment to *FuelSolutions* CoC 72-1026
- **SENTRY** DSS Amendment uses same or similar methodologies in many areas:
  - Fuel Qualification
  - Technical Specifications
  - Shielding Analysis Methodology
  - Vertical Transfer operations and equipment
- Approach of adding canisters and casks is similar to amendments made to other DSS CoCs. Notable examples:
  - 72-1004 Standardized NUHOMS® was initially 24P and 52B; added 32PT & PTH1, 37PTH, 61BT & BTH, and 69BTH
  - 72-1014 HI-STORM 100 was initially MPC-24 and -68, and HI-STORM 100 cask; added MPC-32, HI-STORM 100S and 100U (underground VVM)

Fuel Qualification

- Minimum cooling tables developed using similar methodology as FS W21 and W74
  - Primary safety parameters, dose rate and heat load, form the basis for fuel acceptance
  - Discrete analysis used to develop fuel cooling tables for each canister which “pre-qualify” cooling times for ranges of fuel assembly classes (given their burnup and enrichment)
- Approach allows a greater percentage of the fuel assemblies which currently reside in commercial power reactor spent fuel pool inventories to be qualified for storage, thus reducing dose by allowing more older, colder fuel to be qualified. In addition, it minimizes the need for supplemental qualification calculations to be performed by the licensee prior to each canister loading.

