NAC INTERNATIONAL

Pre-submission Meeting, July 31, 2012
NAC-LWT Amendment for NRU/NRX

Agenda

- Introductions
- NRU/NRX package overview
  - Structural
  - Thermal
  - Shielding
  - Criticality
- Licensing and schedule considerations
- Q&A session

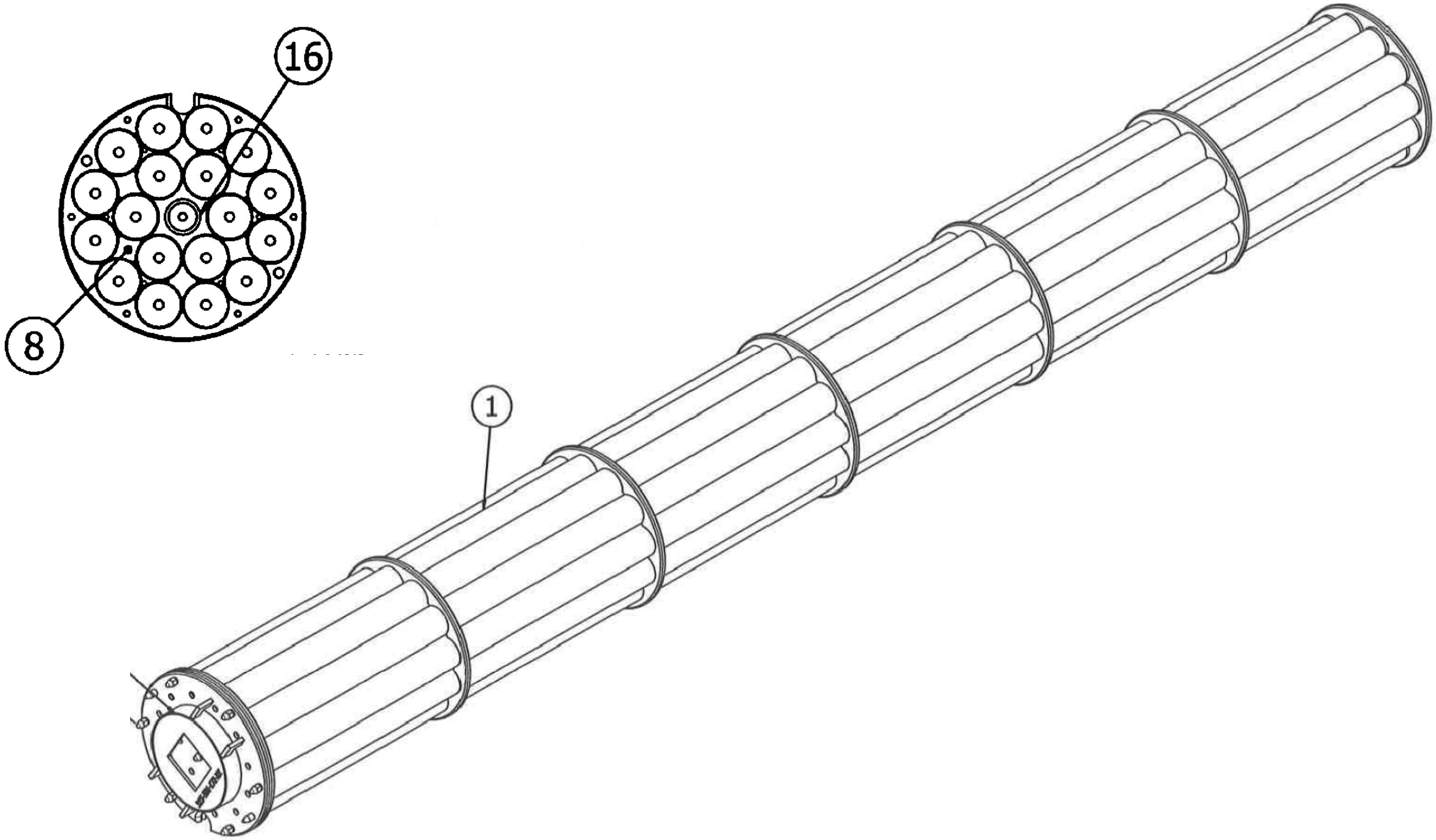
Package Overview

NRU/NRX

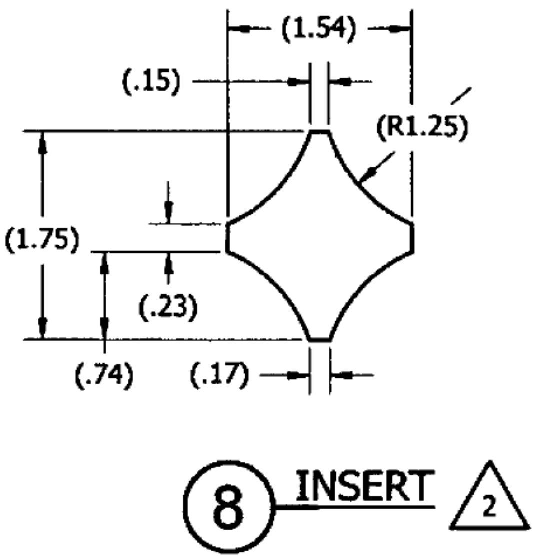
NRU/NRX Package Overview

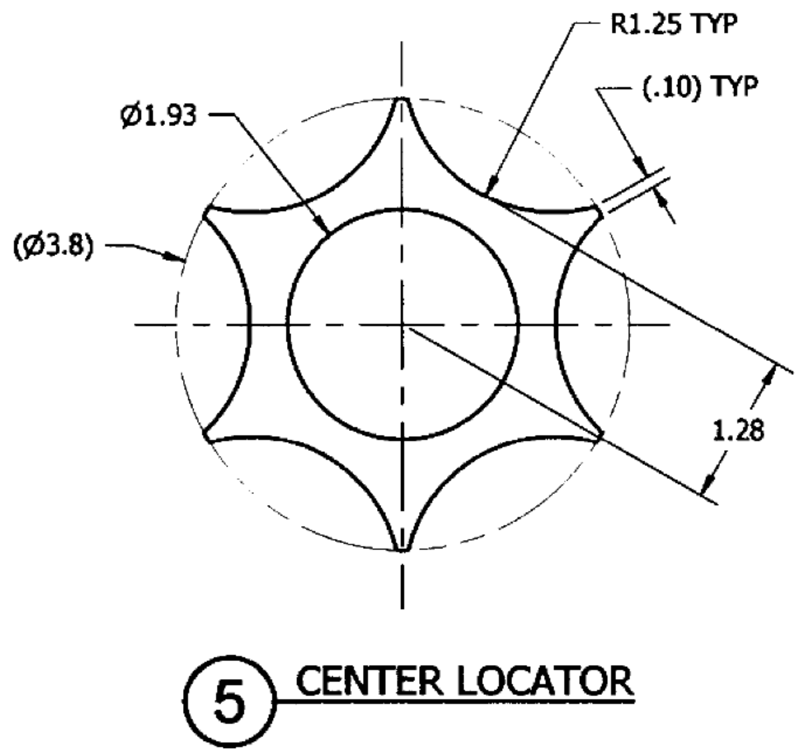
