

# Transport of BR2 Cobra Fuel in the ATR FFSC Packaging

**AREVA Federal Services LLC**

under contract to

**Battelle Energy Alliance, LLC**



# Agenda



- ▶ **Introductions**
- ▶ **Review of ATR FFSC packaging**
- ▶ **Description of Cobra Fuel**
- ▶ **Licensing strategy**
- ▶ **Air transport approach**
- ▶ **Summary of preliminary criticality results**
- ▶ **NRC feedback**
- ▶ **Project schedule**

# Introductions



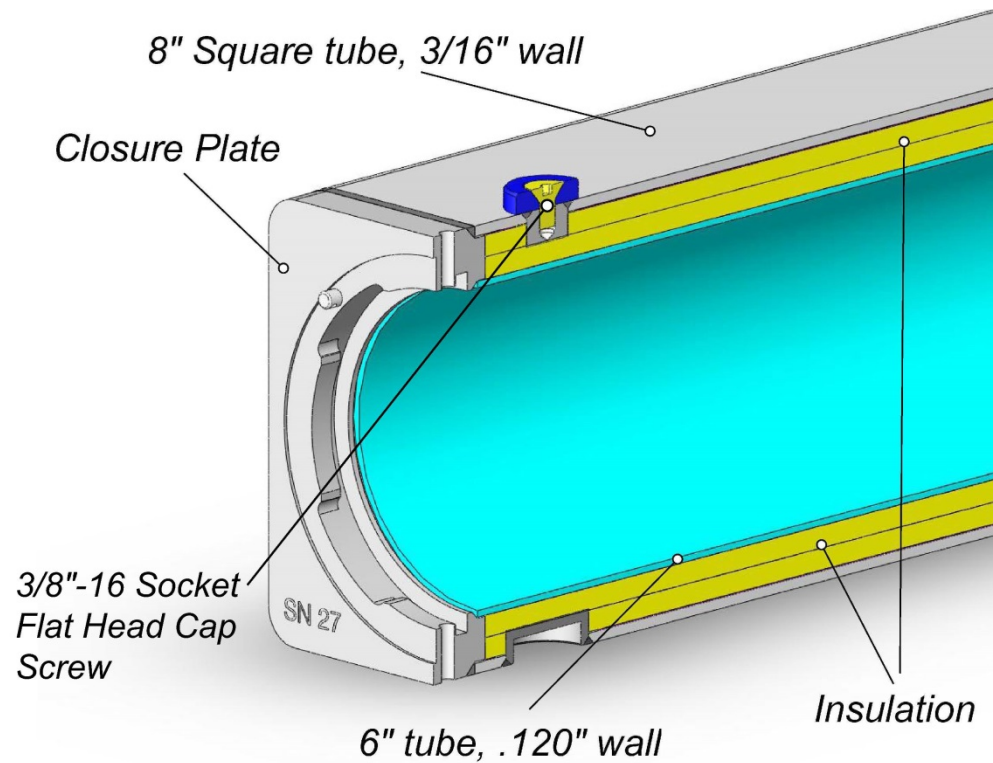
## ► Introductions

# ATR FFSC Packaging



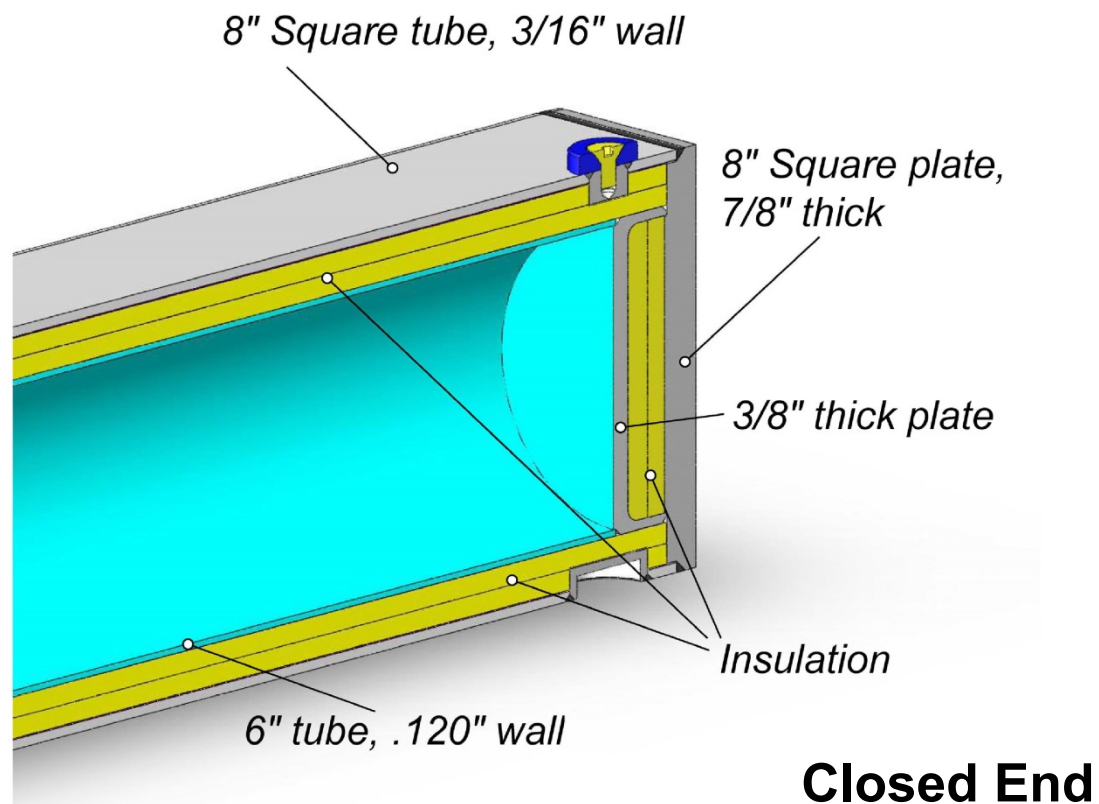
- ▶ The ATR FFSC packaging holds CoC USA/9330/AF-96
- ▶ It was developed to transport a single, unirradiated ATR fuel element from the fuel manufacturer to the ATR reactor
- ▶ Since then, several fuels have been added:
  - ◆ MURR
  - ◆ MIT
  - ◆ RINSC
  - ◆ Various loose plates and Design Demonstration Elements
  - ◆ Small quantity payloads
- ▶ Type A fissile quantity