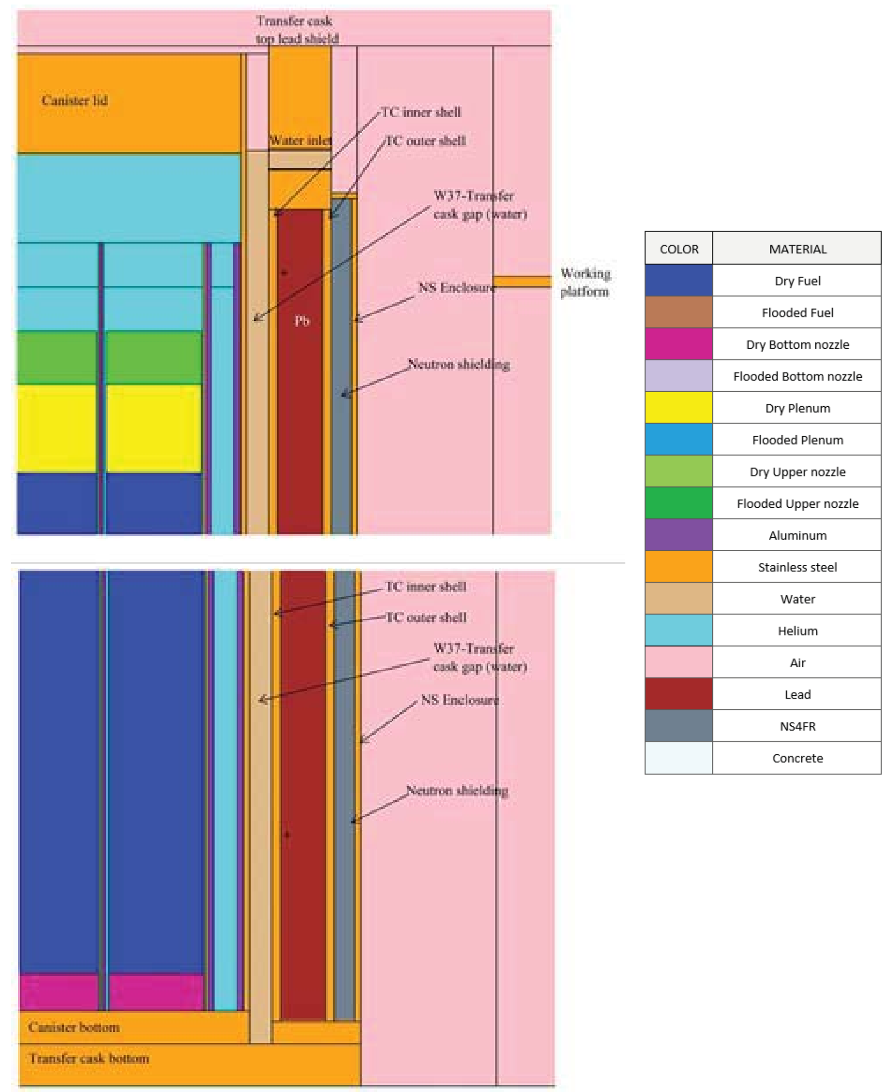
Criticality – Key Assumptions

Moderator exclusion is assumed under accident conditions, so the limiting situation occurs during the loading of the fuel in the SFP

W37 (37 Cell Basket)	W21H (20 Cell Basket)
• The inherent geometry of the fuel basket design	• The inherent geometry of the fuel basket design
• Burnup credit	• Permanent fixed neutron-absorbing panels in the fuel basket structure in the W21H Canister 30 % B_4C
• A zone administrative limit on the maximum enrichment	• Uniform Fresh fuel 5.0 wt%
• An administrative limit on the minimum soluble boron concentration in the water for loading/unloading fuel ≥2600 ppm	• An administrative limit on the minimum soluble boron concentration in the water for loading/unloading fuel ≥1900 ppm

Shielding

- Use of typical methods for dose rates and fuel cooling tables
  - Monte-Carlo design basis shielding calculations done using MCNP (new for **SENTRY** DSS viz. FS)
  - adjoint calculations using DORT to support limiting cooling times for burnup/enrichment combinations other than design basis
  - source terms generated by ORIGEN2

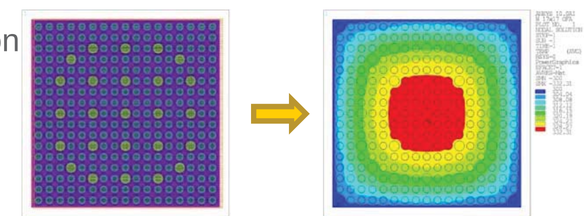


Confinement

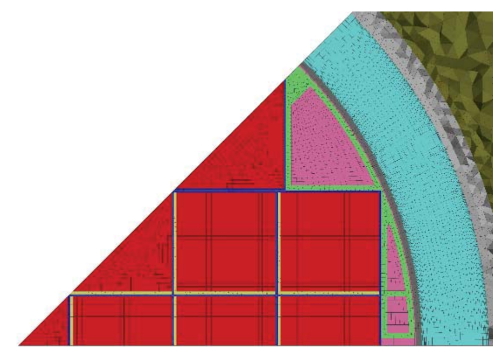
- Confinement of radioactive materials in the **SENTRY** DSS is provided by the canisters; the storage overpack and transfer cask providing physical protection and shielding for the canister during all conditions.
- Confinement boundaries are: cylindrical shell, bottom end closure plate, top end closure lid, vent and drain penetration covers, and associated welds. Designed to meet NUREG-2215 expectations for leaktightness.
- Vacuum drying and helium backfilling provide a non-oxidizing environment to protect fuel assemblies against cladding degradation.
- Welded closure lid and closure ring provide redundant closure of the canisters, satisfying the requirements of 10 CFR 72.236(e).

Thermal Analysis

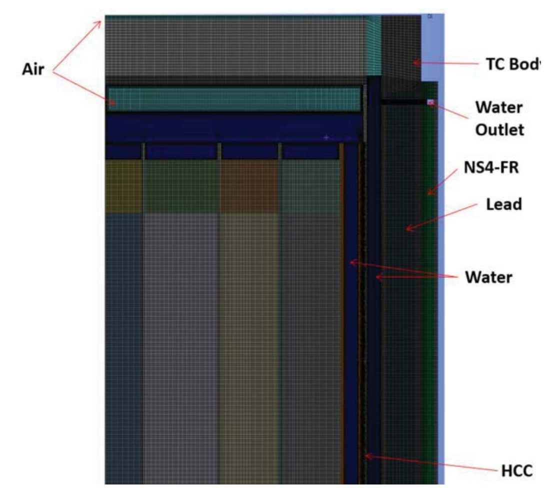
- Thermal Analyses developed following the guidance of SRP **NUREG-2215**, **NUREG-2152** CFD Best Practice Guidelines and **V&V 20-2009** ASME Standard for Verification and Validation in CFDs and Heat Transfer



