Preliminary Assessment of the Proposed PRIMO (Rod BD8) MOX Fuel Performance Benchmark

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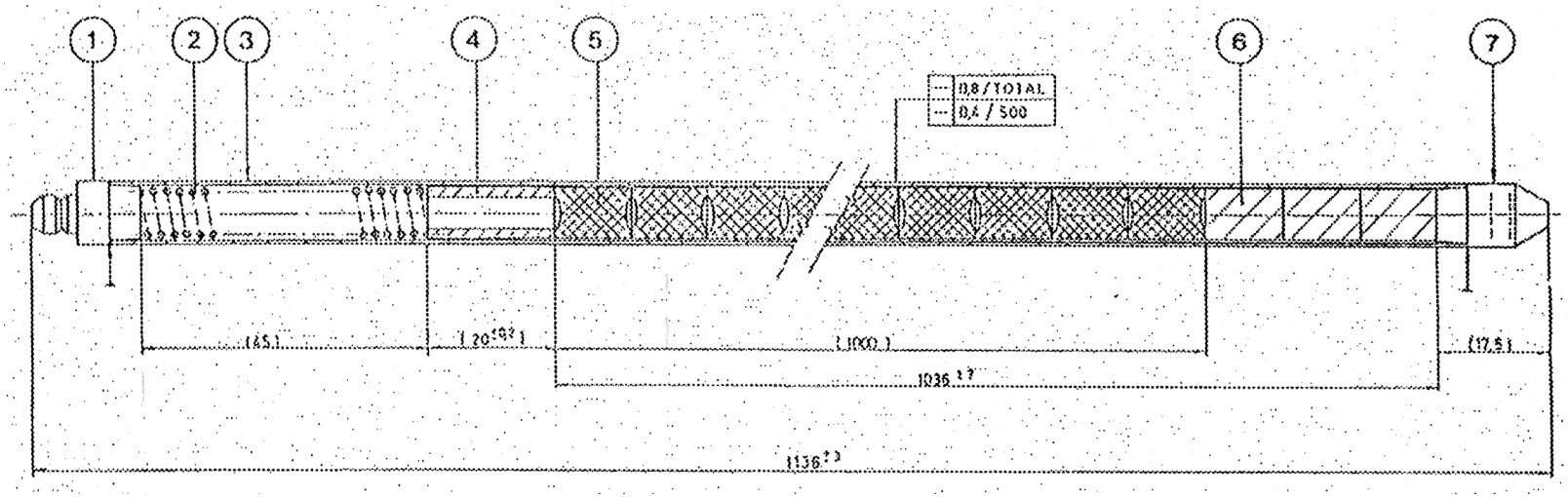
Proposed PRIMO MOX Fuel Performance Benchmark Exercise

- Data* prepared by Dr. Paul van Uffelen (SCK-CEN, MOL, Belgium-Summer 2002) [Dr. van Uffelen is currently at ITU in Karlsruhe]
- The PWR Reference Irradiation of MOX fuels (PRIMO) program was started in October 1986
  - Jointly organized by SCK-CEN and BN with 10 additional co-sponsors
- Benchmark data based on the irradiation of PRIMO rod BD8
  - Rod manufactured at BN using the MIMAS process (1983 fabrication campaign)
  - Base irradiated in the BR3 reactor of SCK-CEN (cycles 4D1 and 4D2)
  - Ramp tested in the OSIRIS reactor at Saclay