- Fuel basket is designed to accommodate both the National Research Universal (NRU) and National Research Experimental (NRX) fuel
- Basket is designed to retain any gross particulate from damaged fuel
- Basket accommodates up to 18 NRU or NRX fuel rod bundles
  - NRU bundle consists of 12 fuel rods
  - NRX bundle consists of 7 fuel rods
- Lower spacer used to limit axial movement of the fuel basket

NRU/NRX Package Overview (cont'd)

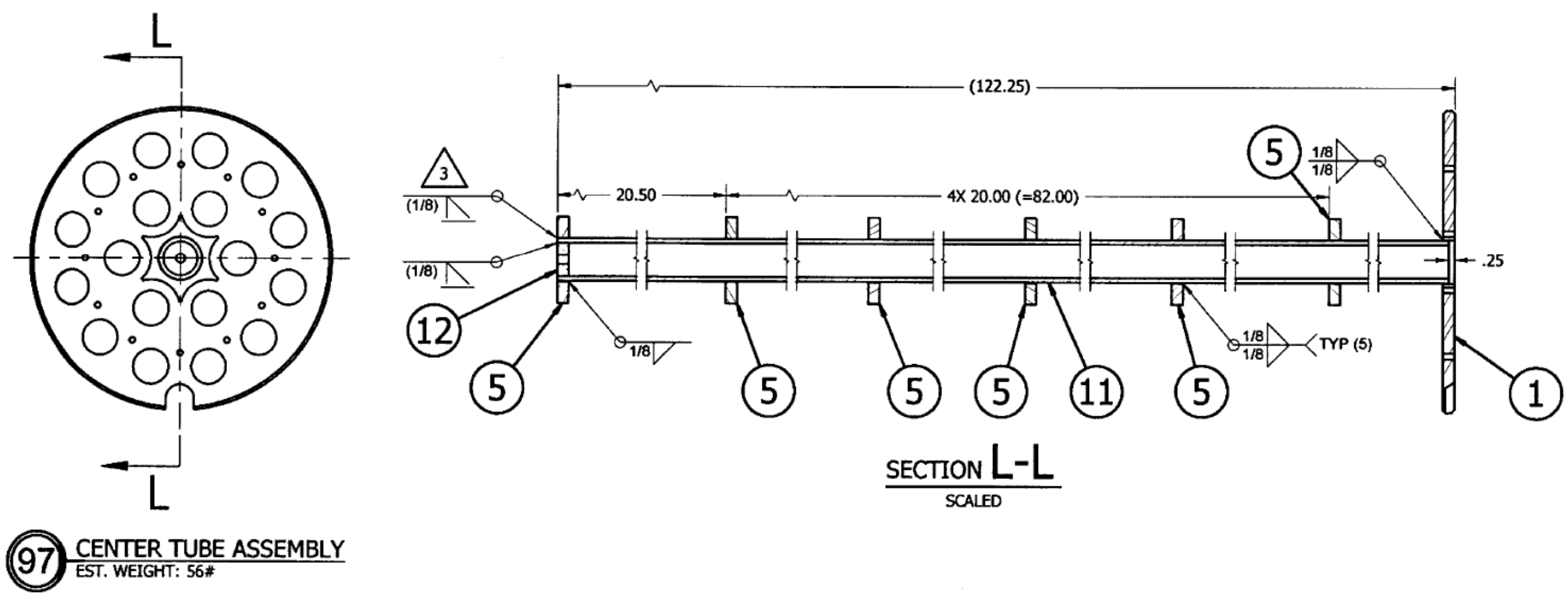


NRU/NRX Package Overview (cont'd)

