Fuel and Graphite Technology Development Status

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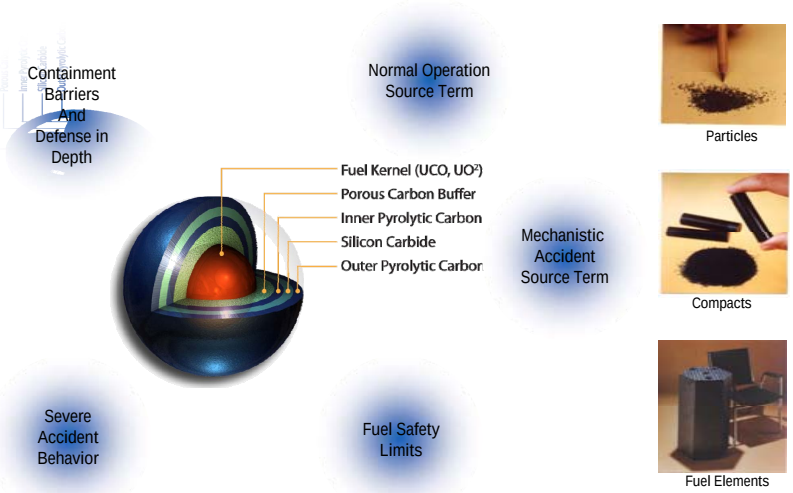
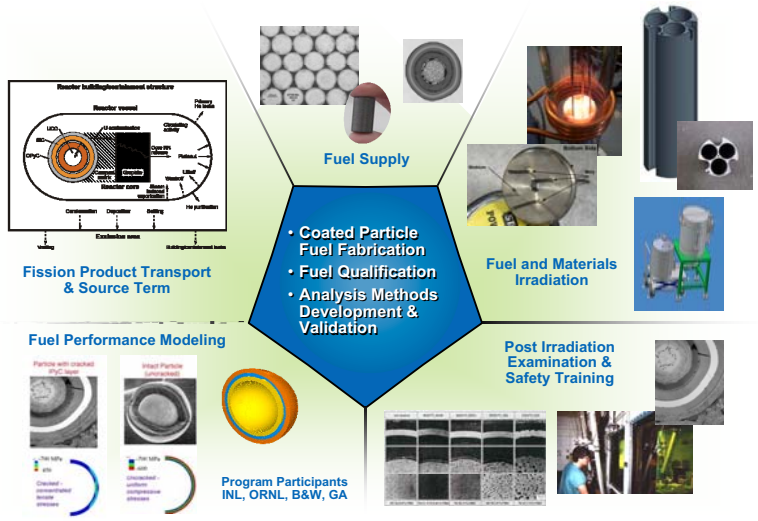
Key Technology Development Areas

- Fuel Development and Qualification
- Source Term Qualification
- Graphite Materials Qualification
  - Structural (non-fuel) graphite
  - Ceramic composites (Cf/C and SiCf/SiC)
  - Structural ceramics (Fused silica, SiC, alumina)
- High Temperature Material Qualification
  - Intermediate heat exchanger (IHX)
  - Hot Duct and hot piping materials
  - Reactor Pressure Vessel (RPV)
  - Core structural metals (core barrel, control rods)
- Design and Safety Methods and Validation