*presented at TFRD6, Paris, July 2002

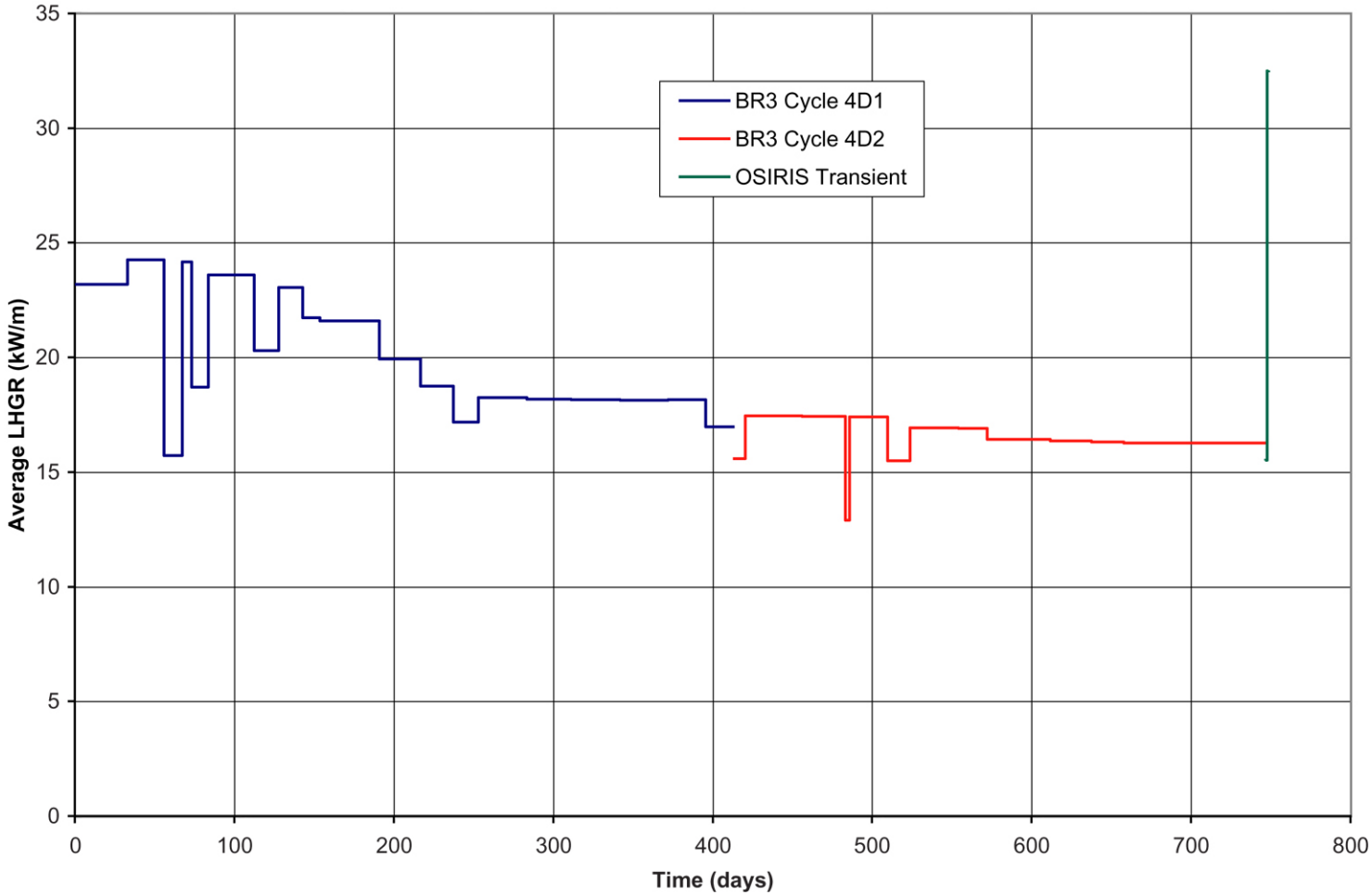
General Schematic of PRIMO Rod BD8



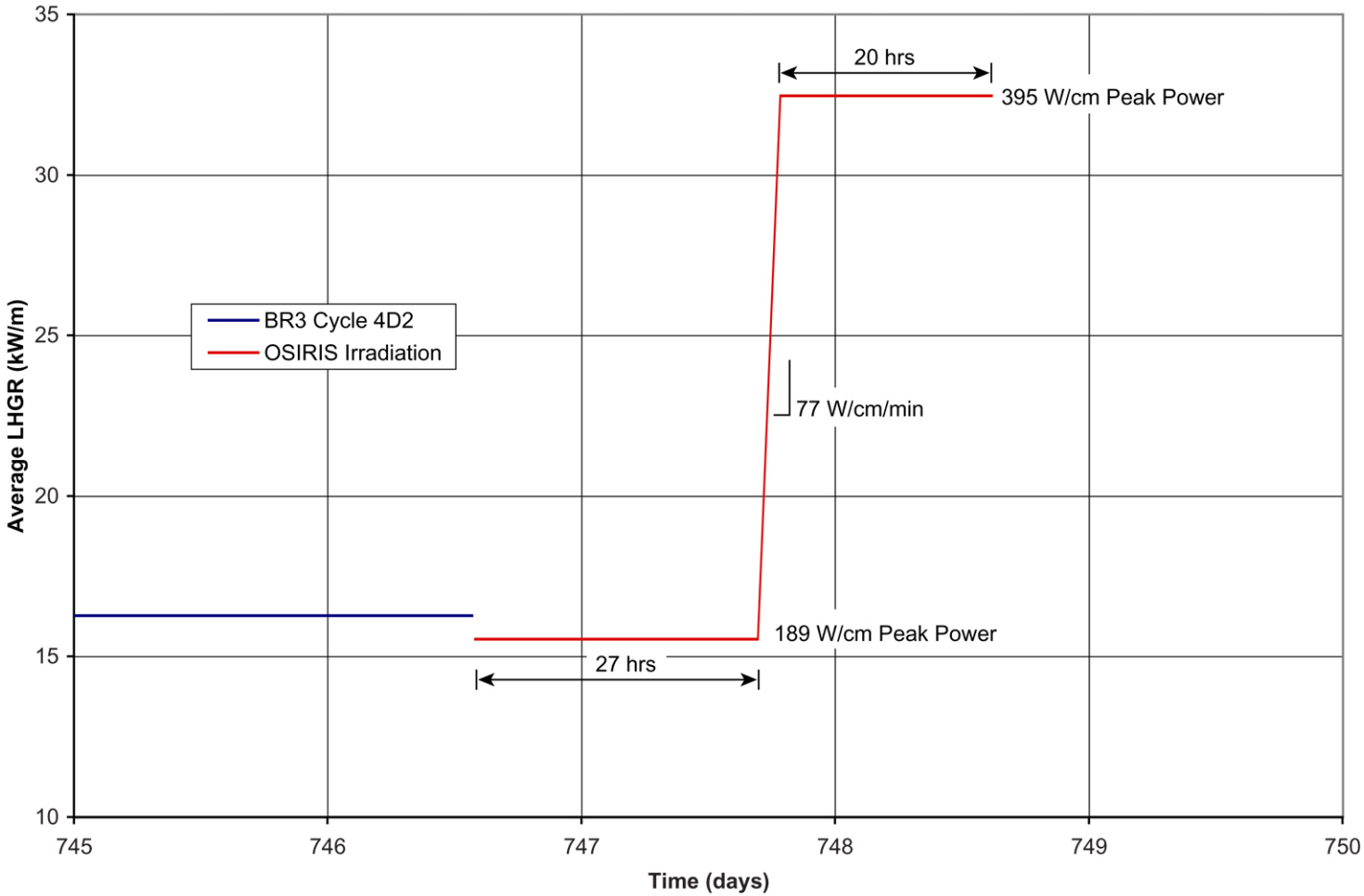
Units in mm

① Upper-end plug
② Hold-down spring