# ATR FFSC Packaging

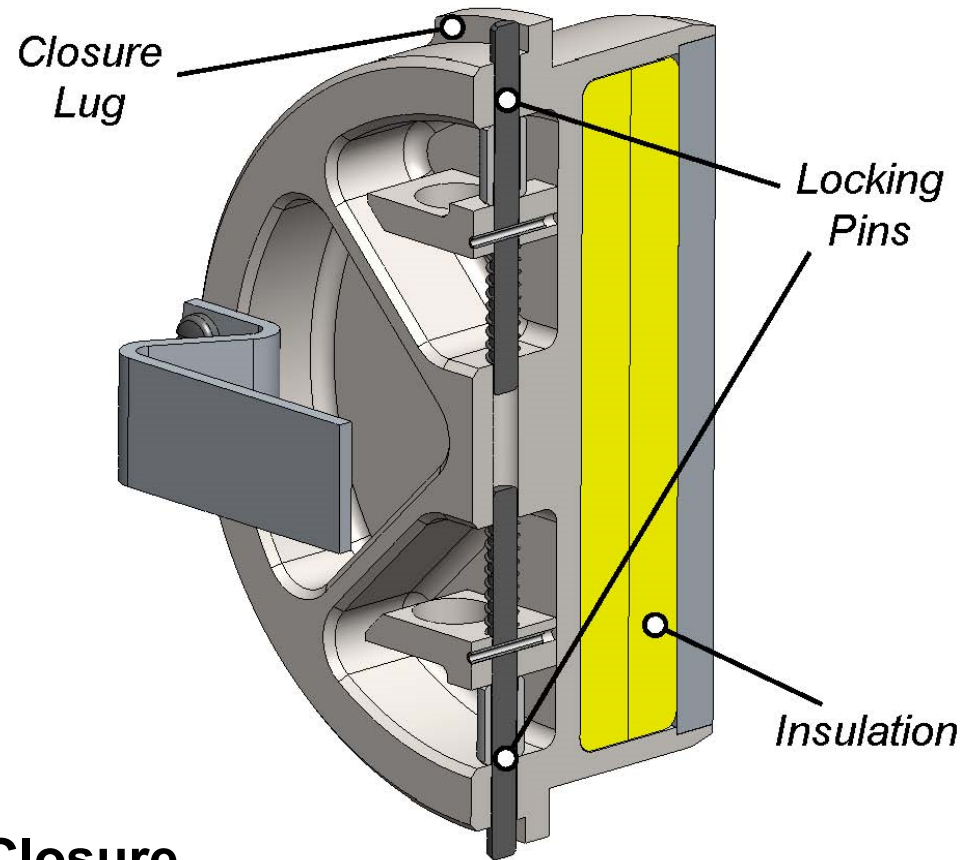


**Open End**

# ATR FFSC Packaging



# ATR FFSC Packaging



## Bayonet Closure

# ATR FFSC Packaging



- ▶ **Outer dimensions: 8 inches wide × 8 inches tall × 72.5 inches long**
- ▶ **Inside dimensions: Cylindrical cavity 5.76 inches in diameter, 67.88 inches long**
- ▶ **Weight:**
  - ◆ 290 lb package gross weight
  - ◆ 50 lb maximum payload weight (including fuel handling enclosure)
- ▶ **All structural materials of packaging are Type 304 stainless steel**
