
AREVA

Considerations for Two New Fresh MOX Fuel Transportation Packages

Charles Temus
Project Manager
NRC, Rockville MD

August 11, 2010

Purpose

- To discuss the use of the fuel cladding as the containment boundary for both PWR and BWR MOX fresh fuel packages
  - MOX Fuel Rod fabrication
  - Lessons learned from Type B Fresh Fuel package testing
- Methods of demonstrating containment integrity
- Plans for New MOX Package Designs

Cladding as Containment

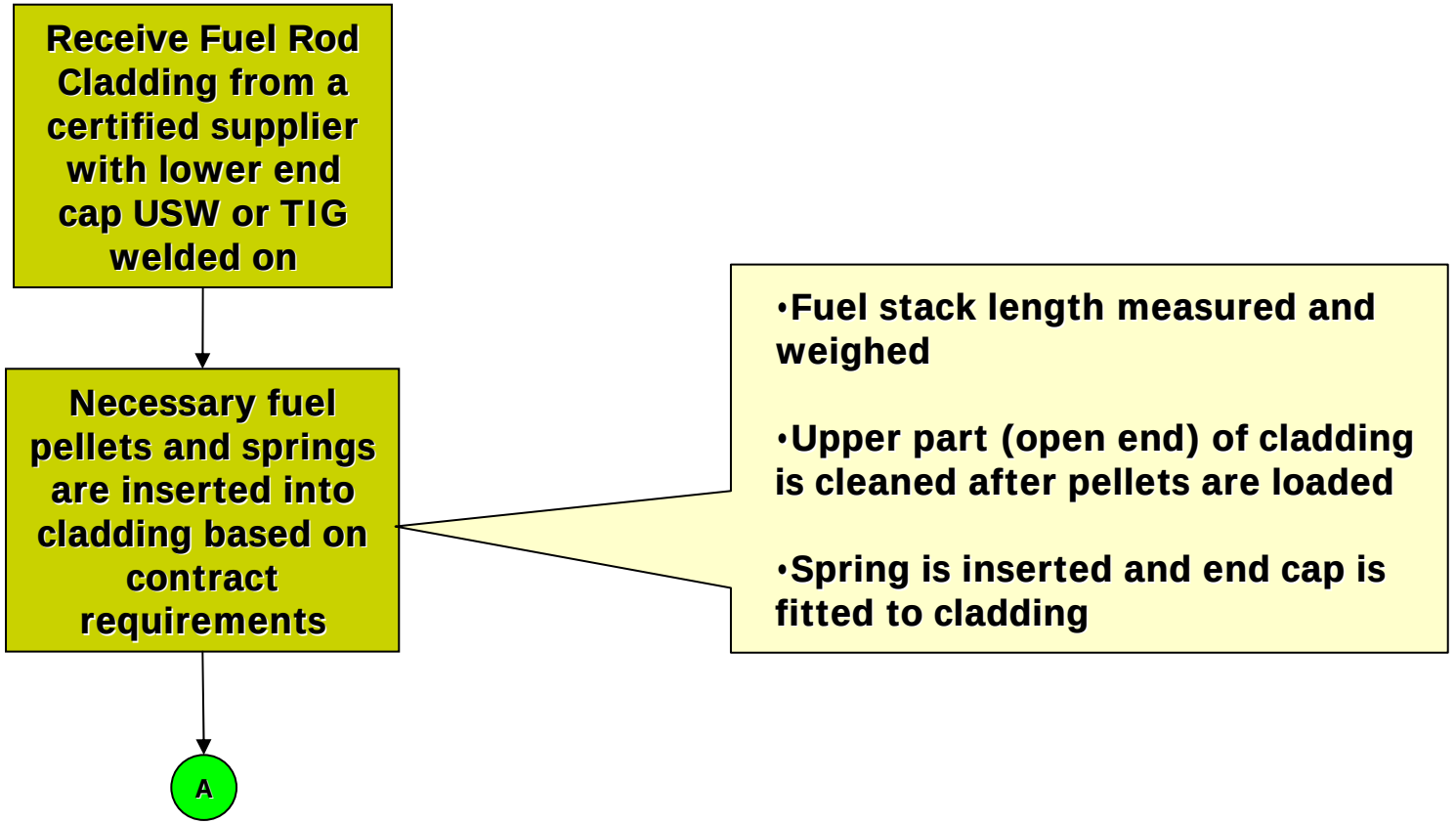
- **Plutonium within the fuel cladding is in solid form of sintered metal oxide.**
- **Current regulations have no special containment requirements for plutonium as long as they meet Type B Fissile requirements.**
- **Recently licensed Type B Fresh Fuel packages RAJ-II and the MAP packages have demonstrated that the cladding can meet containment requirements.**