③ Cladding tube
④ Spacer tube
⑤ UO_2-PuO_2 fuel pellets
⑥ UO_2 blanket pellets
⑦ Lower-end plug

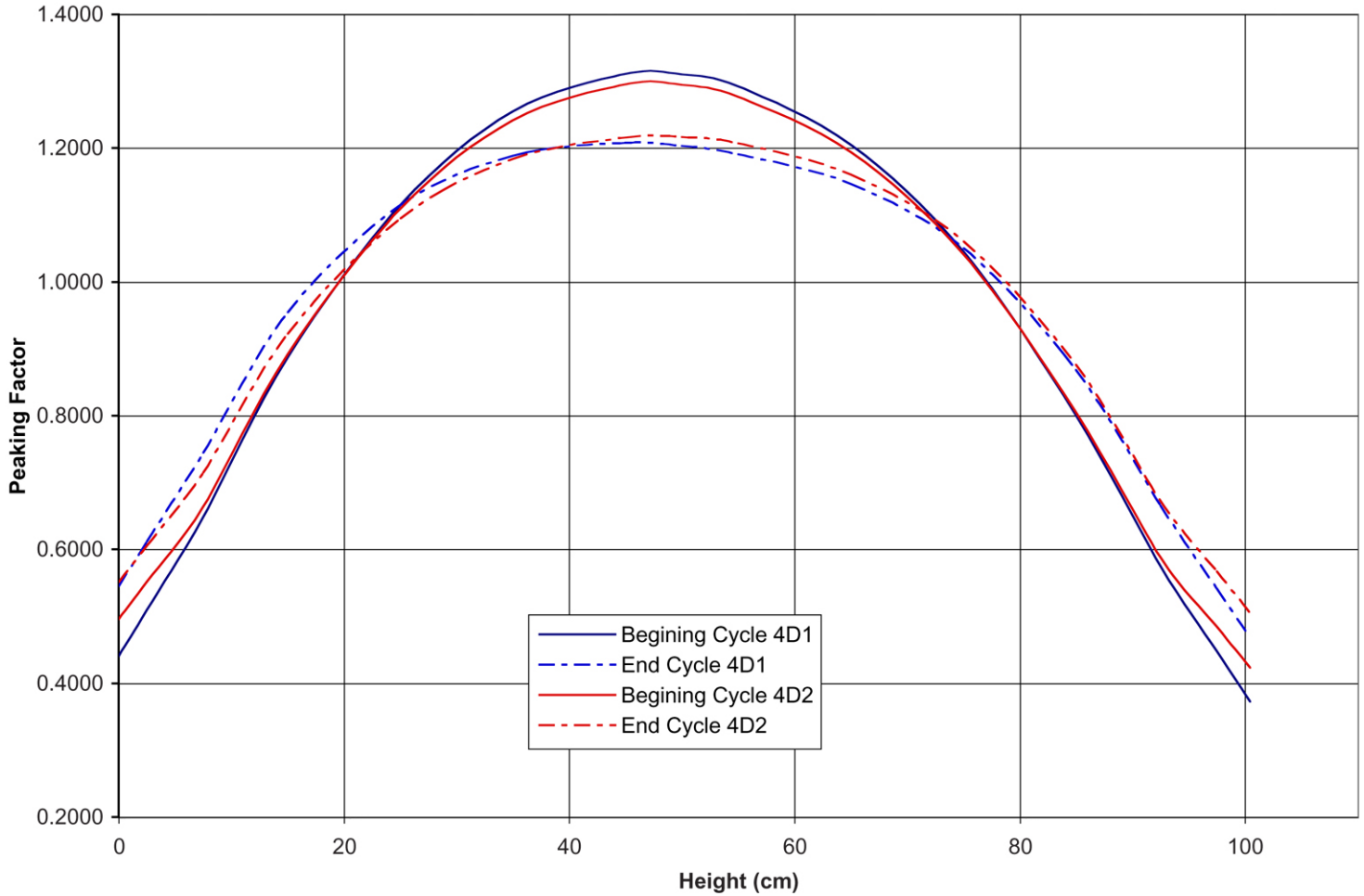
PRIMO Rod BD8 Power History



PRIMO Rod BD8 Power History (continued)



