Approach for Response to TN-40 Transport Application RAI-2
March 2009

Transnuclear, Inc.

General Information – Section 1

1-1 (and 5-7) Reference requests and fuel data

- ***Table describing TN-40 Cask contents that was removed from Rev. 1 of the SAR has been revised and returned to Section 1.2.3***
- ***Material added to Section 1.2.3 in Rev. 2 of the SAR has been retained.***
- ***The TN-40 contents will not include "damaged fuel" as defined in ISG-1, Rev. 2.***
- ***TN will provide copies of documents requested by NRC in RAI-1.***

1-2 Definition damaged fuel

- ***Provide the Safety Analysis for the various defects that are allowable for UNDAMAGED fuel. Provide a definition for DAMAGED fuel***
- ***The UNDAMAGED fuel described in SAR Section 1.2.3 is not the same as that described in ISG-1***
- ***The intent of the definition in SAR Section 1.2.3 was to describe UNDAMAGED fuel as anything that not not DAMAGED (where DAMAGED is the ISG-1 definition)***

1-2 Definition damaged fuel

- ***The use of the "double negative" to define the authorized contents is clearly not intended to allow fuel assemblies with "certain" defects that require Safety Analyses***
- ***Section 1.2.3 will be modified to revise the definition of these fuel assemblies (that are allowed) and also to change the nomenclature from UNDAMAGED to XXXX (INTACT, REGULAR, NORMAL)***
- ***In addition, the ISG-1 definition of DAMAGED fuel will be provided and Section 1.2.3 will be revised to state that the XXXX fuel assemblies shall not be DAMAGED***

Structural – section 2

2-1 Damaged fuel structural integrity evaluation

Question: Perform structural integrity evaluation of the fuel rod cladding by considering the “undamaged” fuel assembly configuration characterized with (1) uniform bowing and (2) missing, displaced, or damaged structural components

- The application is for transport of intact fuel assemblies only
- In response to RAI 1-2, the application further clarifies the definition of intact fuel and explicitly prohibits transport of damaged fuel

2-5 and 2-6 Slapdown transverse g load vs side drop transverse g load

	Basket Location	RT	-20 °F
Side Drop	Center	57	68.4
Slap Down	End	61	73.2

- 75g in current analyses (68.4 x 1.08 (DLF)) bounds all cases except -20 °F Slap Down
- Top and Bottom Ends of the basket (8” sector) for -20°F Slap Down will be analyzed
  - Temperatures at basket ends for -20°F are ~150°F cooler than temperatures at basket center for 100°F ambient; current analyses conservatively uses temperatures based on 100°F ambient
  - Fuel loads at the ends are lower because end fittings weight is less than fuel weight at center (current analyses)
  - Preliminary results show that the stresses are below their allowable for 80g and margin of safety for buckling is higher than for the side drops

2-7 and 2-13 Fuel cell tests for plastic instability load analysis

Question: As a code alternative, add the fuel basket cell wall load limit tests for demonstrating structural stability of the basket under the 30-ft free drop accident

- The margin of safety for buckling for the slap down analyses (response to RAI 2-5 and 2-6) is higher than the margin for safety for side drop analyses. Therefore, analyses are sufficient to demonstrate the basket structural acceptability

2-9 HAZ Fracture Toughness

- ***Information provided in response to first round of RAI, Question 2-15 indicates that tested base metal, HAZ and weld metal have comparable impact properties. The minimum test impact value was greater than 60 ft-lbs, compared to the 18 ft-lb design minimum.***
- ***Welds are performed to ASME requirements (procedures, materials and qualifications) and thus insure adequate performance.***
- ***Weld design is based on 10CFR71 requirements that assume the cask is to be used multiple times. Each TN-40 is to be used for a single transport.***
- ***Gamma shield welds are not part of the containment boundary.***