Cladding as Containment (cont.)

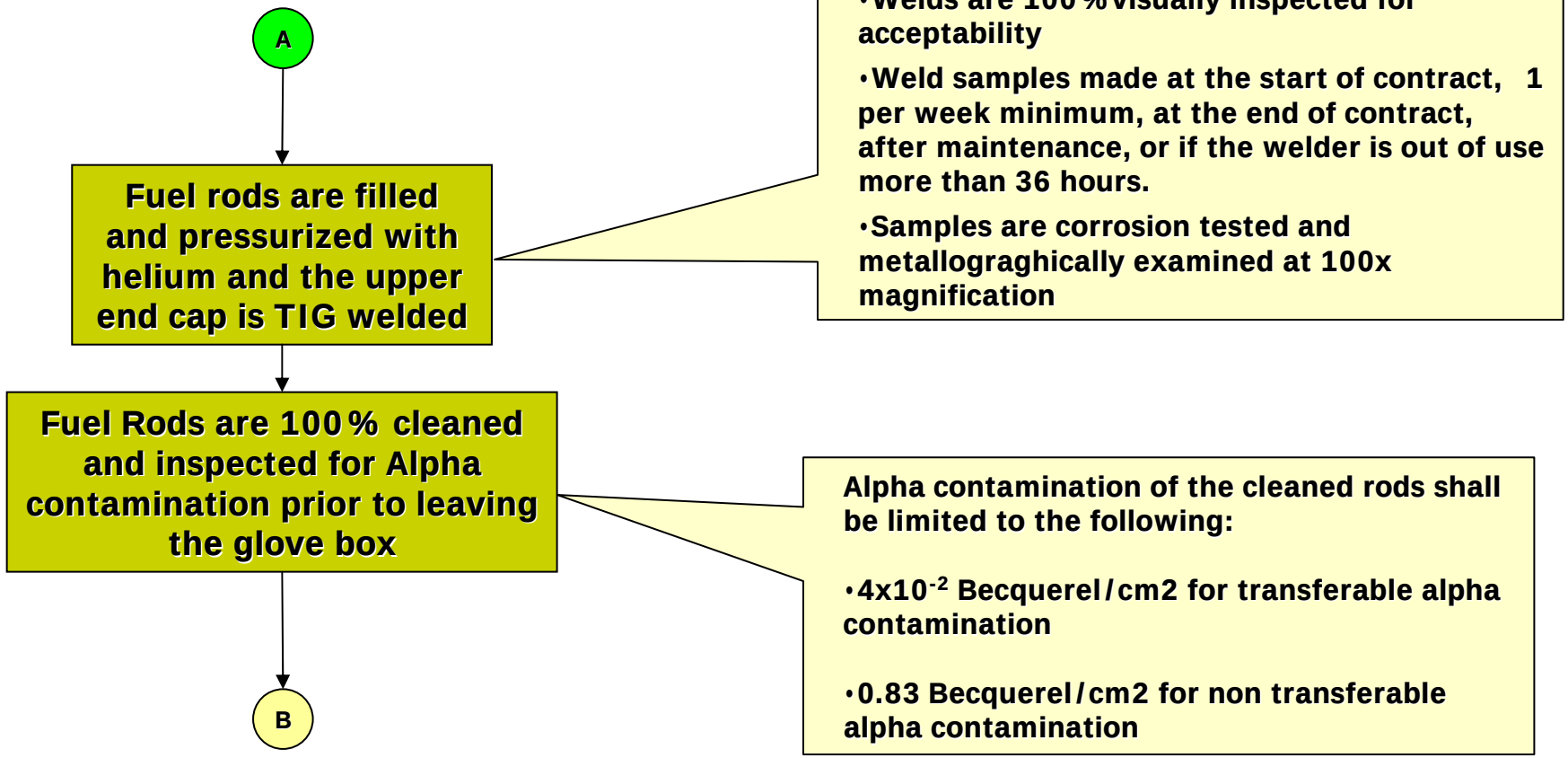
- **Under NCT the containment will be "leak tight" in accordance with ANSI N 14.5 although may not be required.**