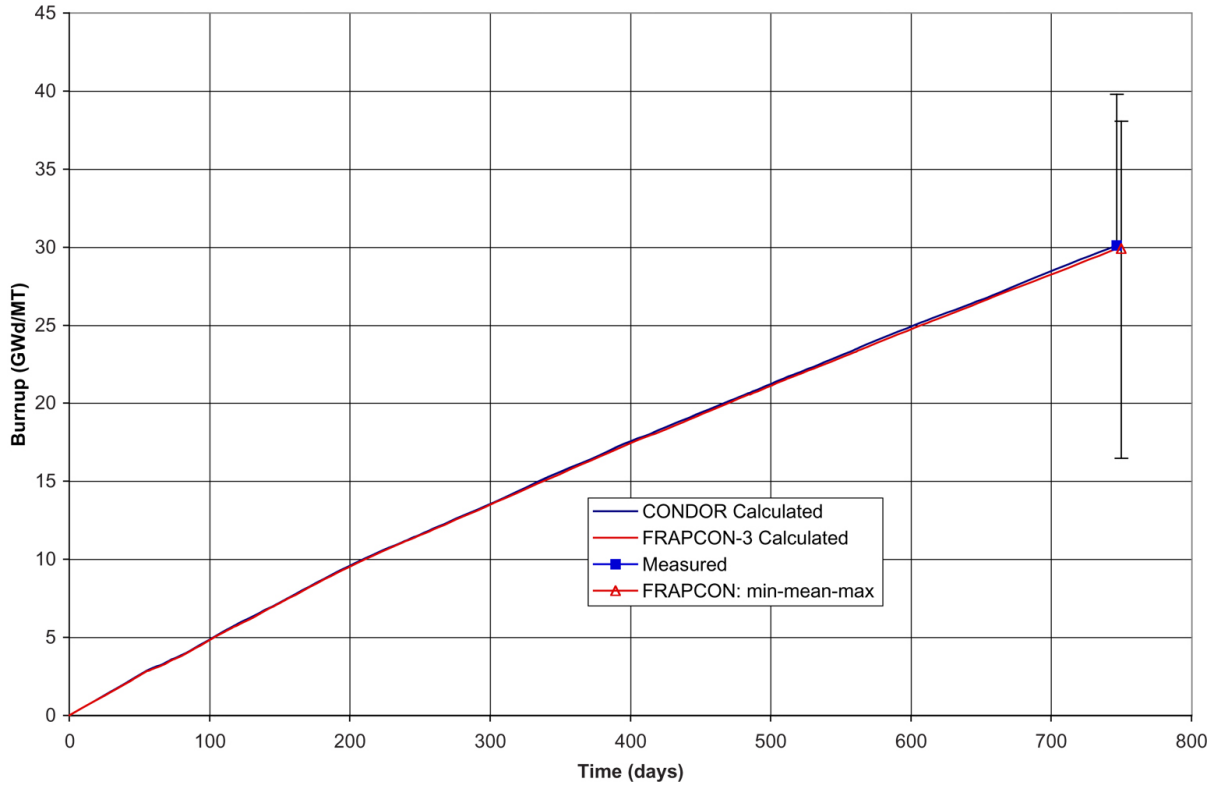
BR3 Reactor Core Power Shape (Cycle 4D1 and 4D2)



