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SPM 14-037

September 3, 2014

Director, Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attn: Document Control Desk

Subject: GEH Request for Special Authorization to Use the Model No. 2000 Package, Docket No. 71-9228 – Supplemental Information

References:
1) Model 2000 Shipping Cask-Certification Number 9228 Rev. 25, Docket Number 71-9228, Package Identification USA/9228/B(U)F-96, Rev. 25
2) NRC/GEH Meeting, 2/12/14
3) GEH Request for Special Authorization to Use the Model No. 2000 Package, Docket No. 71-9228, S.P. Murray to Director, Division of Spent Fuel Storage and Transportation, 6/30/14
4) GEH Request for Special Authorization to Use the Model No. 2000 Package, Docket No. 71-9228 – Supplemental Information, S.P. Murray to Director, Division of Spent Fuel Storage and Transportation, 8/26/14
5) NRC Request for Additional Information – J. Vera to K.B. McGowan dated 8/29/14

Dear Sir or Madam:

As requested by NRC Spent Fuel Storage and Transportation staff on August 29, 2014 (Reference 5), attached is the additional requested information and a redacted (public) copy of the request.

Please contact Bryce MacDonald at 910-819-6537 or myself if there are any additional questions.

Sincerely,

Scott P. Murray, Manager
Facility Licensing

Commitments: None

Attachments:
1. GEH Response to Request for Additional Information
2. GE Model 2000 Special Authorization Request (Redacted Version)

Cc: J. Vera, NRC SFS&T, Washington, D.C.

Attachment 1

NRC request for additional information - J. Vera to K.B. McGowan dated 8/29/14

Clarify the discordance between the assumptions in the shielding analyses and the structural analysis regarding bolt deformation and PIG lid separation, and justify compliance with regulatory requirements relating to the information requested below.

The application provides shielding analyses for normal conditions of transport (NCT) and hypothetical accident conditions (HAC), where a primary assumption is that the lid of the internal component identified as the PIG is fully closed. However, in the structural demonstration for HAC 30-foot drop, the applications states that an expected yield value for the steel the bolts are made of is 30,000 psi at 100°F, while the calculations show a resulting tensile bolt stress of 48,107 psi. This implies that, at 100°F (and ergo, at the assumed temperature used throughout the application of 200°F), the bolt has exceeded the yield stress and plastic deformation is to be expected. This plastic deformation could result in lid separation. In turn, this separation could open up streaming paths that have not been evaluated in the application.

In addition, the bolt preload calculation is based on a minimum yield strength of 30,000 psi at 100°F. Staff determined that the bolt preload is expected to result in tensile stress of around 25,000 psi. However, a lower yield strength should be expected at the higher assumed temperature used throughout the application (200°F). This could result in the bolt exceeding yield due to preload as the temperature rises within the package.

This information is needed to determine compliance with 10 CFR 71.47.

GEH Response

The RAI is divided into two parts. Each RAI part is be addressed below.

RAI Part 1: Bolt Elongation Impact on Shielding

Clarify the discordance between the assumptions in the shielding analyses and the structural analysis regarding bolt deformation and PIG lid separation, and justify compliance with regulatory requirements relating to the information requested below.

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Response

Despite the estimated bolt elongation predicted in the Boat Sample Shipping Pig assembly during hypothetical accident conditions, an adequate shielding boundary of 2.935 inches, as assessed in Ref. 2, is maintained. Thus, a new streaming path, line of sight gap, is not introduced to the shielding. The following calculations demonstrate the basis of this response.

Basis

In Section 5.2.5.4 of Ref. 2, the maximum axial force in the Boat Sample Shipping Pig bolt during hypothetical accident conditions is calculated to be 9,174 lb. This total load combines the bolt preload and impact load at a maximum cask internal temperature of 200˚F. These thermal and impact conditions are further addressed in Ref. 2, Section 5.2.5.4 - 5.2.5.5.

Ref. 2 then calculates the maximum effective stress in the bolt corresponding to a localized area of the bolt to assess failure. In this analysis, the maximum global tensile stress in the bolt is calculated instead to provide a realistic basis for the bolt elongation. The maximum global tensile stress corresponds to a different axial cross-section of the bolt than the peak stress calculated in Ref. 2.

$$\sigma_a = \frac{F_{a,\ total}}{A_s}$$

$F_{a,\ total} = 9{,}147\ lb$ per Ref. 2, page 27

$A_s = .2243\ in^2$ per Ref. 2, page 28

$$\sigma_a = \frac{9{,}147\ lb}{.2243\ in^2} = 40{,}900\ psi$$

The 304 stainless steel stress-strain curve in Ref. 5 shows minimal difference in strain at the stress of interest; thus, the bolt material properties at 200˚F are interpolated between the curves shown for room temperature and 400˚F. According to Ref. 5, this equates to less than 4% strain in the bolt at 200˚F; thus, 4% strain is conservatively used.