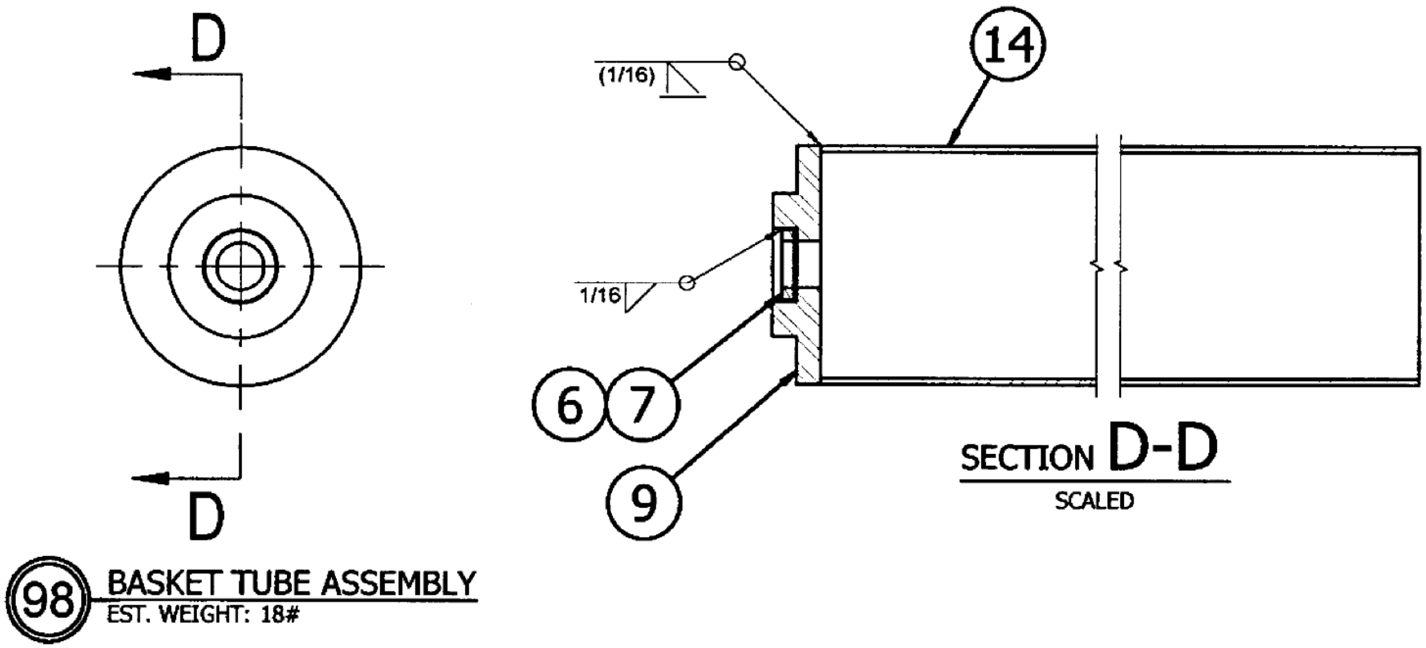




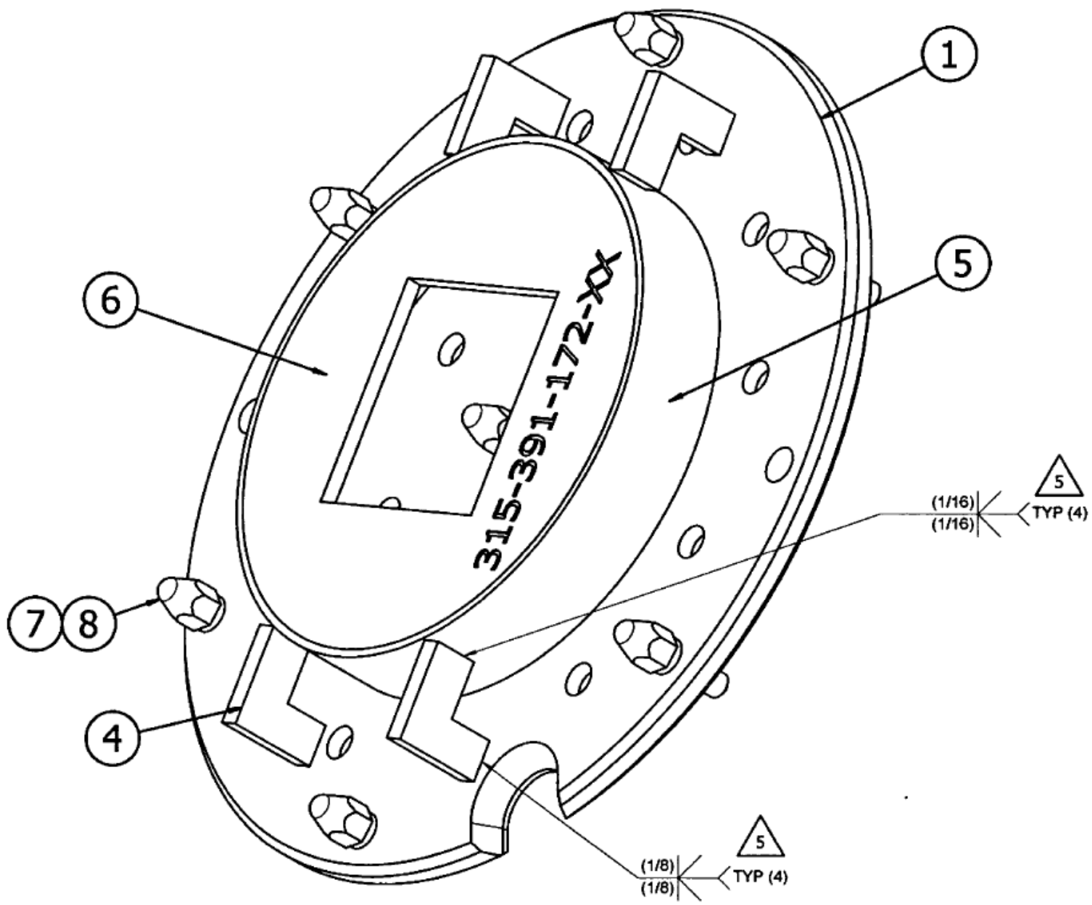
NRU/NRX Package Overview (cont'd)