ORNL FRAPCON-3 v1.3 Model of PRIMO Rod BD8

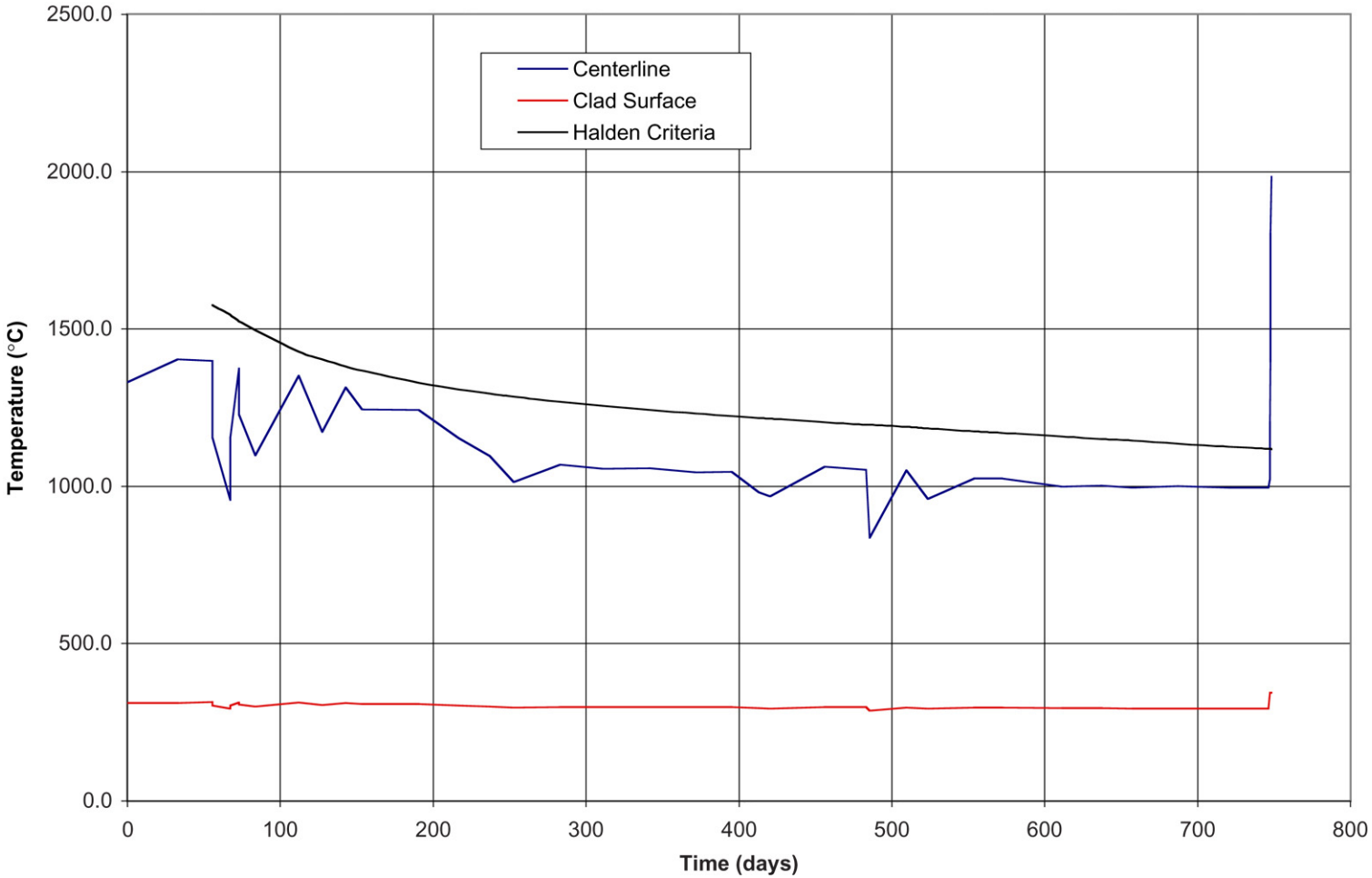
- Ten equal-length axial nodes (total fuel length of 1004.7 mm)
- Seventeen (17) radial nodes within the fuel
- 48 time steps (includes 6 time steps for initial ramp to power and 4 time steps for OSIRIS ramp)
- Rod average linear heat generation rates and axial peaking factors from problem definition for BR3 irradiation cycles
- OSIRIS conditioning and power ramp per problem definition
  - Assumed: OSIRIS power shape same as BR3 4D2 end-of-cycle
- Rod surface conditions
  - BR3, computed by FRAPCON-3 for specified core mass flux, inlet temperatures etc. (per problem definition)
  - OSIRIS, 342°C (water saturation temperature at 150 bar pressure) – per problem definition
- Fuel rod geometries per problem definition
- Pu and U isotopics per problem definition
- Fuel densification per problem definition
- Fuel swelling per FRAPCON-3 models