To estimate the total elongation of the bolt, the length of the bolt which is not engaged in the Pig Base (Ref. 4) is calculated. The length of the bolt which is not engaged in the Pig Base is considered to elongate, while the bolt length which is restrained by the base is not. The elastic strain in the bolt is considered a negligible contribution to the total bolt elongation; thus, all strain is conservatively considered plastic.

Ref. 6 is the stainless steel Pinned Cap Screw used in the assembly, and it has a 2.75 inch length. When bolted in place, mating the Pig Lid and Pig Base (Ref. 3 and 4), only part of the threaded bolt length is engaged in the Pig Base. Below the length of the bolt which is not engaged is calculated, and the corresponding estimation of bolt elongation is calculated.

$Bolt\ length\ unengaged\ \ in\ lid = 2.50\ inch - .63\ inch = 1.87\ inch$ per Ref. 3

$Bolt\ length\ unengaged\ \ in\ base\ due\ to\ 90°\ chamfer = \frac{.78\ inch - .625\ inch}{2} = .0775\ inch$ per Ref. 4

$Total\ Bolt\ length\ unengaged = 1.87\ inch + .0075\ inch = 1.95\ inch$

$$Bolt\ elongation\ estimation = 1.95\ inch \times .04 \frac{inch}{inch} = .078\ inch$$

The Pig Lid has a 1.00 inch recessed feature with a .25 inch chamfer which serves to maintain the source within the Pig Base cavity. With the estimated bolt elongation of .078 inch, the Pig Lid can separate from the Pig Base by this amount. However, the feature will remained recessed (1.00 - .25 - .078) = .672 inch within the Pig Base cavity.

Thus, the shroud sample source, its geometry depicted in Figure 5-1 of Ref. 2, page 13, remains within the adequate shielding boundary assessed in Ref. 2 during hypothetical accident conditions and a new streaming path is not introduced. Nominal dimensions are applied in this analysis, as manufacturing tolerances do not affect the conclusions of this analysis.

RAI Part 2: Bolt Yield under Preload at Cask Maximum Internal Temperature

> In addition, the bolt preload calculation is based on a minimum yield strength of 30,000 psi at 100°F. Staff determined that the bolt preload is expected to result in tensile stress of around 25,000 psi. However, a lower yield strength should be expected at the higher assumed temperature used throughout the application (200°F). This could result in the bolt exceeding yield due to preload as the temperature rises within the package.
>
> This information is needed to determine compliance with 10 CFR 71.47.

Response

The bolts remain below yield under preload at the cask maximum internal temperature of 200˚F. The following calculations demonstrate the basis of this response.

Basis

In Ref. 2, the bolt preload is determined based on the temperature of the assembly during loading operations, which is 100˚F. This response assesses the impact of the bolt preload during cask maximum internal temperatures of 200˚F. Thermal and loading conditions during the hypothetical accident condition free drop are applied from Ref. 2, Section 5.2.5.4 - 5.2.5.5.

In Section 5.2.5.5 of Ref. 2, the maximum preload in the Boat Sample Shipping Pig bolt during transport is calculated to be 4,800 lb. The corresponding peak tensile stress and the maximum global tensile stress in the bolt are calculated below. The peak tensile stress in the bolt only applies to the bolt cross-section corresponding to the hole designed for the retention pin insertion. The maximum global tensile stress in the bolt corresponds to the rest of the bolt length.

$$\sigma = \frac{F_{preload}}{A}$$

$F_{preload} = 4{,}800\ lb$ per Ref. 2, page 29

$a_{tensile} = .1907\ in^2$ per Ref. 2, page 28

$A_s = .2243\ in^2$ per Ref. 2, page 28

$$\sigma_{peak} = \frac{4{,}800\ lb}{.1907\ in^2} = 25{,}170\ psi$$

$$\sigma_{global,\ maximum} = \frac{4{,}800\ lb}{.2243\ in^2} = 21{,}400\ psi$$

To determine the yield strength of 304 stainless steel bolt material at 200˚F, interpolation of Ref. 5 shows the yield strength to be greater than 28,000 psi. Therefore, neither the bolt peak tensile stress nor maximum global tensile stress exceed yield due to the preload at cask maximum internal temperature.

DESIGN INPUTS AND REFERENCES

1. 001N0888, Rev. 0, Boat Sample Shipping Pig.

2. 14-026 GEH Request for Model No 2000 Special Authorization, June 30, 2014, Attachment 2.

3. 001N0942, Rev. 0, Pig Lid.

4. 001N0916, Rev. 0, Pig Base.

5. Atlas of Stress-Strain Curves, ASM International, 2002, page 183, SS.041 and SS.042.

6. 001N0959, Rev. 0, Pinned Cap Screw.