- Fuel Assemblies are modeled as a porous media with **bounding effective thermal properties** of the different types of fuels and configurations, and the hydraulic behavior characterized in **NUREG CR-7144** with appropriated **friction loss coefficients**



- Analysis of the steady-state storage **Normal Operating Conditions**, was performed using detailed 3D CFD modelling for both canister W37 and W21H in the Storage Overpack
  - Various loading patterns were analyzed for each canister
- Analysis of the **Off-normal** and **Accident** Conditions were analyzed using the most limiting loading pattern of Normal Conditions
  - 3D CFD analyses for Off-normal and Extreme Ambient Temperature
  - 2D CFD analyses for transient analyses of Hypothetical Accident Conditions (Fire, Burial and 100% Blockage)



- Transient analysis for **Loading Operations** performed using 2D axisymmetric model
- All CFD analyses have been performed with **ANSYS FLUENT v18.2**
- All cases analyzed show that **SENTRY** DSS is within compliance limits

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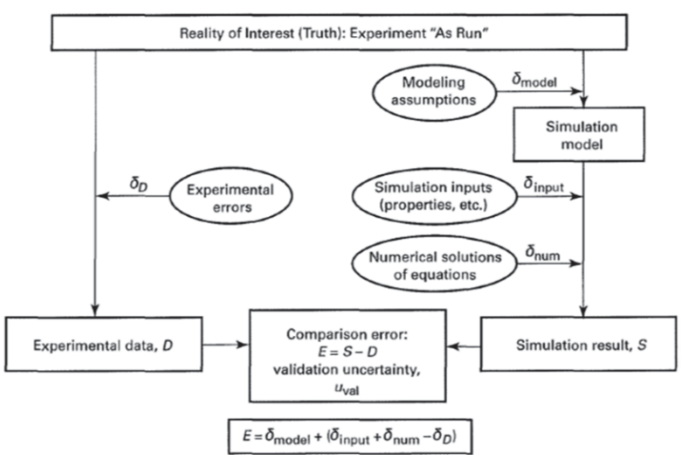
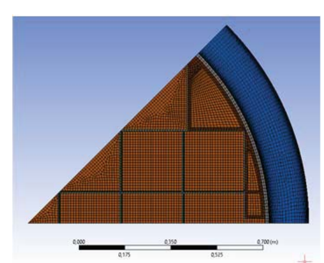
Thermal Analysis

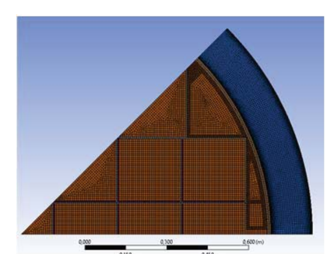
- **V&V 20-2009 ASME Standard for Verification and Validation in CFDs and Heat Transfer** establishes steps to assess the quantification of the degree of accuracy of computational simulations
- Errors in a simulation can be assigned to one of three categories;
  - Model error (δ_{model}) due to modeling assumptions and approximations,
  - Numerical error (δ_{num}) due to the numerical solution of the equations
  - Input error in the simulation result (δ_{input}) due to errors in the simulation input parameters.
- **Model error (δ_{model})**
  - Modeling assumptions and approximations have been made in a conservative way
- **Numerical error (δ_{num})**
  - Verification of the code itself, has been made to determine that the code is free of mistakes (Fluent V&V code verification)
  - Process to estimate u_{num} is only based on solution verification and it is composed of three contributions: round-off error, iterative error and discretization error.
  - Discretization error dominates. To estimate the discretization error has been performed the **Grid Convergence Index (CGI)** method proposed by Roache. Three meshes (coarse, medium and fine) have been created for the different CFD models.
- **Input error (δ_{input})**
  - To quantify input uncertainty propagation has been use a deterministic methodology based on the law of propagation of uncertainty
  - Input data has been divided in 3 categories; Material properties (density, specific heat, conductivity, viscosity, emissivity), geometrical (tolerances and gaps) and boundary conditions
- The **ASME V&V 20-2009** provides detailed information to evaluate the validation uncertainty (u_{val}). Validation uncertainty can be estimated through the root sum square of the different uncertainties