- ▶ **Insulation is ceramic fiber**

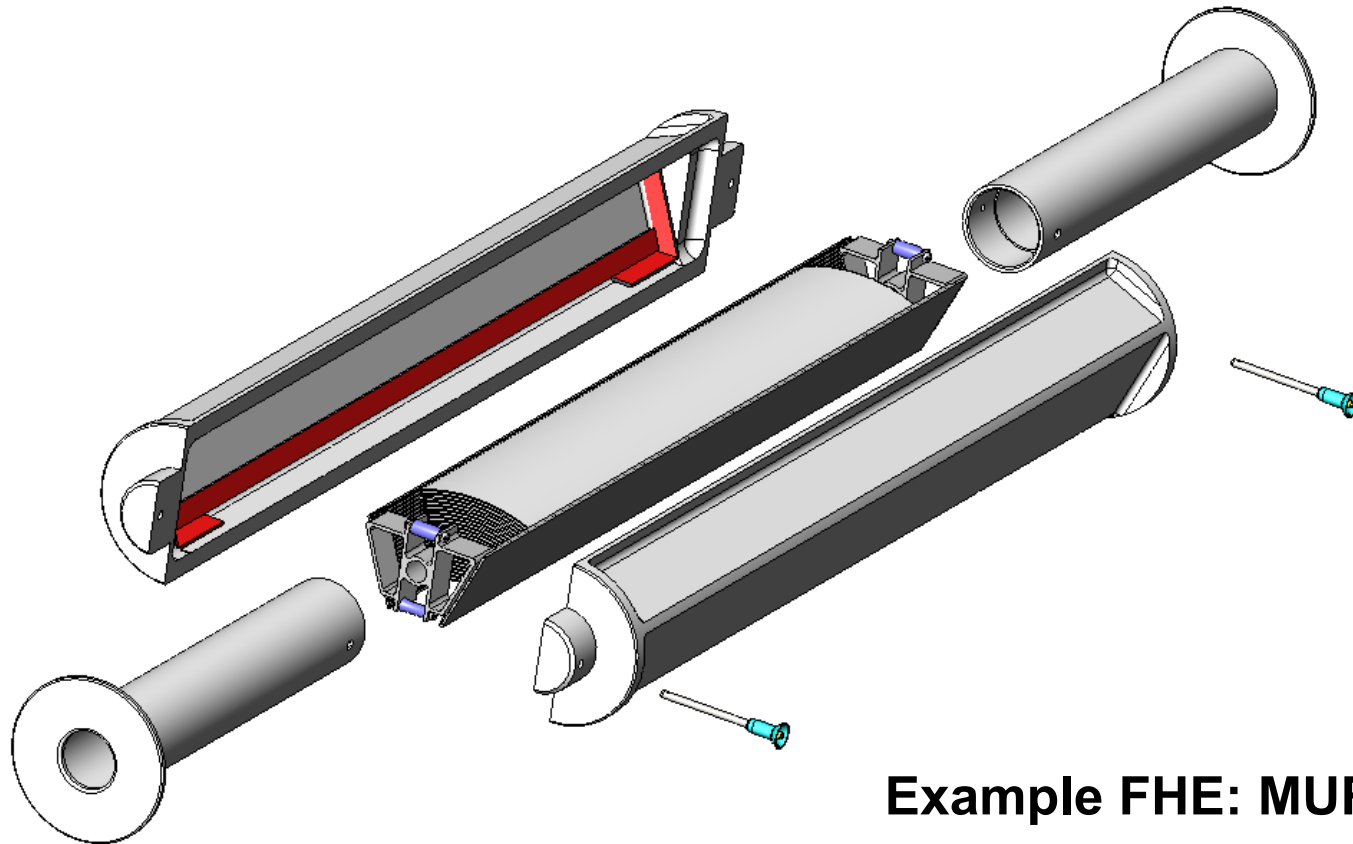


# ATR FFSC Fuel Handling Enclosure



- ▶ All fuel elements or loose plates located in fuel handling enclosures (FHE)
- ▶ FHEs provide convenience and investment protection, do not have a safety function
- ▶ Two types of FHE currently used: sheet metal weldment (ATR fuel) and machined from billet (all others).
- ▶ All FHE are made from aluminum
- ▶ Cobra fuel will have custom FHE, expected to be of the machined type