NRU/NRX Package Overview (cont'd)

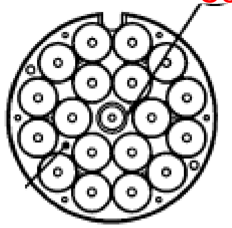


NRU/NRX Package Overview (cont'd)



NRU/NRX Structural Overview

Basket Cross Section

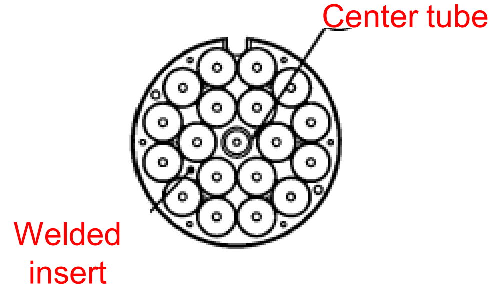


- Maximum of 18 NRU/NRX fuel elements
  - NRU/NRX weight: 11 pounds each
- Each fuel element is contained in a separate basket tube (2.5” OD, 0.06” wall thickness)
- Tubes are joined along their length, and constrained around a structural center tube by 7 disks at a 20.5 inch pitch
- All structural components are comprised of stainless steel type 304
- Total basket assembly weight is 450 lbs.
- Spacer is inserted in cavity to minimize contents motion (115 pounds)
- Total transport contents weight is enveloped by 4000-pound licensed weight
- Cask body evaluation is not required
- Basket is qualified under Subsection NG
  - Weld quality factors are included in the stress evaluation

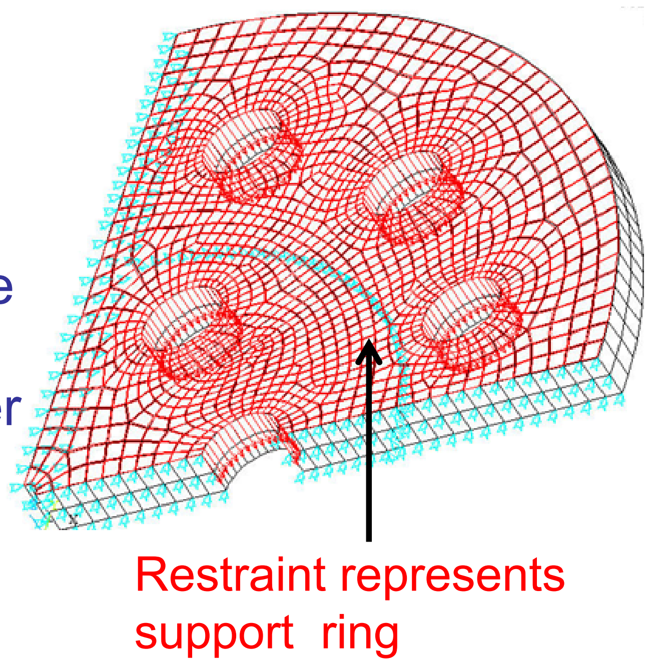
NRU/NRX Structural Overview (cont'd)

- Normal and accident drop conditions for the basket are evaluated using hand calculations
  - Tubes are treated as simply supported beams
  - Buckling evaluated as cylinders using Blake
  - Disk-cavity bearing stress evaluated using Roark
- Bottom end plate for the bottom end drops are evaluated using quarter symmetry FEA model
  - Simulates the effect of load transfer from the tubes to the end supports bearing against the cask cavity
- Top end plate is evaluated using a similar quarter symmetry model for the top end drop