2-12 5% strain hardening rate for Stainless steel and Aluminum alloy

- SA-240 Type 304 – NUREG/CR 0481

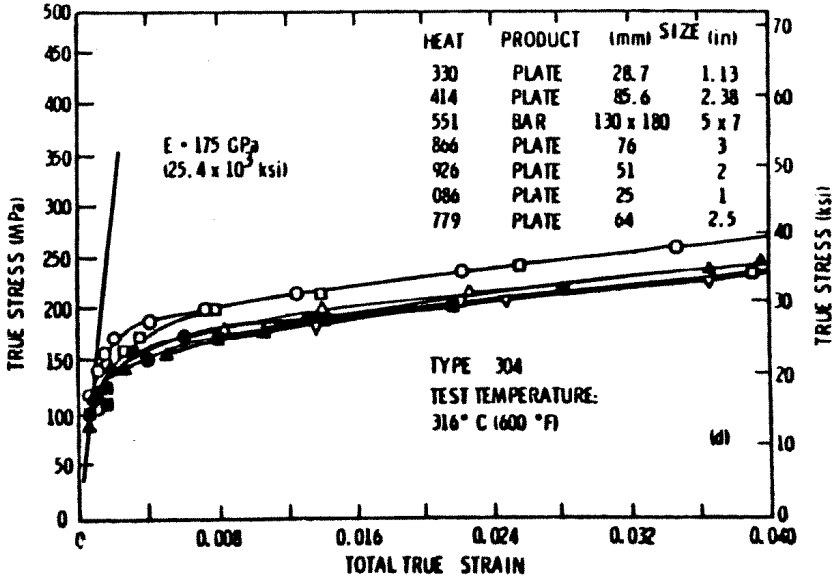

Figure 7. Heat-to-heat variation in stress-strain diagram for 304 stainless steel tested at (a) 24°C, (b) 93°C, (c) 204°C, and (d) 316°C [4].

- Using 5% strain-hardening rate is conservative because it will yield higher stresses
- The maximum stress in the SS Boxes is 29.2 ksi (201 MPa), i.e., low plastic strain

2-12 5% strain hardening rate for Stainless steel and Aluminum alloy

- SB-209 Type 6061-T651
  - All P_m limits ($0.7S_u$) are below S_y, therefore no effect on Pm stresses
  - Kaufman, J. Gilbert, "Properties of Aluminum Alloys: Tensile, Creep, and Fatigue Data at High and Low Temperatures," gives elongations of 17 – 70% for 6061-T651
  - Using 5% strain-hardening rate is conservative because it will yield higher stresses

Shielding – section 5

5-1 (8-3 8-4 and 8-6) Neutron Shielding / Absorber testing and dose rate measurement

- ***RAI 5-1: Include the response to RAI 5-1 (first round) in the SAR and include a requirement for a neutron dose rate measurement prior to transport in the CoC***
- ***RAI 8-3: Modify Section 8.1.5 to include a test of the as-fabricated neutron shield***
- ***RAI 8-4: Justify why there is no need to perform a test to assure the presence and functioning of neutron absorbers***
- ***RAI 8-6: Modify Section 8.2.4 to provide a periodic test of the neutron shield***

Neutron Shielding and dose rate measurement

- ***The TN-40 casks are currently fabricated/loaded under a site specific Part 72 license***
- ***Cask surface dose rate measurements (both neutron and gamma dose rates) are part of Part 72 Technical Specifications***
- ***Neutron shielding resin will not lose its effectiveness under long term storage conditions***
- ***The Part 71 CoC application will be revised to limit the use of TN-40 for a one-time transportation use***

Neutron Shielding and dose rate measurement

- ***Per Staff's recommendation for one-time transportation use:***
  - ***Neutron dose rate measurements taken during initial loading (Part 72 storage) can be utilized as acceptable for test purposes***
  - ***New neutron dose rate measurements to be taken at selected locations prior to transport to ensure the efficacy of the neutron shielding***
  - ***A periodic test is not necessary***
  - ***Section 8.1.5 / Section 8.2.4 will be modified accordingly***

Neutron Absorber Testing

- ***The fixed poison material (Neutron Absorber) in the TN-40 cask is BORAL®***
- ***The B-10 loading for storage is verified per Part 72 acceptance criteria***
- ***The thermal neutron absorption and the total neutron fluence during storage conditions are insignificant compared to the number of B-10 atoms present – will be shown using simple, bounding calculations***
- ***For one time transportation – verification at the time of initial loading (under Part 72) is sufficient***