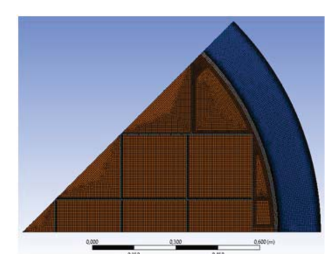
Coarse



Medium



Fine



Structural Analyses

- Appropriate evaluations performed for structural acceptance of all components
  - Canisters: W37 & W21H (ASME Section III, Div 3, WC)
  - Baskets: W37 & W21H (ASME Section III, Div 3, WD)
  - Transfer Cask: W110 (ASME Section III, Div 1, NF and ANSI N14.6)
  - Storage Cask: W180 (ACI-349, AISC-360, and ANSI N14.6)

- Load combinations
  - Normal Operating Conditions
  - Off-Normal Operating Conditions
  - Handling
  - Accident Conditions

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Structural Analyses

- Normal Operating Conditions (NOC) and Off-normal Operating Conditions (OOC)
  - Bounded for Handling Cases (crane factor apply a factor of 1.15 to NOC and OOC)
- Handling
  - Performed using classical stress analysis and ANSYS
  - Evaluated to the requirements of ANSI N14.6 and guidance of NUREG-0612 for handling devices
- Accident Conditions
  - Internal and External (Flood) Accidental Pressures
  - Vertical Drops
    - Storage Cask analyses provides boundary conditions to be applied in Canister+Basket analyses (number of g's)
      - Performed using LS-DYNA
      - Results demonstrate compliance of storage cask with ACI-349
    - Canister + Baskets
      - Performed using ANSYS
      - Results demonstrate compliance with ASME acceptance criteria

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Structural Analyses

- Accident Conditions (cont.)
  - Non-mechanistic tipover – Storage Cask analyses provides boundary conditions to be applied in Canister analyses (number of g's)
    - Storage Cask
      - Performed using LS-DYNA
    - Canister
      - Performed using ANSYS Classical
      - ASME acceptance criteria confirms confinement integrity is maintained
  - Earthquake
    - Performed using classical stress analysis and ANSYS
  - Accident Temperatures: Fire and Maximum Accident Temperature (100% Blockage)
  - Missiles impact on Storage Cask
      - Performed using ANSYS
- All analyses demonstrate compliance of **SENTRY** DSS components with structural requirements of applicable codes and standards

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Westinghouse Non-Proprietary Class 3

Thank you! Questions?

Enclosure 4

SENTRY™ Dry Fuel Storage System Pre-Submittal Meeting - Proprietary Closed Meeting

November 2019

Enclosure 5

SENTRY™ Dry Fuel Storage System Pre-Submittal Meeting – Non-Proprietary Closed Meeting

November 2019

This is the non-proprietary version of the slides.