Basket Cross Section



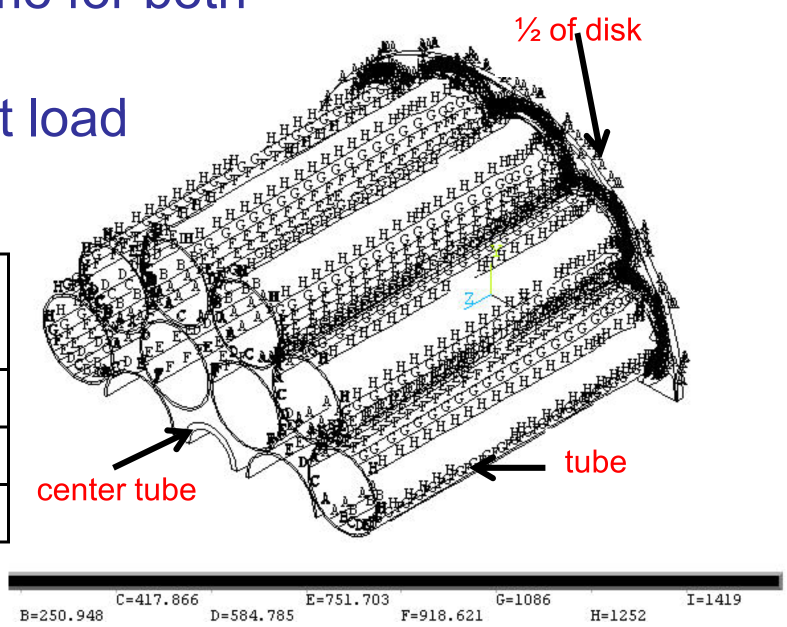
End Plate Model



NRU/NRX Structural Overview (cont'd)

- Thermal stresses are evaluated using quarter symmetry periodic 3D ANSYS model
  - Captures stresses due to radial gradient and the welded components
  - Temperatures are imported from the thermal model
    - Element/node models are the same for both
  - Thermal stress < 2ksi
    - Minimum stress is due to low heat load
- Minimum Safety Factors

Component	Normal Condition	Accident Condition
Basket Assembly	9.71	1.94
Basket Lid	1.85	1.79
Spacer Assembly	6.21	6.32

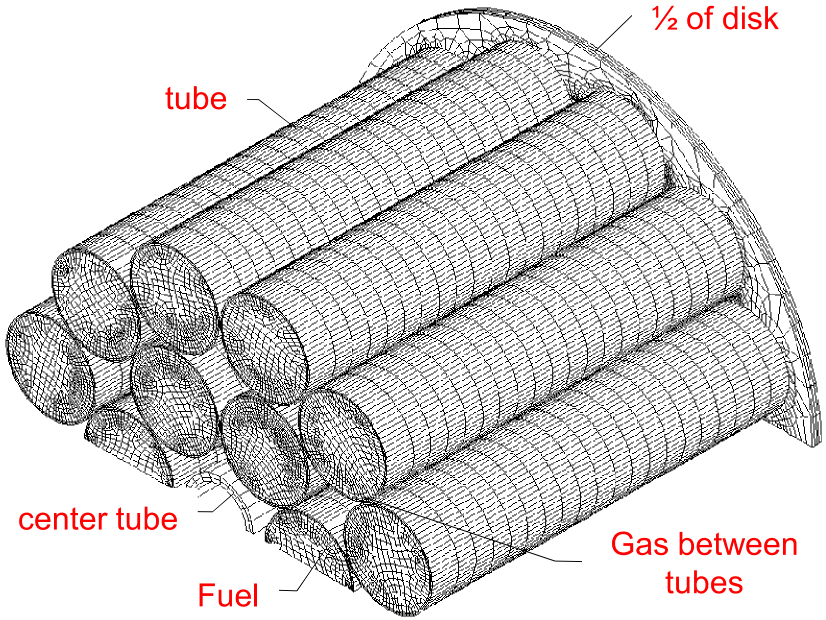


NRU/NRX Thermal Overview

- LWT is transported in an ISO container used in the current LWT SAR
- LWT cask is backfilled with helium
- Total heat load in the cask cavity is 200 W (bounds actual 171 W)
  - 108 inch active fuel length
  - No peaking factor is required
- The current ANSYS model in the SAR for the LWT cask body and ISO container is used to determine the inner shell surface temperature for the NRU/NRX contents
  - Model was previously used for MTR and SLOWPOKE fuel contents
  - Heat load (200 W) is applied to the cask inner shell surface of the model
  - Insolance is applied to ISO container surface

NRU/NRX Thermal Overview (cont'd)

- Quarter symmetry 3D periodic model used to determine maximum temperatures
- Fuel region is conservatively modeled as helium conduction
- All voids in the basket are modeled as helium conduction
- Radiation matrix models radiation from tube outer surface to cask inner shell
- 0.05 inch radial gap between disks and cask inner shell is modeled with helium
- Cask inner shell temperature is applied to outer layer of nodes of the model
- Maximum normal condition fuel temperature is 182°F
- Fire accident condition is bounded by the 1.26 kW MTR evaluation (385°F)