PRIMO Rod BD8 Burnup

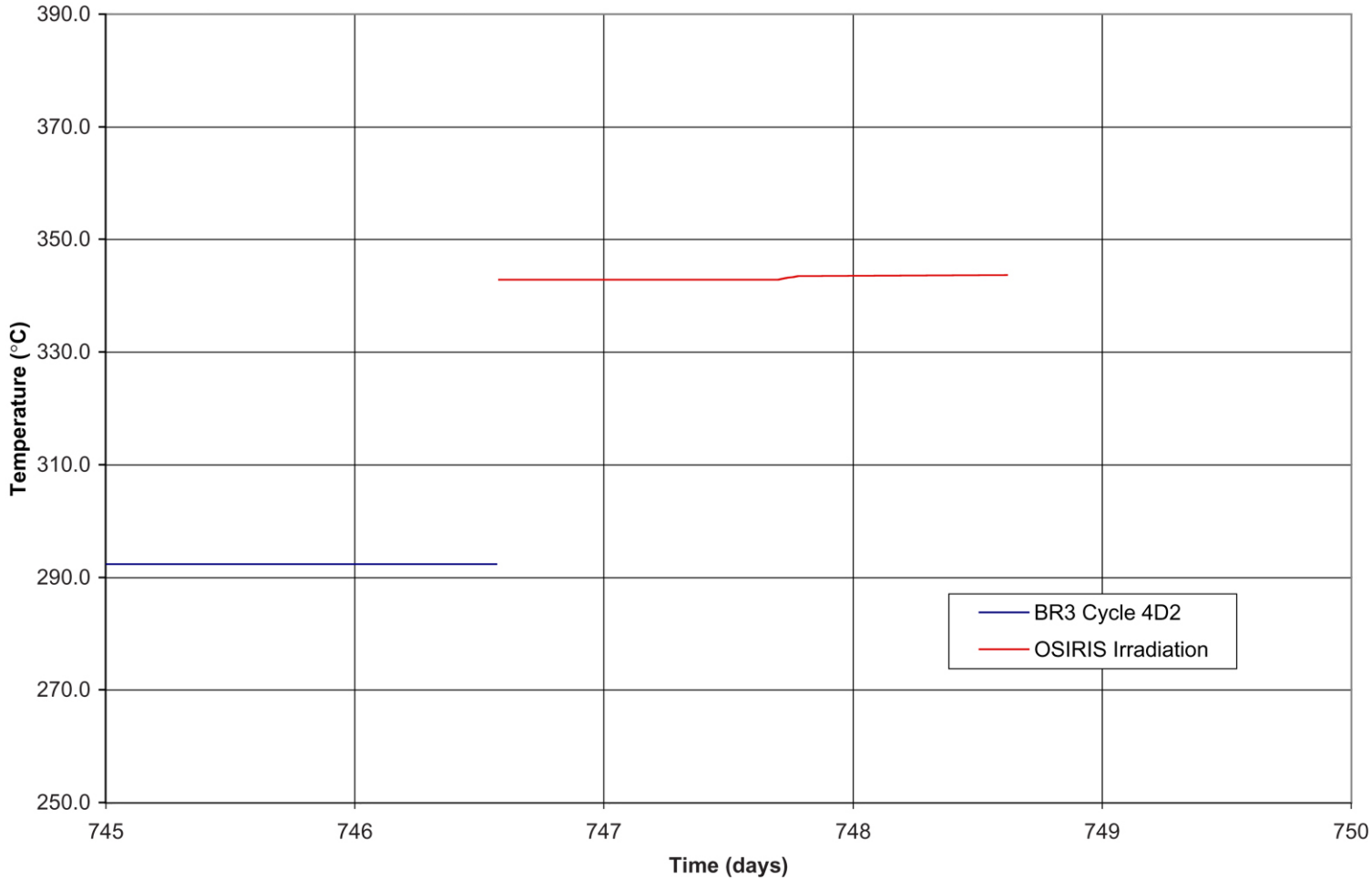


- **Conclusion: excellent agreement between CONDOR and FRAPCON-3, due to**
  - **Problem definition for fuel mass (geometry, density, isotopics)**
  - **Specification for average LHGRs and irradiation times**

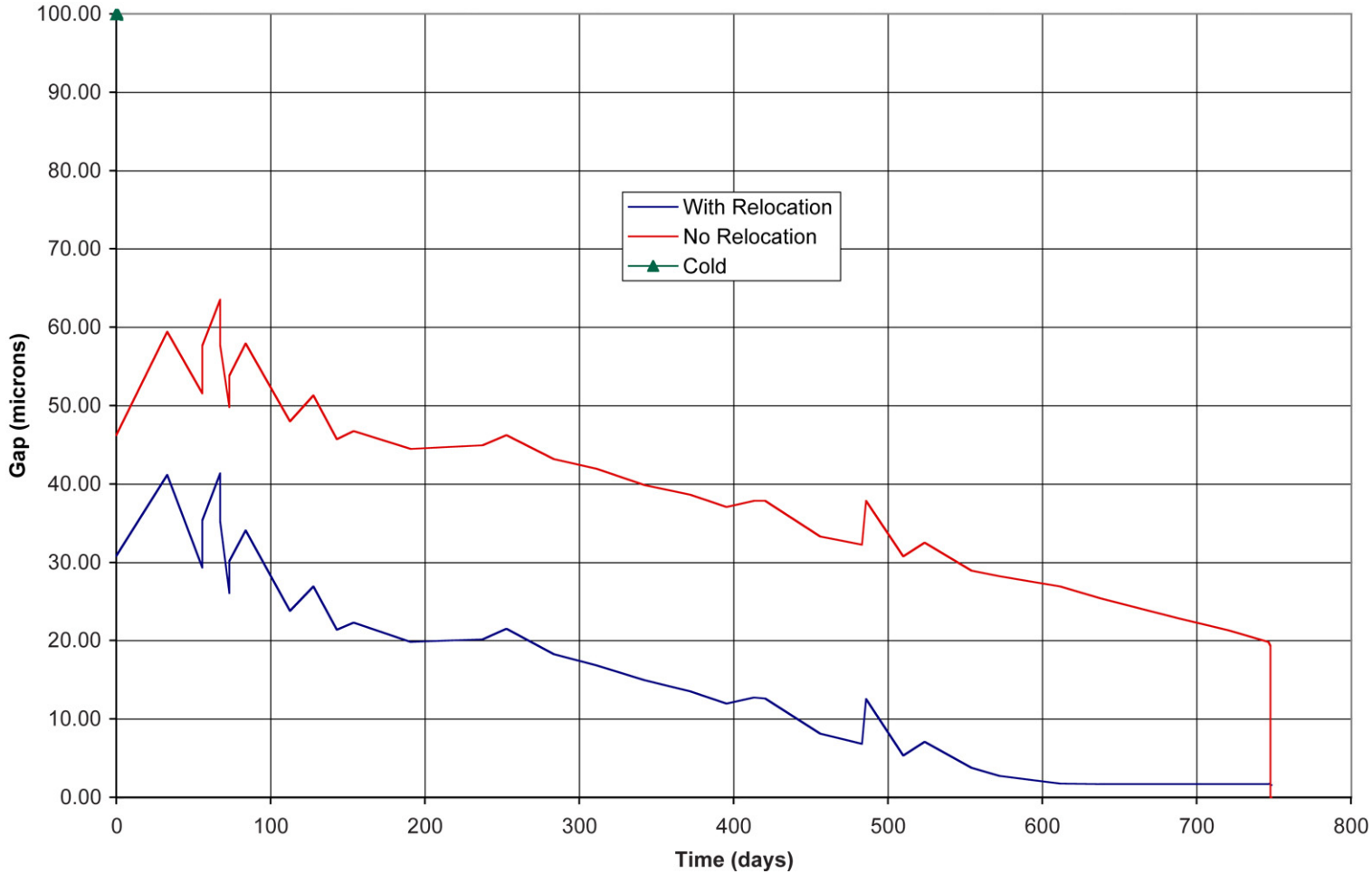
FRAPCON-3 Calculated Rod Temperature (Node 5)