5-2 Fuel Assembly with natural or low enriched axial blanket – shielding analysis

- ***Prairie Island fuel assemblies contain fuel assemblies with 6-inch blankets***
- ***All the fuel assemblies containing blankets are the "design basis" WE 14x14 standard fuel assemblies***
- ***The burnup of the blanket regions is significantly lower***
- ***Axial burnup profile employed in TN-40 transport calculations is based on bounding profiles from fuel irradiated at Prairie Island including fuel with blankets – a comparison is shown in Figure 1***

5-2 Fuel Assembly with natural or low enriched axial blanket – shielding analysis

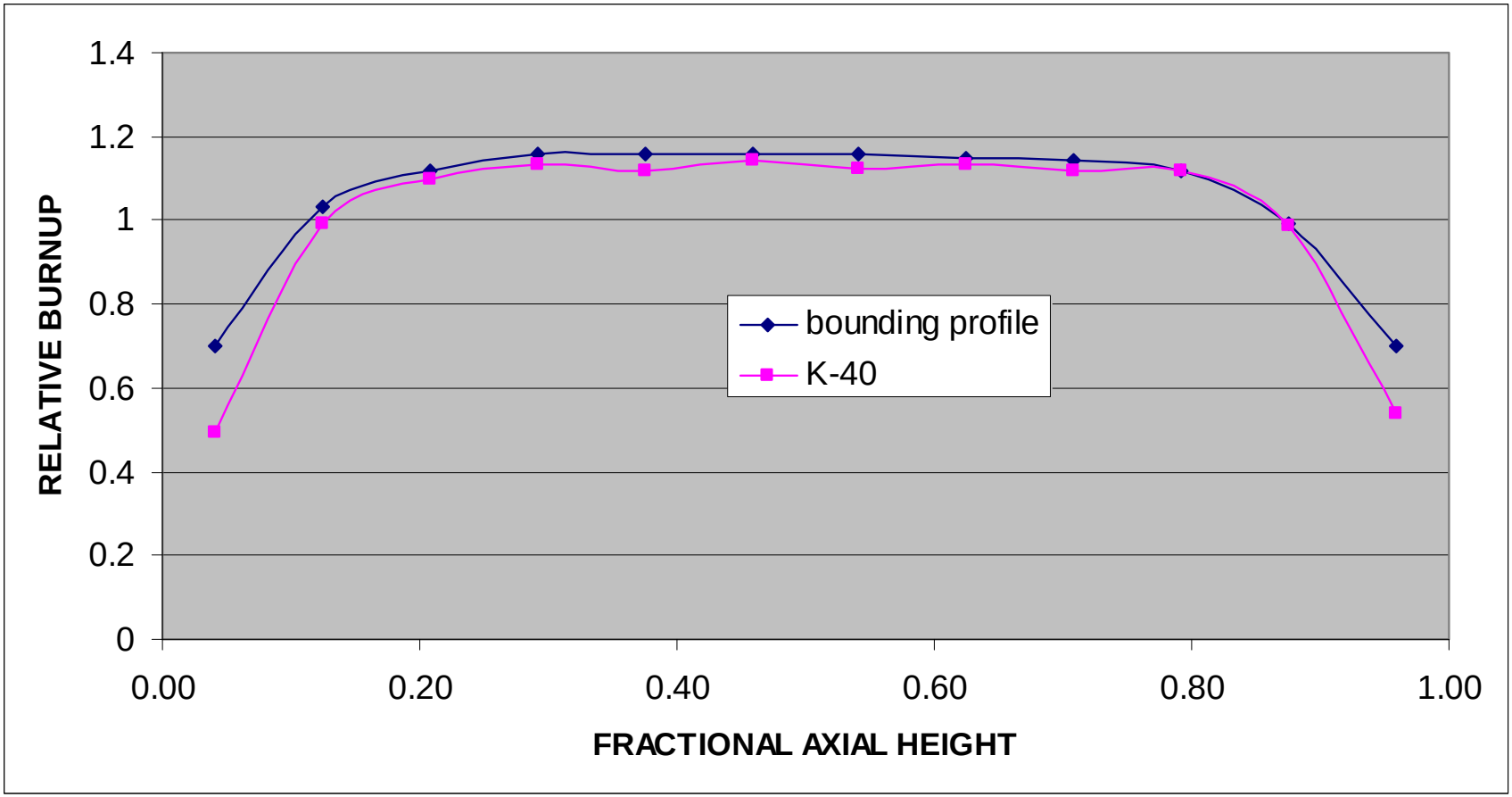

Figure 1: Axial Burnup Profile

5-2 Fuel Assembly with natural or low enriched axial blanket – shielding analysis

- ***The use of bounding profile ensures that the most penalizing profile is utilized that accounts for blanketed versus un-blanketed fuel***
- ***Enrichment used in the shielding analysis is "average" and includes blankets***
- ***Burnup used in shielding analysis is "average" and includes blankets***

5-6 Package tolerance in shielding evaluation

- ***Shielding calculations are performed using nominal dimensions only. Tolerances for the purpose of shielding have not been considered for the following reasons:***
  - ***Design basis Westinghouse 14x14 Standard fuel assembly with the bounding neutron and gamma source terms are utilized in the shielding evaluation***
  - ***The fuel qualification methodology calls for conservatively adjusting the enrichment / burnup and cooling time of the loaded fuel assemblies (Table 5-8)***
  - ***Calculated dose rates are generally higher than measured dose rates demonstrating the conservatisms in the shielding analysis methodology***

5-6 Package tolerance in shielding evaluation

- ***2m dose rates – to meet the applicable transportation dose rate limits – are calculated from 2m from the end of the impact limiters and not the vehicle***
- ***Consistent with the response to 5-1, the shielding "test" will determine a reasonable ("as fabricated / as loaded") margin to the regulatory limit***

Maintenance - section 8

8-5 Thermal Acceptance Tests

- ***All thermal analyses are carried out using conservative methodologies and heat loads***