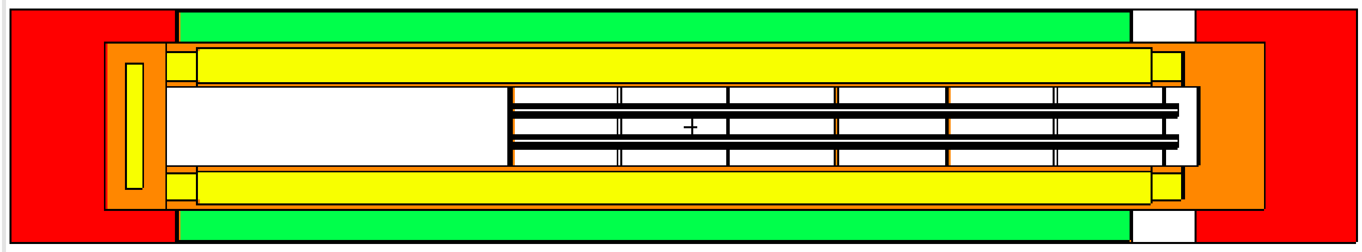
NRU/NRX Shielding Overview

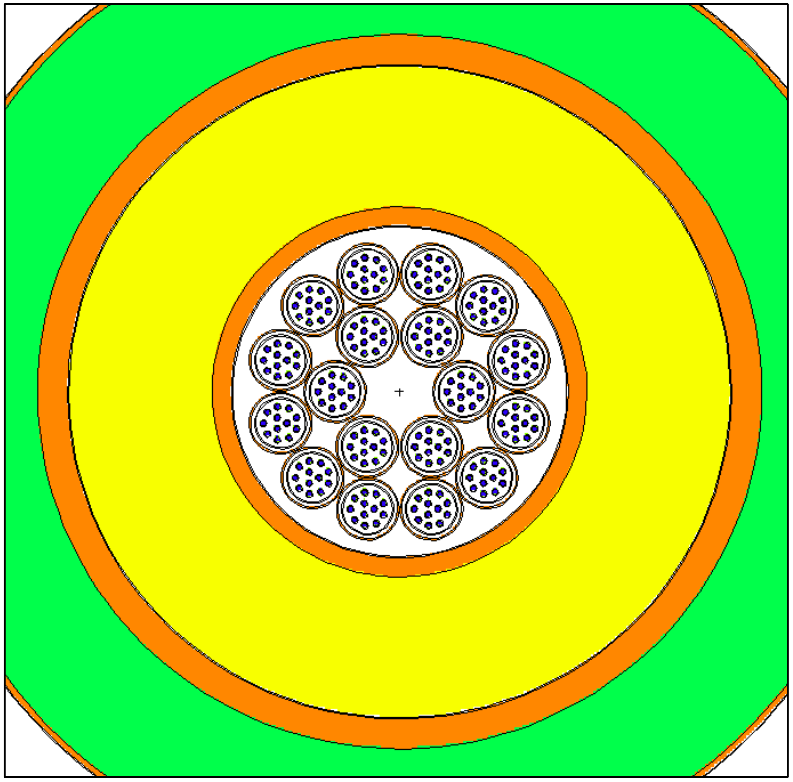
- Source term calculated using SCALE/TRITON
  - Single cell modeled for NRU and NRX cores
    - Compared against “Supercell” model that is representative of the reactor lattice configuration
    - Single cell model shown to be more conservative for the source term evaluation
  - Conservatively adjusted fuel parameters (lower enrichment and higher ^{235}U mass) to maximize source
  - Source terms based on 238-group library calculation to minimize cross-section collapse effects

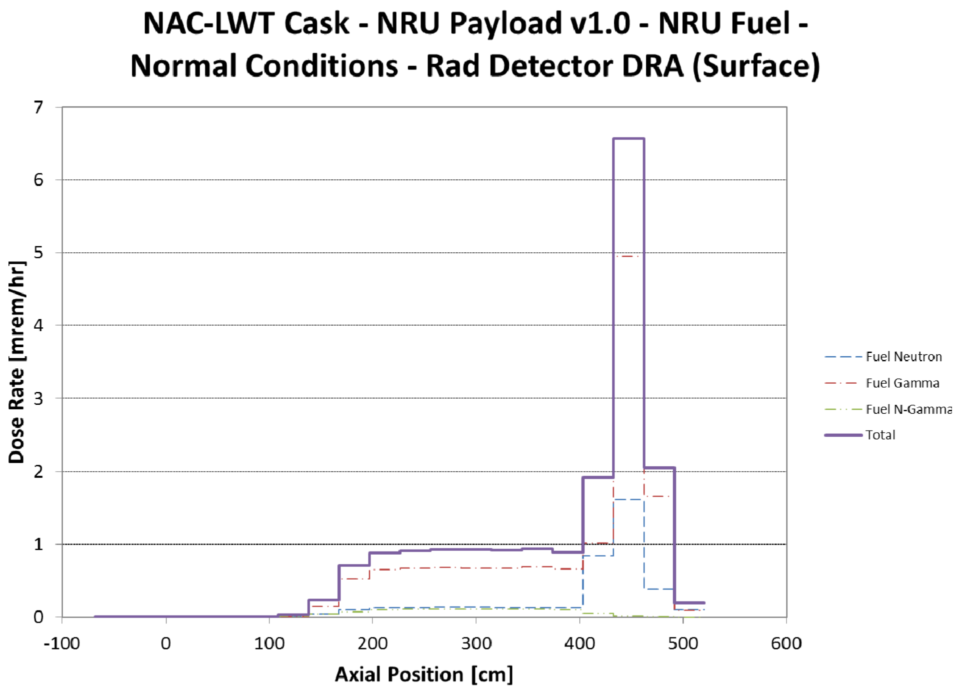
NRU/NRX Shielding Overview (cont'd)

