Development Needs for Advanced LWR Fuels

GAIN Fuel Safety Research Workshop
INL
May, 2017

Jim Malone
Chief Nuclear Fuel Development Officer
Lightbridge Corporation

Lightbridge Fuel Is Designed for Safety

1250°c	360°c
Conventional Fuel	**Lightbridge Fuel**

- ✓ Metal fuel has better heat transfer
- ✓ Does not generate hydrogen gas under design basis accidents
- ✓ Buys more time to add water to cool a reactor

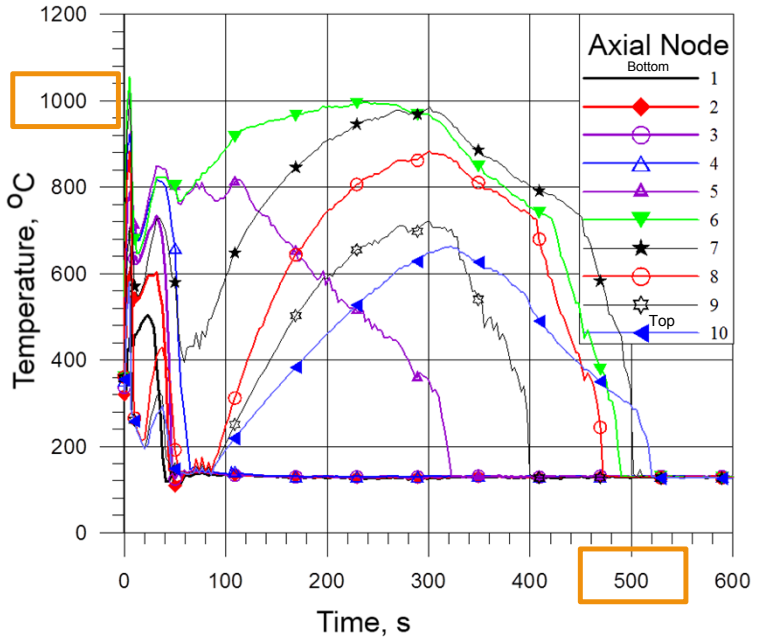
Efficient heat transfer

Enhanced structural integrity

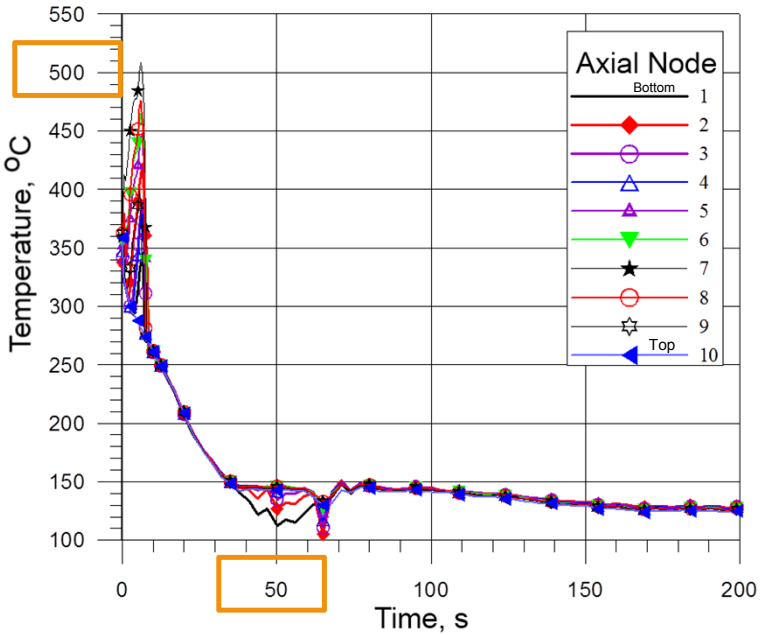
Reduced operating temperature

VVER-1000 Large Break LOCA:
Cladding Temperature Comparison

Peak cladding temperature of Lightbridge-designed metallic fuel is well below steam-Zr reaction temperature during design basis LOCA.



VVER-1000 UO_2 fuel – 448 W/cm (13.6 kW/ft)



Lightbridge tri-lobe fuel – 550 W/cm (16.7 kW/ft)

What is Important to Fuels?

- Fuel and Material Behavior during AOOs
  - Steam Zirconium reaction
  - Fission product release
  - Maintaining coolable geometry
- Fuel and Material Behavior during Beyond Design Basis Accident (BDBA)
  - Time to onset of steam zirconium reaction
  - Extent of steam zirconium reaction
  - Maintain coolable geometry
  - Avoid release of fission products

What is Important to Fuels?

- Material Properties versus Burnup
  - Mechanical properties
    - Due to normal operation
    - In case of AOO or BDBA
    - Fast flux for samples
- **Timely** conduct of necessary experiments
  - Halden and ATR are hard to access from a schedule perspective
  - Can the NSUF help?

What Does the Lightbridge Test Program Look Like?

- First Phase is focused on manufacturability (Areva, U of Lille; Areva, LTBR)
- Second Phase is focused on irradiation programs
  - Thermal Conductivity tests versus burnup at Halden
  - Burnup Tests at Halden for other properties
    - Growth (Radial and Axial)
    - Swelling
    - Property changes with Burnup (Does the fuel retain strength?)
    - Fission product mobility

What is important to Fuels?

- Proof of principle
  - Fuel
    - Will it perform as expected?
    - Look for what we don't know (**Avoid surprises** – INPO)
      - Channel distortion in BWRs
      - CIPS in PWRS
  - Reactor materials

Test Reactor Parameters

- Don't limit the scope
  - Sample enrichment up to 19.7 w/o
  - Minimize need to take the test reactor off line
  - Multiple loops to accommodate varied test needs
    - PWR
    - BWR
    - New Reactor types (SMRs, fast reactors, not water cooled)
    - Sample cooling capability
- Cannot ignore the need for auxiliary needs
  - Hot Cells
  - Radiography
  - Skilled technicians

Capability Needs

- Obtain data to support licensing
  - Corrosion and heat transfer changes versus burnup
  - Mechanical properties versus burnup
  - Look for contra indications (In line with no surprises)
  - Fuel Growth due to irradiation

- Improve ability to diagnose fuel failures
  - Braidwood - Byron had to go to Sweden
  - LaSalle had to go to Sweden
    - **Need domestic capability**
      - International **consumes time** and money
  - Neutron Radiography at at least one place