# ATR FFSC Fuel Handling Enclosure



**Example FHE: MURR**

## Cobra Fuel



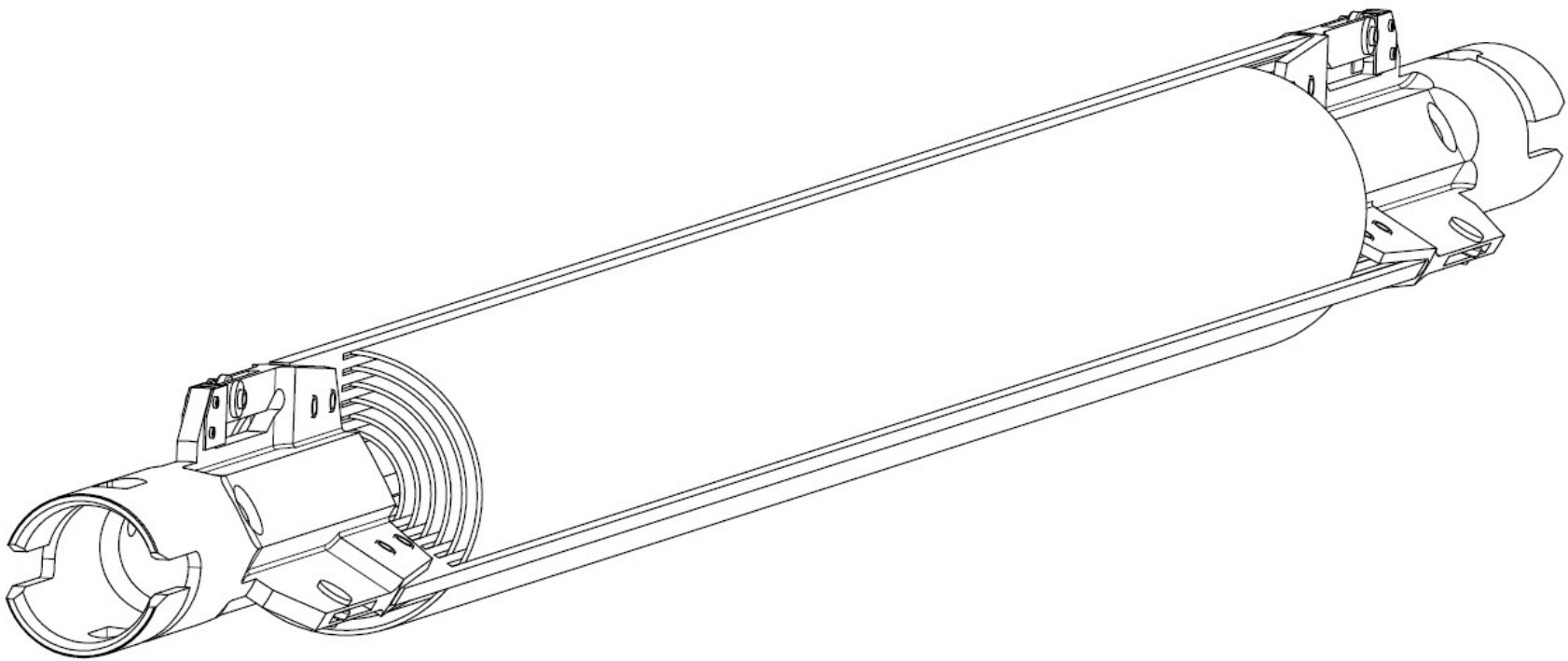
- ▶ **Cobra fuel is used at the BR2 reactor at SCK-CEN in Belgium**
- ▶ **Reactor is in process of conversion to LEU**
- ▶ **Source of HEU fuel is being transitioned to BWXT**
- ▶ **Transport of HEU elements, LEU elements, and loose plates is required**
- ▶ **Air transport is required**

## Cobra Fuel



- ▶ **Cobra fuel element constructed in similar fashion to other plate-type fuels**
- ▶ **Curved plates swaged into rigid spacer components**
- ▶ **Consists of 3, 120° segments of plates with circular curvature, 6 concentric layers**
- ▶ **Spacer bars riveted to end fittings**
- ▶ **Overall length 1543 mm (60.7 inches)**
- ▶ **Bounding diameter ~84 mm (~3.3 inches)**

