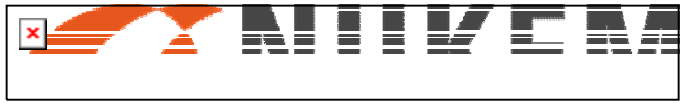


Discussion Topics

- Cask description/comparison
  - Impact Limiter
  - Cask Body
- Application of Computational Modeling Software
  - Impact Limiter
  - Cask Body
- Additional considerations
- Conclusions

Objective

Provide evidence and assurances that an analytical approach can be used to confirm that a replacement radwaste transportation cask will maintain containment during normal and accident conditions of transport

NUKEM

Cask Description/Comparison

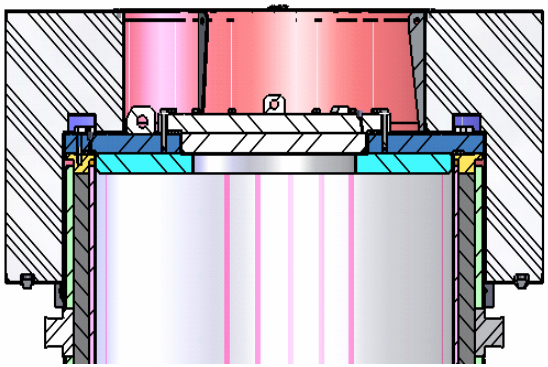
Proposed cask is intentionally designed to incorporate proven configuration, construction, and contents specifications – no novel or unprecedented features are proposed

- 10-165B cask replaces 10-142B cask fleet sun-setted by 10CFR71 rule change
- Contents same: Type B quantities, Cat II normal form of solid low level waste
- Configuration and construction similar to the sun-setted cask and other existing casks
- Payload weight and configuration, and package gross weight similar to existing casks
- Structural joints, containment seals, and shielding configuration details same
- Materials of construction same as existing casks
- No changes to cask or contents have been made that present a new or increased challenge for compliance demonstration by analytical methods

Impact Limiter Description/Comparison

Impact Limiter

- Stainless steel shell
  - The ductility of the steel and the welds ensures that the shell will remain intact during the impact
  - Due to its ductility, stainless steel is used in many existing licensed impact limiters
  - ASME B&PVC materials and Section IX qualified welders provide assurance of the assumed properties and performance
  - Internal stiffeners are not included in the design
    - Crush properties are therefore more homogeneous than for designs with internal stiffeners



Impact Limiter - continued

- Stainless steel shell-continued
  - Attachments to the limiters are designed and positioned to avoid interference with the energy absorption of the impact limiter
  - Design contains a pressure relief feature to mitigate potential hazard of shell pressurization during the hypothetical fire accident
  - Dimensions are similar to other existing licensed impact limiters
    - Shell thickness
    - Overlap
    - Outer diameter
  - Impact limiter shell is leak tested to ensure foam is protected from deterioration from moisture or other contaminants

Impact Limiter - continued

- Foam
  - General Plastics (GP) has been a leader in cellular solids for over 60 years, providing the foam material for most of the currently licensed transportation casks
  - The limiter design uses standard GP FR-3700 foam material to absorb the energy during the hypothetical impact
  - GP has developed extensive material testing data for the FR-3700 foam
    - Temperature effects from -40ºF to 180ºF (and higher) evaluated/quantified
    - Dynamic strain rate effect on the crush strength
    - Crush strength benchmarking to relate the performance of the block form of the foam used in testing and the monolithic form of the foam in the impact limiter

Impact Limiter - continued

- Foam - continued
  - Test data includes the direction of crush parallel to the rise of the foam during the pouring of the limiter (end drop) as well as the direction perpendicular to the rise of the foam (side drop)
  - These effects are identified by factors which are strain dependent
  - GP testing procedures confirm that the crush properties of the actual limiter foam are within ±10% of the nominal product crush strength
    - This is confirmed using samples from the actual pouring of foam for the impact limiter
  - QA procedures ensure that the appropriate procedures are followed for constructing limiters with consistent properties

Impact Limiter - continued

- Foam - continued
  - Parallel crush strength and perpendicular crush strength are sufficiently close to avoid the need of internal stiffeners to maintain the material in the correct orientation for the stiffer direction
  - This confirms the accurate characterization of the foam properties
    - used in the construction of each impact limiter
    - accounts for the variation in the ambient conditions that the impact limiter experiences in service

Cask Body Description/Comparison

Cask Body

- Steel-Lead-Steel Shell Design
  - Inner and outer shells as thick or thicker than shells used in many existing licensed designs
  - Shell and end plate material is ASME B&PVC Sec II ASTM A516
  - Lead is standard specification ASTM B29
- Cylindrical design with aspect ratio close to 1 is common and robust
- Appurtenances limited to those necessary for tiedown and lifting the body
  - Simplifies structural and thermal analysis