- ***The results of these analyses demonstrate adequate margins***
- ***Previous thermal testing of a similar cask demonstrated conservatism of analytical results (Response to first round of RAI, question 3-8)***

8-5 Thermal Acceptance Tests (cont.)

- ***Gaps used in the thermal model bound fabrication tolerances (Reference 3-8-1 in Response to first round of RAI, question 3-8)***
- ***Tests of a similar neutron shield (TN Letter E-18578, "TN-32 Cask Thermal Testing", Docket 72-1021) assumed gaps between the neutron shield and cask shell account for uncertainties in the neutron shield shell fabrication and adequately model the insulation properties***
- ***Based on the above considerations, TN is confident that the analytical results demonstrate the ability of the TN-40 to meet all thermal requirements without the need for thermal testing***

8-7 Thermal Maintenance Tests

- ***The cask will see very small loads under storage conditions***
- ***The material properties of the cask materials are not expected to change significantly under "normal" long term storage conditions (Part 72)***
- ***For one time transportation – surface temperature verification with actual "stored" contents can be utilized as an acceptable test prior to transportation***

Criticality – section 6

6-6 and 6-7 Applicability of criticality benchmarks

- ***The Criticality benchmark section will be expanded to provide the following:***
  - ***Justification for the choice of the selected fresh UO_2 and MOX critical experiments***
  - ***Justification for the use of CRC benchmark results for determination of a USL for the TN-40***
  - ***Inclusion of additional benchmark experiments / results as detailed in the NUREG/CR-6979 report***

6-6 and 6-7 Applicability of criticality benchmarks

- ***The criticality benchmark methodology will also include the following elements:***
  - ***Sensitivity analysis of the experimental data as applied to the TN-40 cask***
  - ***Inclusion of results on the reactivity importance of the various nuclides employed in the calculation***
- ***The biases / uncertainties thus generated to determine the USL are for the purpose of ensuring that the CSAS25 module with the ENDF-B/V cross section library adequately (95/95 basis) calculates the k_{eff} of the TN-40 cask***