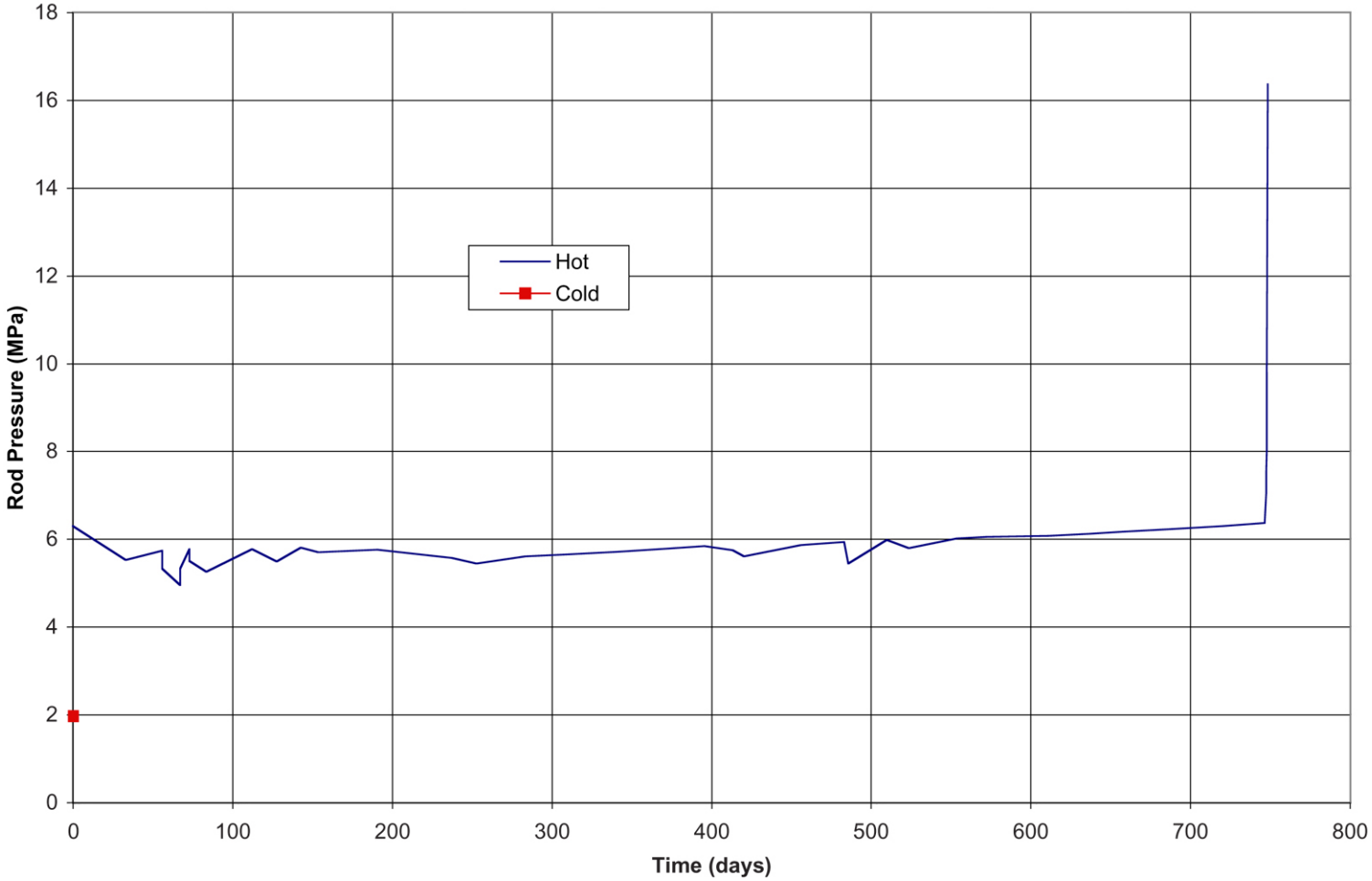
FRAPCON-3 Calculated PRIMO Rod BD8 Clad Surface Temperature