- **Under HAC the containment will be verified to release less than A_2 per week which could correspond to a leak rate of 10^{-3} cc/sec depending on the aerosol concentration from sintered fuel pellets.**

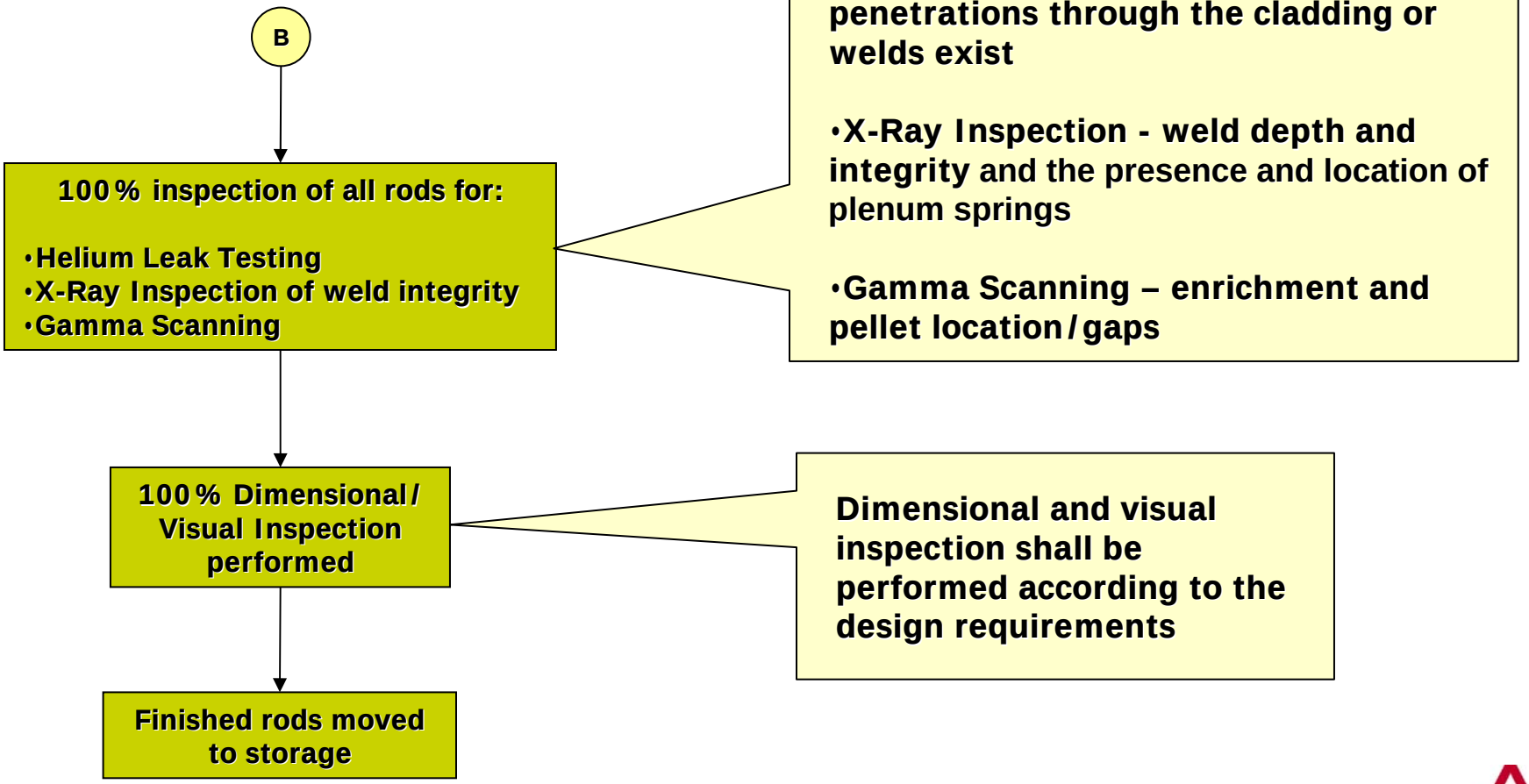
MOX Fuel Rod Fabrication



MOX Fuel Rod Fabrication



MOX Fuel Rod Fabrication



New MOX Package Designs

- **Both the BWR and PWR proposed MOX package designs will be based on current designs.**
  - **PWR based on the MAP package**
  - **BWR based on the ANF-10 package**
- **Design Basis Requirements document will be developed for early identification of regulatory, fuel quality, and user requirements and any potential conflicts.**

Designs Based on Testing

- **Engineer Test Unit for each type of package**
  - **Identify features that may need changing**
  - **Help identify the worst orientations**
- **Certification Test Units for each type of package**
  - **Two full-sized packages that will be tested at the worst orientations**
  - **One package available for fire testing and possible follow-up testing**

AREVA

Lessons Learned: Type B Fresh Fuel Packages

- **Fuel cladding remains intact under HAC test conditions**
  - **Design features protect the fuel rods from damage**
  - **Side drops result in no observable damage to fuel rods**
  - **Slap down drops affect the package closure, but fuel rods only experience minor (elastic) bending**
  - **Puncture drops result in localized damage to the thermal protection, but fuel rods remain undamaged**

Lessons Learned: Type B Fresh Fuel Packages (cont.)

- End drops present potential for buckling of fuel rods and sharp bends at interface between cladding and end cap
- Cladding can experience significant elastic bending without permanent damage, but is susceptible to cracking if buckled cladding undergoes reverse bending
- Effect of end drops are adequately mitigated by design features (e.g., properly sized end impact limiters to reduce acceleration and use of internal “doors” to ensure that fuel rods buckling potential is eliminated