Cask Body - continued

- Cask lid design
  - Typical thick plate, rigid stepped lid configuration nests into cask body, minimizes deflection
  - Partial penetration welds are used for the lids
  - Typical multiplicity of heavy bolts ensure containment
  - Double o-ring seals protected by robust, outboard compression stops
  - Primary lid backed by impact limiter in top axial drop orientation
- Cask thermal shield
  - Typical configuration of stiff, gauged stainless steel outer barrier defining air gap of typical dimensions
  - Minimum discontinuities/penetration limit thermally conductive pathways to cask body
  - Entire exposed cask outer wall between impact limiters protected by shield

Cask Body - continued

- Cask Body
  - Materials of construction
    - ASME B&PVC certified materials provide assurance of material properties
    - ASME B&PVC certified welders and weld procedures provide assurance that welded joints perform to failure as analyzed (certification achieved by destructive coupon tests)
    - ASME B&PVC weld inspections further assure quality of critical cask body welds
    - Only proven, fully precedented materials, welding techniques and joints are used in the cask design
    - Full penetration are used for the shells

Application of Computational Modeling Software

Application of Computational Modeling Software

- ANSYS version 10 used for computing structural loads, analyzing impact consequences, and thermal analysis
- ANSYS Code is used extensively in a wide range of industries involving human safety and safety system performance
- ANSYS extensively V&Ved, nothing distinctive about its application to transportation casks that is cause for concern or justification for additional conservatisms or assurances
- ANSYS used to demonstrate most currently licensed cask designs
- SAR will facilitate NRC review by providing complete documentation and justification of analytical software application, model, material properties, boundary conditions, and assumptions

Impact Limiter Analysis Methodology

- Analysis methodology is based on an iterative solution
  - The impact limiter is displaced in small increments
  - In each increment the strain is recomputed (ratio of total displacement to initial depth of foam)
  - Area of crush is recomputed
    - End drop: area remains constant
    - Side drop: the simple geometric shape of the contact/crush area permits the crush to be calculated by a closed form expression
    - Corner drop: ANSYS pre-processor is used to compute the elliptical-shaped contact/crush area

Impact Limiter Analysis Methodology - continued

- The crush strength is recomputed for each step based on the strain
  - All pertinent factors for temperature, form, strain rate and directions are included
- The incremental energy absorbed is computed based on the crush strength and displacement
- Current acceleration (g) is based on the total crush force/weight + 1 g
- The potential energy is increased by the displacement
- Iterations continue until the total potential energy is exceeded by the energy absorbed by the impact limiter

Cask Body Analysis Methodology

- The structural analysis methodology of the cask body follows the methodology used in existing licenses
  - Meets ASME B&PVC Section III ND criteria
  - Analyses employ linear material properties
  - Gaps between the shells and plates and lead are modeled in detail
  - Impact limiter reaction matches the axial overlap of the impact limiter
    - Calculational methodology embedded in the ANSYS macros are verified by QA procedures
    - Temperature dependent material properties are input
    - *Analysis factor in all material properties at all relevant temperature extremes
    - Accelerations computed in impact limiter analysis are used as input for the cask body analysis: Meets ASME Section III NB criteria

Cask Body Analysis Methodology - continued

- The thermal analysis methodology of the cask body follows the methodology used in existing licenses
  - Maximum heat load is 400 W; applied as a heat flux
  - Solar insolance is specified by 10CFR71
  - Conduction and radiation are employed
  - Convection and radiation from the cask surface employ closed form expressions for the film coefficient
  - Gap between the shells and lead is modeled in detail and conservatively
  - Calculational methodology is verified by QA procedures
  - Fire accident conditions are those specified by 10CFR71

Additional Considerations

Additional Considerations

- Analysis methodology in use for similar radwaste transportation casks for nearly 30 years
- Assurance and conservatisms are commensurate with proposed contents, which involve a hazard that is lower than that of spent fuel
- Substantial costs of scale model or full scale testing unjustified for cask without novel or unprecedented features or contents
- Inequitable to further burden owners of sun-setted cask designs that are already compelled to bear the costs to develop and license replacement designs, or to address a generic benchmarking or validation concern that is relevant to a number of licenses
- No indications from operating fleet of similar casks that an issue exists that requires further benchmarking or validation

Conclusion

Conclusion

The combination of proven, fully precedented design features and contents limitations for the proposed replacement low level waste transportation cask and the application of similarly proven and broadly embraced analytical tools provide adequate assurance of compliance with the regulations, requirements, and expectations of the NRC relevant to this cask and the hazards involved in its use.