- Source applied in 3-D detailed MCNP model to determine dose rates for normal and accident conditions
  - Includes detailed "as cut" fuel assembly model
    - Basket spacer conservatively not modeled
  - Normal conditions with neutron shield and impact limiter intact
  - Accident condition – lead slump, removal of neutron shield and impact limiter
  - Fuel is uranium-aluminum metal alloy not subject to fuel debris formation observed in oxide fuels
  - Expected transport index (TI) < 1.0

NRU/NRX Shielding Overview (cont'd)







NRU/NRX Criticality Overview

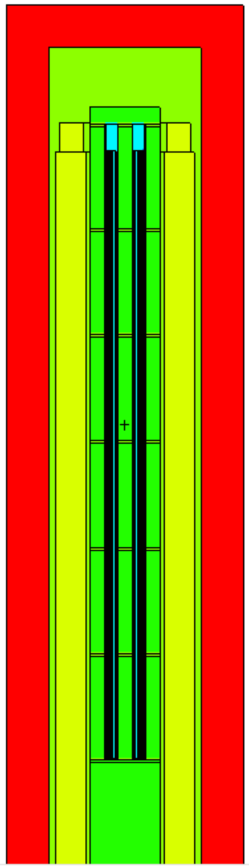
- MCNP5 v1.30 evaluation using primarily ENDF/B-VI cross section
- Code validated for use with highly enriched fuel
- Detailed geometry modeled using tube/basket configuration designed for NRU/NRX fuel in the NAC-LWT
- Evaluated both undamaged fuel and fuel debris
  - Fuel debris evaluated as fuel/water mixtures occupying all void spaces inside tube
    - Uranium/aluminum fuel matrix not expected to produce significant debris

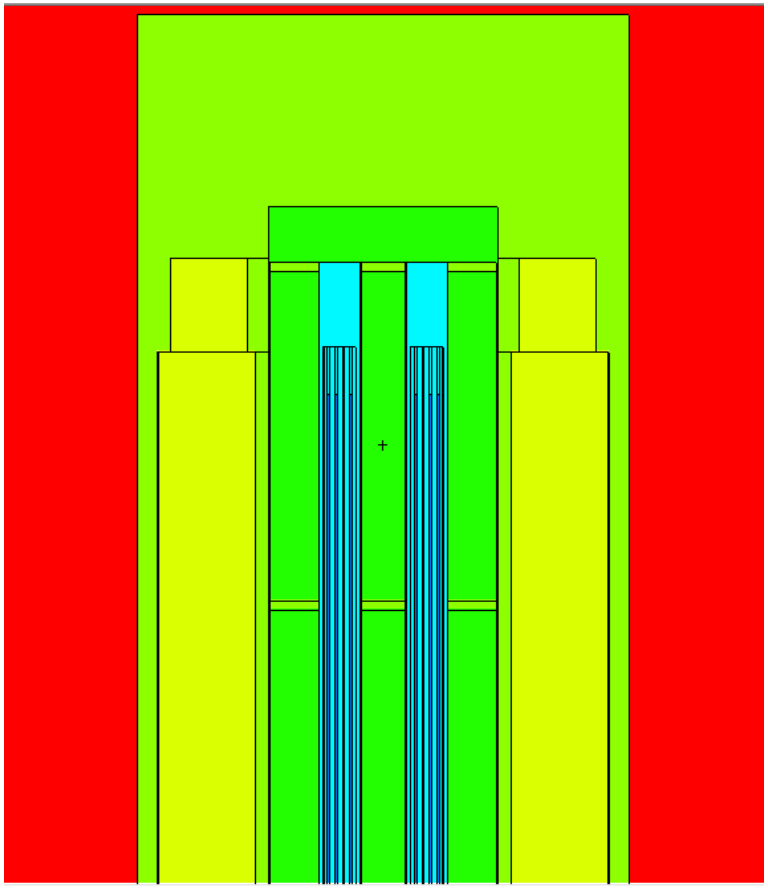
NRU/NRX Criticality Overview (cont'd)

- Evaluated
  - Tube/basket manufacturing tolerances
  - Geometric perturbations
  - Interior and exterior moderator densities to arrive at maximum reactivity conditions as specified in 10 CFR 71.55 and 59
  - Included in moderator density studies is an evaluation of preferential flooding (i.e., moderator density different in tube and cask cavity)
  - 71.59 analysis based on single cask (CSI = 100)

NRU/NRX Criticality Overview (cont'd)