# Cobra Fuel



# Cobra Fuel



- ▶ Fuel plates have a “sandwich” design similar to other approved ATR FFSC fuels
- ▶ Fuel “meat” composed of:
  - ◆ HEU: up to 94% enriched  $UAl_x$  with Gd or Sm burnable poison
  - ◆ LEU: up to 20% enriched Uranium silicide with Gd burnable poison
- ▶ U-235 loading:
  - ◆ HEU: <420g U-235 per element
  - ◆ LEU: <450g U-235 per element

# Licensing Strategy



- ▶ **Three different criticality demonstrations for existing payloads:**
  - ◆ Geometry control assuming intact fuel (ATR Fuel, ATR loose plate basket)
  - ◆ Geometry control with maximum spacing of intact plates (MIT, MURR)
  - ◆ Optimally moderated fissile slurry (Small quantity payloads)
- ▶ **Cobra fuel will use the slurry method**
  - ◆ Simplest approach is chosen to expedite regulatory approval (both US and Belgian)
  - ◆ Restricts transport capacity (large CSI) but meets current needs
  - ◆ Anticipate a later amendment for geometry control with maximum plate spacing to increase transport efficiency
- ▶ **No change to the ATR FFSC packaging**
- ▶ **New, non-safety FHE**

# Licensing Strategy



- ▶ **Optimally moderated fissile slurry defines most reactive configuration of U-235 loading, water, and materials of FHE and fuel**
- ▶ **Includes up to 100g of polyethylene sheeting (bagged fuel)**
- ▶ **No credit taken for burnable poison**
- ▶ **Slurry fills package payload cavity (package remains intact based on certification test results)**
- ▶ **Except for an adjustment of U-235 loading and CSI, approach will be identical to currently-certified small quantity payload**
- ▶ **Acceptance criteria:**
  - ◆ **Maximum loading of U-235 LEU and HEU**
  - ◆  **$K_{\text{eff}} < \text{USL}$**
  - ◆ **CSI of approximately 30 (3 packages per transport)**



# Licensing Strategy



## ► Structural

- ◆ Structural behavior will be very similar to existing payload cases
- ◆ Fuel construction, materials, and weight falls within existing range
- ◆ FHE construction, materials and weight falls within existing range
- ◆ Load pathway between Cobra fuel, FHE, and ATR FFSC packaging is the same as existing payload cases
- ◆ No new drop tests or structural analyses are planned

## ► Thermal

- ◆ Thermal behavior will be very similar to existing payload cases
- ◆ Fuel materials and thermal mass fall within existing range
- ◆ Thermal pathway between packaging, FHE, and fuel is the same as the existing payload cases
- ◆ No new thermal analyses are planned

## ► SAR submittal will expand on these points

# Air Transport



- ▶ To maintain schedule and improve security, fuel will be transported to Belgium by air
- ▶ Requirements of 10 CFR §71.55(f) will be met by assuming a reconfiguration of the packaging and contents in the worst case spherical geometry
- ▶ Assumes a sphere of materials of single package with U-235 contents arranged in most reactive configuration, reflected by 20 cm of water, neglecting burnable poison
- ▶ Method has received approval for ES-3100 (NRC CoC USA/9315/B(U)F-96)
- ▶ Method has been revalidated by DOT for TN-BGC-1 (F/313/B(U)F-96)

# Preliminary Criticality Results



- ▶ LEU slurry: 700g U-235
- ▶ HEU slurry: 500g U-235
- ▶ Bounding CSI = 31.3 (3 packages per conveyance)
- ▶ Maximum  $K_{\text{eff}} = 0.9160 < \text{USL of } 0.9209$
- ▶ Air transport: 2,000g U-235 (HEU),  $K_{\text{eff}} = 0.574$ 
  - ◆ 2,000g chosen to bound other possible future payloads
  - ◆ Certificate should allow air transport of all approved fuel types up to 2,000g U-235

# Feedback



## ► Staff questions and comments

# Project Schedule



- ▶ **Expected SAR amendment submittal: mid September 2016**
- ▶ **Requesting RAIs by December 31, 2016**
- ▶ **Revised CoC by March 31, 2017 pending acceptable responses**
- ▶ **Additional schedule elements:**
  - ◆ **DOT Certificate of Competent Authority – minimal schedule impact expected**
  - ◆ **FANC revalidation**