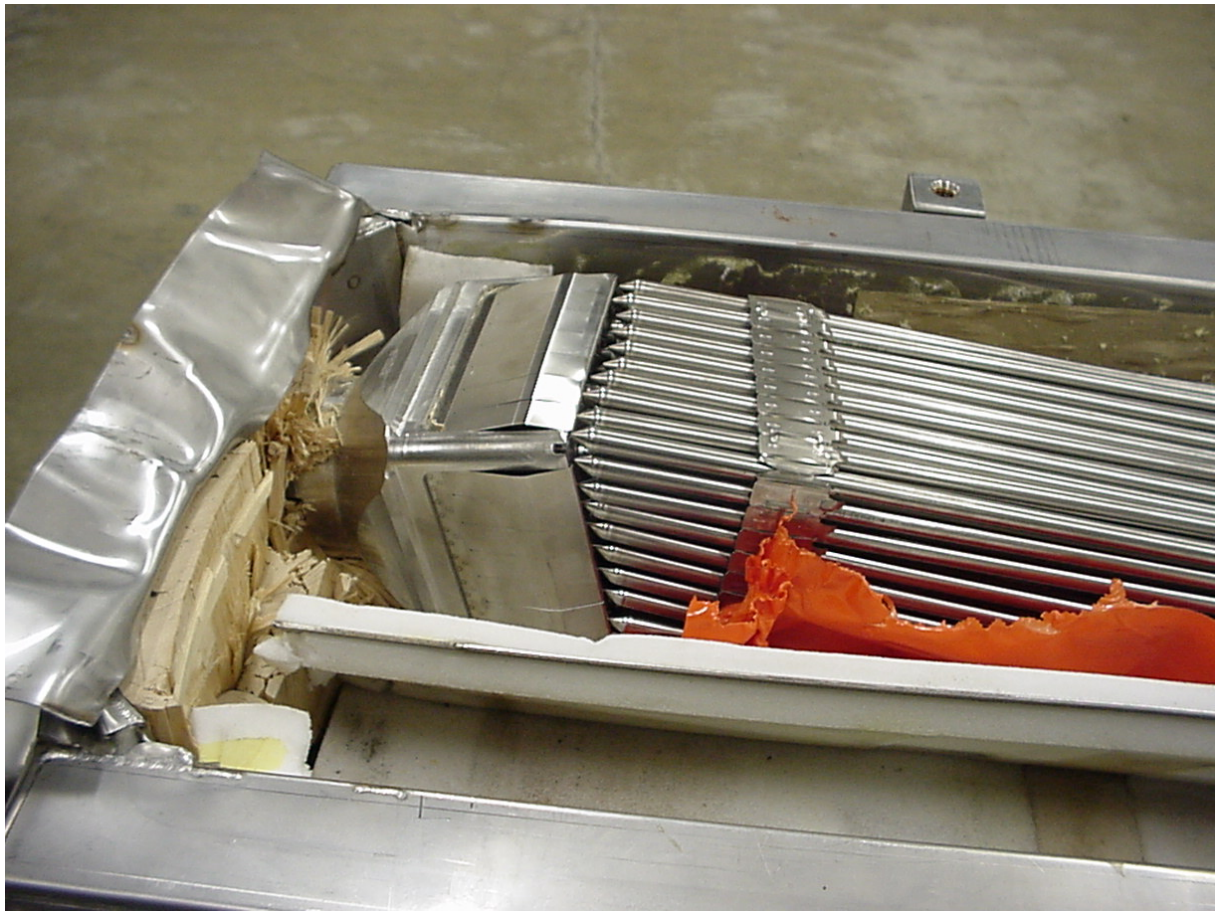
AREVA

Thermal Performance

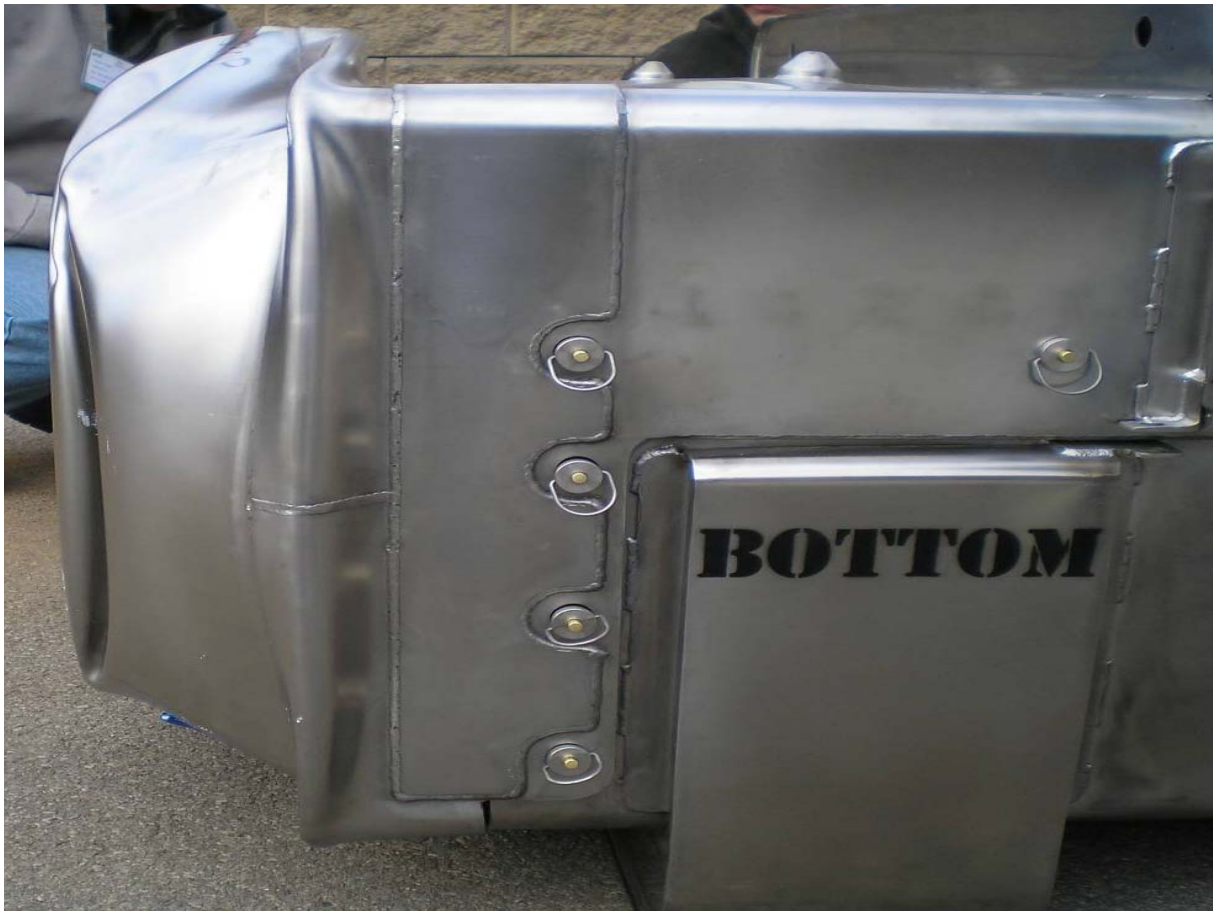
- **Fuel is designed for high temperature operation in the reactor with large margins of safety.**
  - **Fuel has been heated to failure and only has failed at temperatures over 800° C**
  - **All packaging protects the fuel to below the 800° C of the HAC thermal events**
- **For PWR packages, thermal protection can protect both moderator and neutron poison material.**