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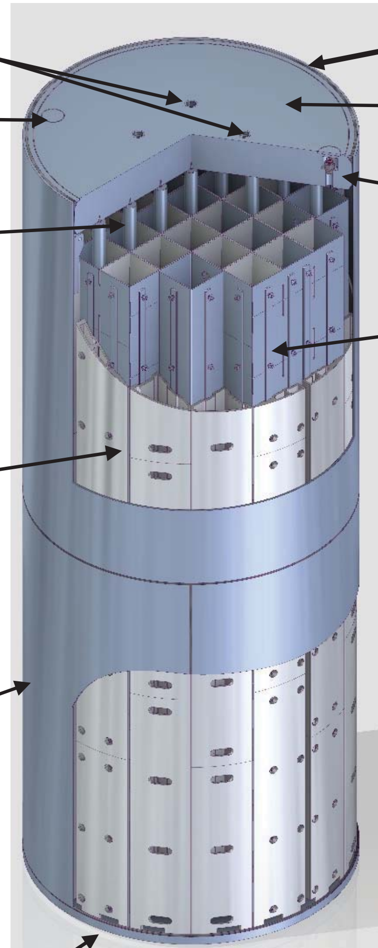
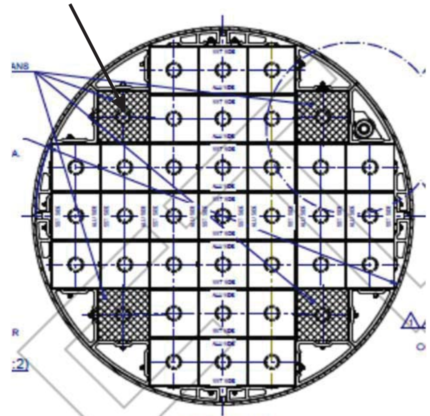
SENTRY™ Dry Fuel Storage System Pre-Submittal Meeting – Proprietary Closed Meeting

Robert Quinn, Director
Global Spent Fuel Storage and Disposal

Key Features – W37



Damaged Fuel Can Positions (4)