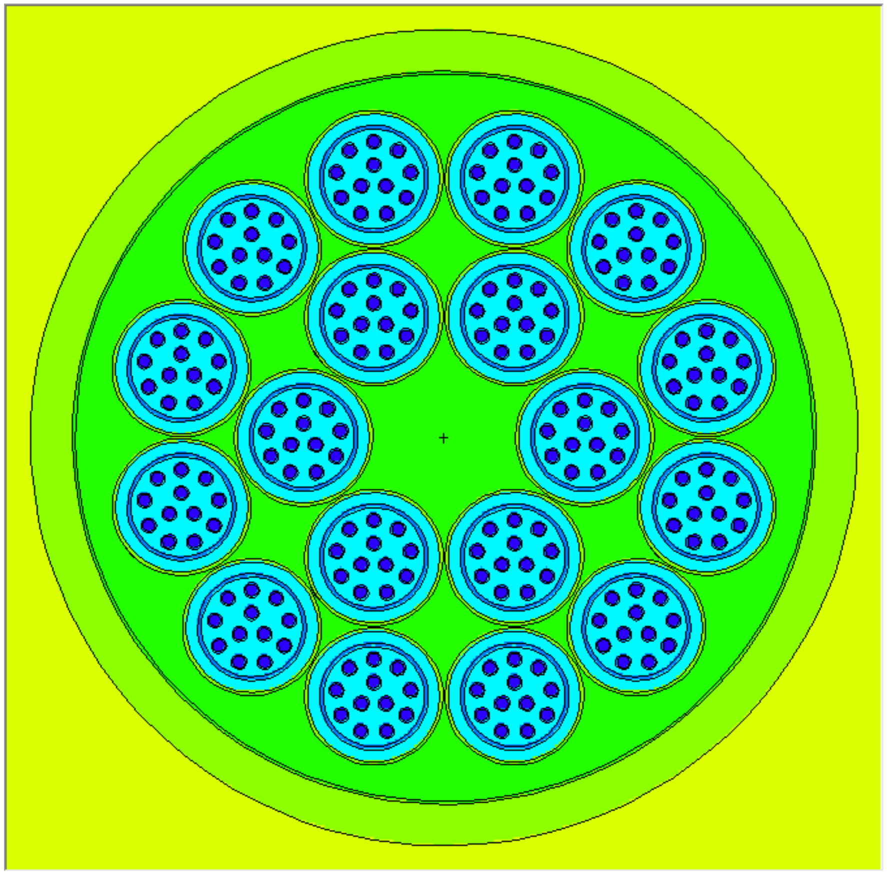
- Model Images

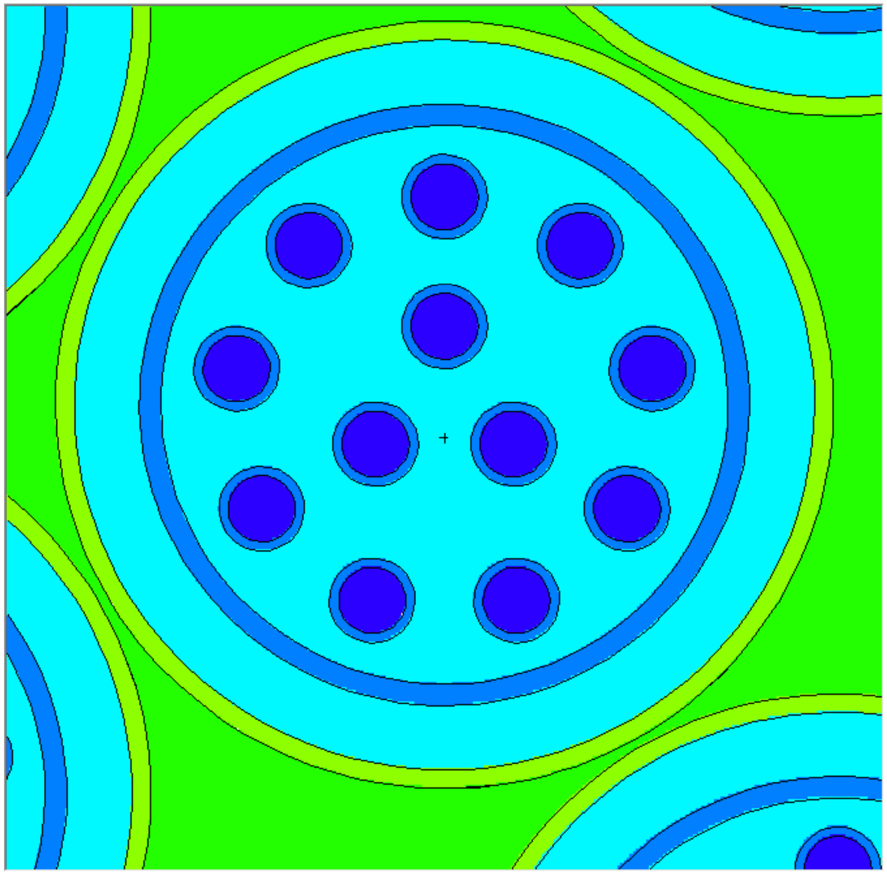




NRU/NRX Criticality Overview (cont'd)

- Model images cont'd





NRU/NRX Criticality Overview (cont'd)

- Maximum reactivity (k_{eff} + 2σ) of 0.9275
  - Maximum reactivity due to preferential flood condition

Licensing and Schedule

CONSIDERATIONS

Licensing and Schedule Considerations

- Intend to submit application early September
- Conduct post-submittal meeting late September
- To support NRU/NRX clients, NAC is requesting revised CoC to be issued by March 2013

Q&A Session