RAJ-II Certification Testing

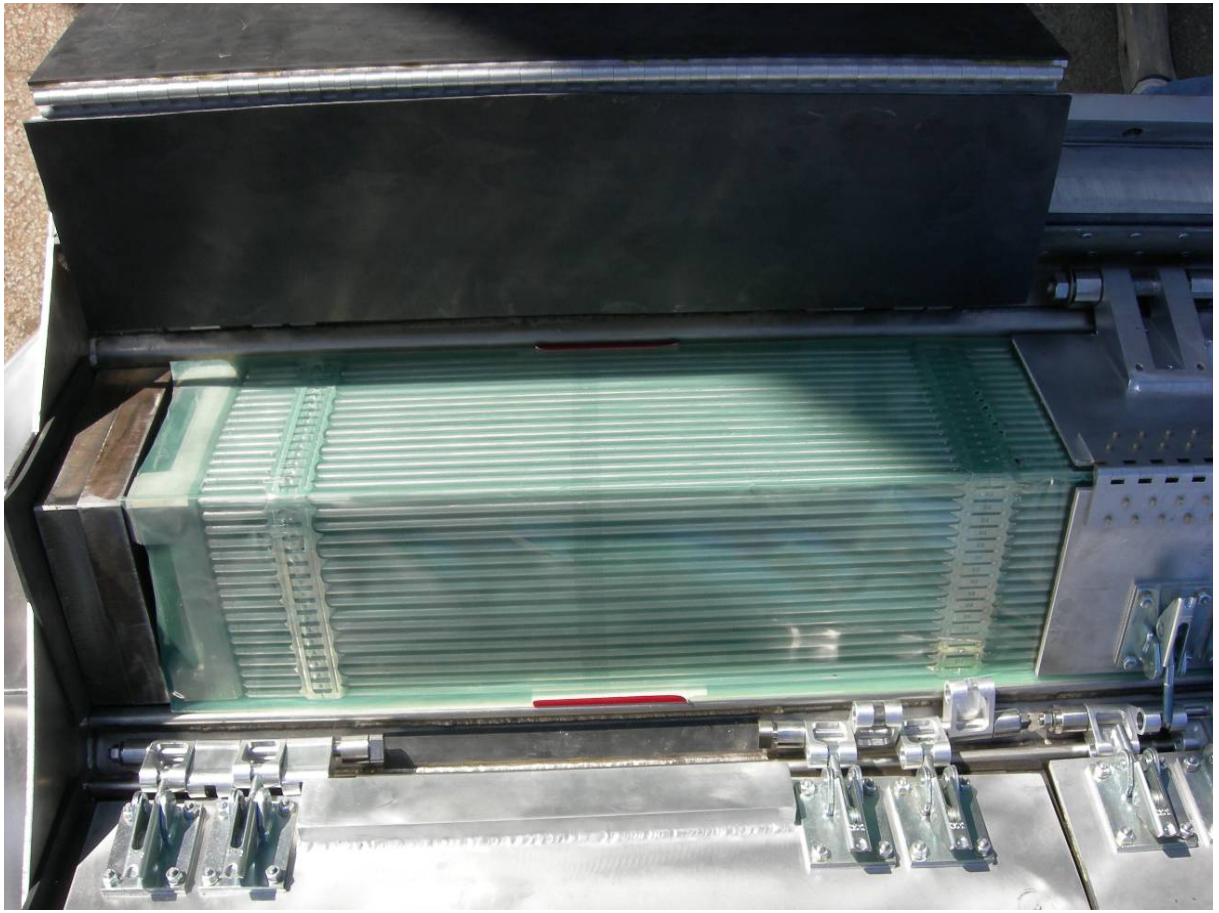
BWR Fuel After End Drop



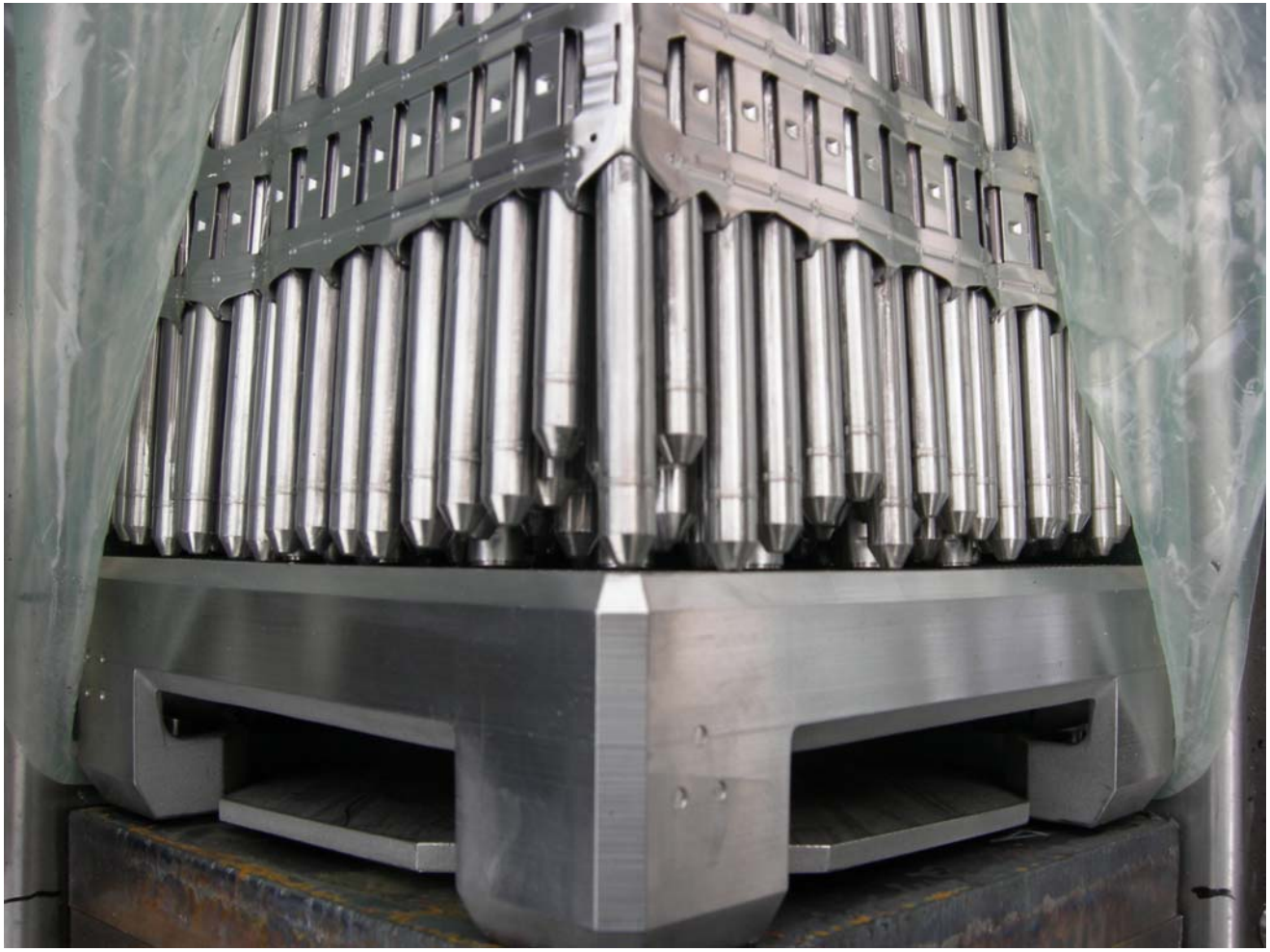
MAP CTU End Drop



PWR Fuel After End Drop



PWR Fuel After End Drop



After Slap Down

After Side Drop Top Down

After Puncture

After Thermal Test

Moderator Post Fire

Design By Test

- Lessons learned from previous packages
- Engineering Test Unit for each Model
  - Handling Tests
  - Road Tests for vibration acceptance
  - Drop and Puncture tests to determine worst orientations

Design By Test (cont.)

- **Currently Planning Fabrication of 3 Certification Test Units**
  - **Road Tests and back up should additional testing be required**
  - **Handling Tests**
  - **Series of Drop and Puncture tests to be spread over a minimum of two units, possibly three**
    - End Drops for attacking fuel containment
    - Slap down and side drops with puncture for determining maximum damage
    - Thermal Test if necessary
      - PWR needs testing for protection of neutron Poison and Moderator