Performance

Max burnup: 65 GWd

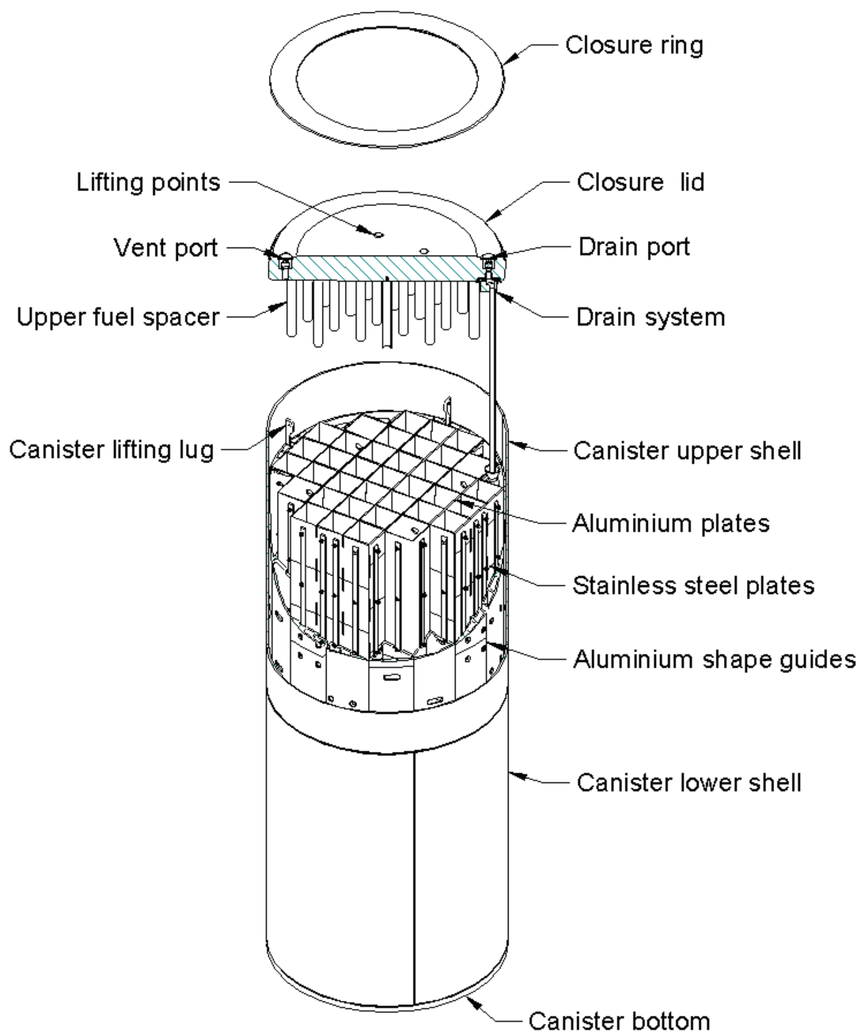
Cooling time: 3 years

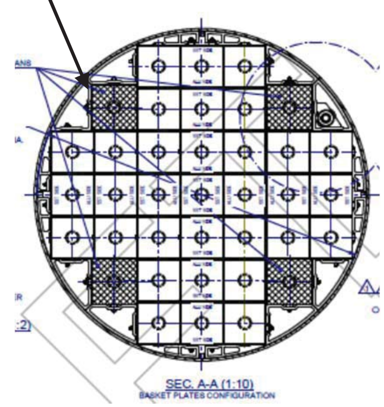
- Heat rejection: 45kW
- Max assembly heat load: 1.7kW
- 37 positions (4 positions available for damaged fuel cans)

Design (a,c)

- Burnup credit + pool boron credit (a,c)

Key Features – W37





Performance

Max burnup: 65 GWd

Cooling time: 3 years

- Heat rejection: 45kW
- Max assembly heat load: 1.7kW
- 37 positions (4 positions available for damaged fuel cans)

Design (a,c)

- Burnup credit + pool boron credit (a,c)

Key Design Features – W21H

(a,c)

Performance

Max burnup: 65 GWd
Cooling time: 1.5 years

- Max heat rejection: 65kW
- Capacity: 20 SFAs
- Max assembly heat load: 4.375kW

(a,c)

Zone Loading Configurations – W37

(a,c)

Enrichment and Burnup Requirements – W37

(a,c)

Zone Loading Configurations – W21H

(a,c)

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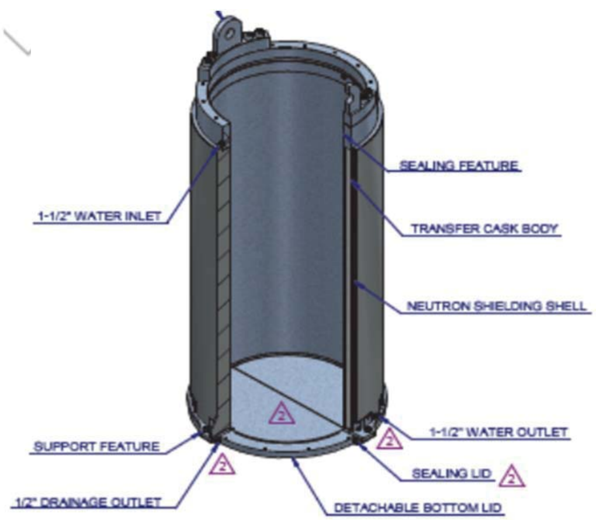
Key Design Features – W110 – TC



TRANSFER CASK - HCC CONFIGURATION

(a,c)

Design

- Walls made of SS, Lead and Resin (NS4-FR)
- Bottom removable to load canister in the SO (a,c)

Two configurations

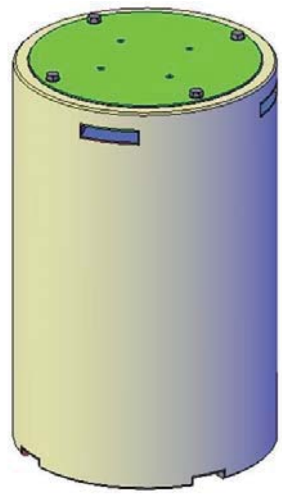
- ***SENTRY*** *W37:* Standard configuration

(a,c)

Key Design Features – W180 – Storage Cask

(a,c)

[ ]



SENTRY W180 Exterior

(a,c)

[ ]