Coated Particle Fuel Performance is a Key to HTGR Concept

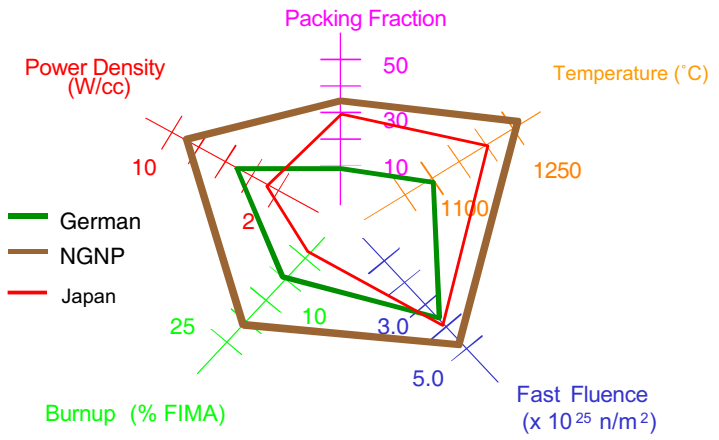


NGNP Fuel Program Elements

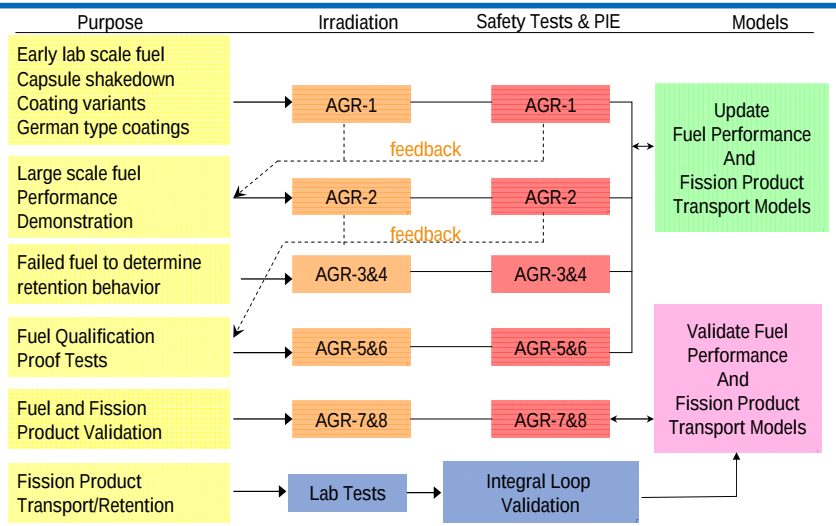


Performance Envelope for NGNP TRISO-coated Particle Fuel

Radar plot of five key parameters of fuel performance



Overview of NGNP Fuel Development and Qualification Program Activities

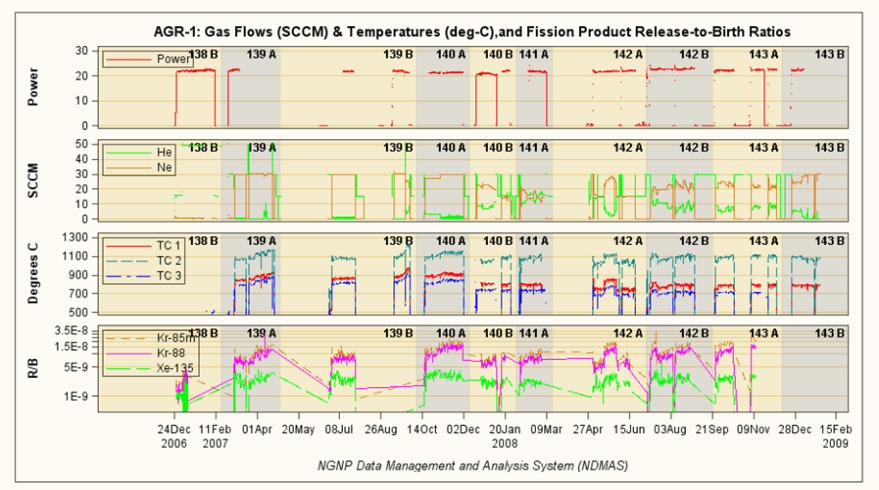


AGR-1 Irradiation Conditions After 413 EFPD (Preliminary Data)

Capsule	Peak Compact Burnup (% FIMA)	Peak Compact Fast Neutron Fluence (10^{25} n/m^2, E>0.18 MeV)	Capsule Average Fission Power Density (W/cm^3)	Time-Average Peak Temperature (°C)	Time-Average Volume-average Temperature (°C)	Kr-85m Release to Birth Ratio
6	11.3	1.94	83.0	1035	920	2.9 x10^{-8}
5	13.4	2.42	94.4	1121	985	2.7 x10^{-8}
4	14.5	2.65	97.1	1177	1044	1.7 x10^{-8}
3	14.6	2.69	98.3	1122	988	2.1 x10^{-8}
2	14.2	2.53	96.7	1133	995	2.1 x10^{-8}
1	12.8	2.16	85.7	1171	1037	1.7 x10^{-8}

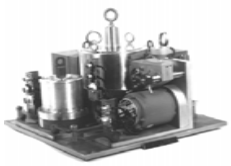
300,000 particles and no failures; expect to go to 18% FIMA