      - BWR may not be needed based on thermal data showing that fuel integrity is maintained when exposed to temperatures of the fire

AREVA

Demonstration of Fuel Cladding Integrity

- **Helium leak testing of the assemblies post-test**
  - **Fuel integrity and helium content validated at fabrication**
  - **Leak testing of assemblies using a chamber after HAC testing**
  - **Methodology currently being developed to detect and verify presence of sufficient quantity of helium**
    - Based on previous testing, a minor leak (5×10^{-5} cc/sec He) was detected as much as two weeks later. Qualification testing may be adequate.
    - Option is to breach each rod after testing to verify the presence of helium.

AREVA

Testing

- **Certification Test program will be developed based on testing of the Engineering Test Unit and lessons learned from previous packages.**
- **Test Plan will be discussed with NRC prior to testing.**
- **Various Environmental Conditions will be considered to determine worst conditions.**

Testing (cont.)

- **Leak testing and verification methodology will be reviewed with NRC prior to certification testing.**
- **Certification testing will be conducted with simulated fuel assemblies using rods that are pressurized with helium, sealed, and leak tested similar to actual fuel rods prior to testing.**
- **Fuel assemblies will be leak tested post HAC testing per ANSI N14.5.**

Certification

- **Separate applications will be submitted for PWR and BWR MOX Fresh Fuel Packages.**
- **Applications will be specific to MOX project fuel.**
- **Demonstration of compliance with 10 CFR 71.**

Anticipated Schedule

- **Design Basis Requirements Document** — **May 2011**
- **ETU Testing** — **January – February 2012**
- **CTU Testing** — **January – February 2013**
- **Applications to the NRC** — **April 2013**
- **Expected approvals** — **October 2014**

Summary

- **Develop a PWR and BWR Fresh Fuel Package for MOX fuel.**
  - **Design based on using the fuel cladding as containment**
- **New packages will be developed based on currently certified Type B non-irradiated fuel packages.**
  - **MAP and ANF-10 Packages**
- **Compliance will be demonstrated primarily through physical testing.**

AREVA