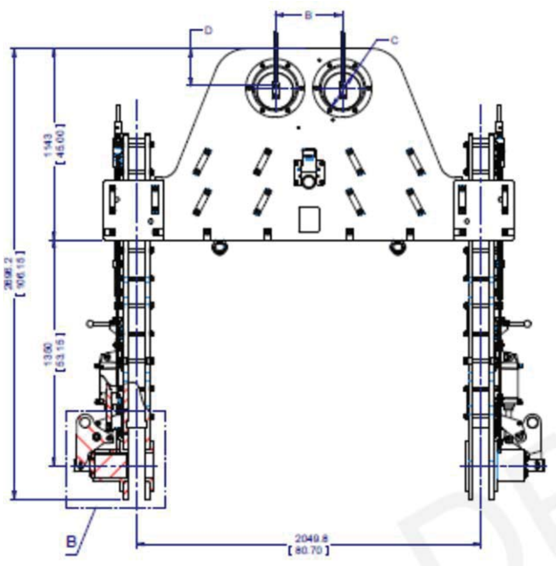
Design

- Reinforced concrete with an inner steel liner
- Patented vent design (patent pending)

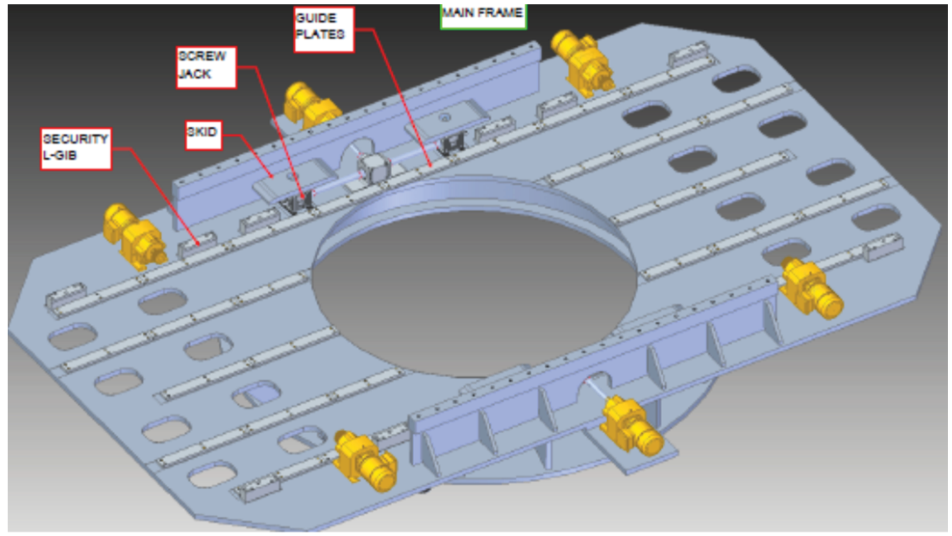
Two configurations

- ***SENTRY*** *W37:* standard configuration (a,c) [ ]

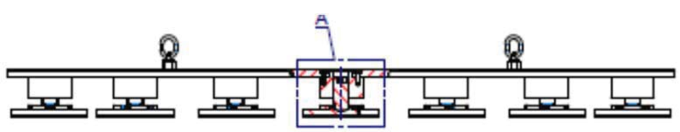
Auxiliary Equipment



TC Lifting Yoke



TC Storage Cask Mating Device



Pool Leveling Platform

Onsite Transfer Device

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Canister Content Comparison

Parameter	**SENTRY** W21H	**SENTRY** W37
Max heat load per canister (kW)	65	45
Number of assemblies per canister	20	37 (a,c)
Average heat load per assembly (kW)	[	]
Number of assemblies >3.2 kW		
Max heat load assembly	4.375	1.7
Max heat assemblies allowed	[	] (a,c)
Min. Cooling Time (months) for max heat load assembly	18	36
Time to Fully Offload spent fuel pool including final core after shutdown (mo.)**	[ ] (a,c)	

(a,c)

[ ]

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Sample Final Core Load

(a,c)

Why are we doing this?

(a,c)

[ ]

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Current Status

- Preparation of 10CFR72 storage SAR is in process
- Submittal of Part 72 CoC amendment application in December 2019
- Submittal of Part 71 CoC application in mid-2020

Westinghouse has committed significant time and resources to develop this "step change" product

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