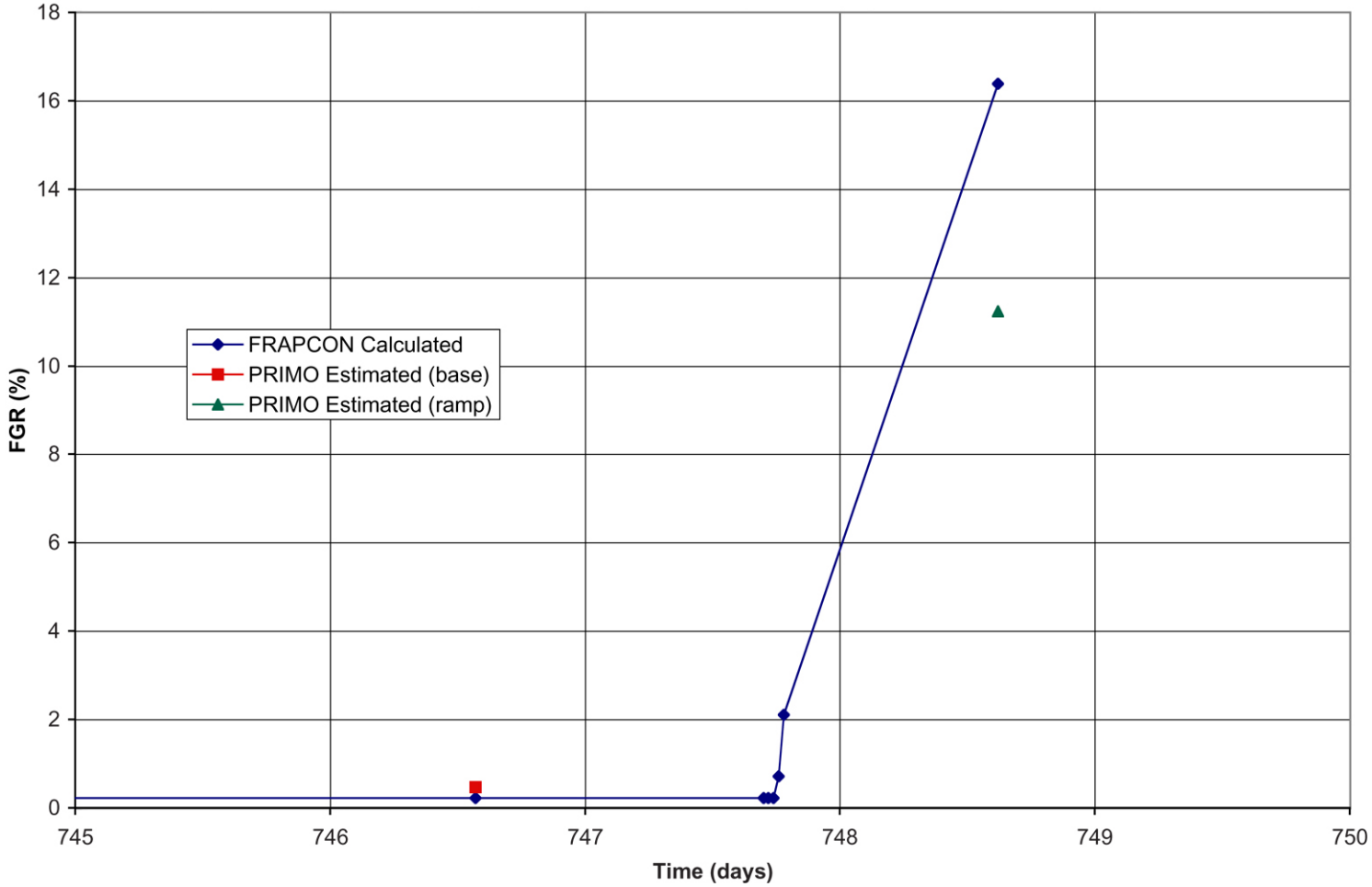
FRAPCON-3 Calculated PRIMO Rod BD8 Node 5 Radial Pellet-to-Clad Gap



FRAPCON-3 Calculated PRIMO Rod BD8 Internal Pressure



FRAPCON-3 Calculated PRIMO Rod BD8 Fission Gas Release



Needed for Clarification of Benchmark Specification

- Fuel/clad (inner) surface roughnesses
- Mean PuO_2-rich particle size (a maximum of 214 μm is specified)
- OSIRIS reactor power shape? (peak linear power of 395 W/cm)
  - End-of-cycle for 4D2 assumed
- OSIRIS reactor preconditioning power of 189 W/cm (peak? or average?)
  - Peak assumed

In Addition to Code-to-Code Comparisons (temperatures, rod pressure, fgr, etc.), PIE of BD8 Provides End-of-Irradiation Code/Experiment Comparison Points

- Clad creep
- Clad irradiation growth
- Fuel column length change
- Fuel burnup
- Fission gas release