AGR 1 Capsule 4 Measurements



Getting Ready for PIE and Safety Testing of Fuel from AGR-1

- Performed at both INL and ORNL
- Test train inspection, disassembly, and metrology
  - Neutron radiography, Gamma scanning, Capsule disassembly, Dimensional measurements, Thermocouple analysis, Flux/melt wire analysis
- Accident Safety Testing:
  - Heating furnaces with Helium internal atmosphere with high temperature heating element (2000ºC max)
  - Automatic cold plate transfer during annealing experiment
  - Reirradiation to get I-131 data
  - Statistically significant amounts of fuel to be tested
- Fuel properties characterization
  - Burnup measurements, Ceramography, SEM/EPMA, Thermal properties, Leach-Burn-Leach, Upgraded IMGA



IMGA at ORNL

EPMA at INL

INL Furnace

ORNL Furnace

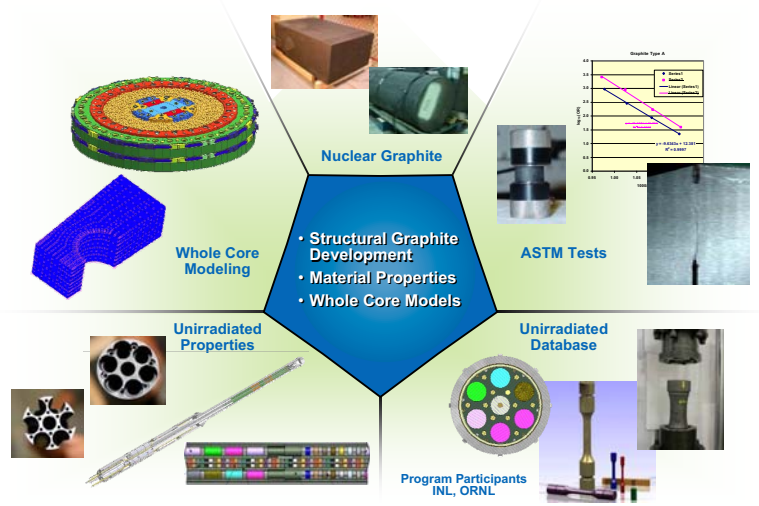
Other Fuel Activities

- Complete fabrication of TRISO fuel for AGR-2
  - Fabrication of industrial scale UCO TRISO from B&W to high burnup
  - Fabrication of UO_2 TRISO from B&W, compacting of PBMR UO_2 particles into compacts
  - Compacting of all particles except CEA using overcoating technology at ORNL
    - High parking fraction (35%) and high matrix density (~ 1.5-1.6 g/cc)
- Complete final design of performance demonstration capsule (AGR-2)
  - Irradiation of US UCO TRISO from B&W and three TRISO UO_2 sources: PBMR, CEA, and B&W
- Complete fabrication of design to fail particles for AGR-3/4

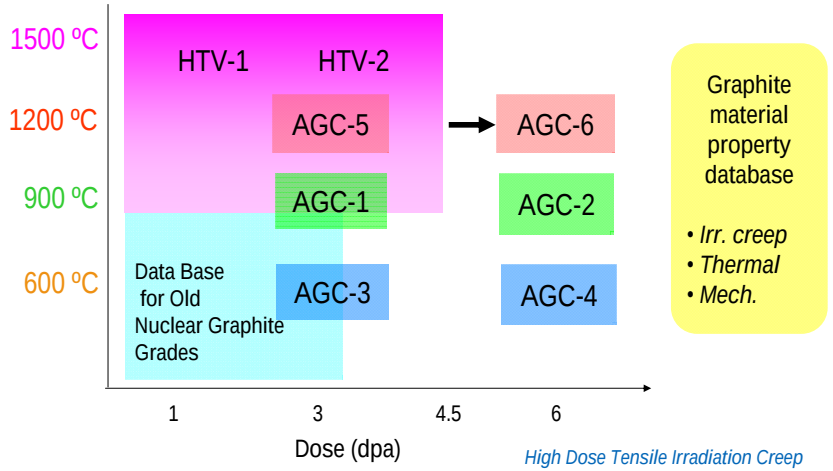
Objectives of Graphite Program

- Qualify new grades of graphite anticipated for future VHTRs (PBMR, NGNP) to demonstrate in-reactor behavior at least as good as that used in former German and U.S. gas reactors. (NGNP is focusing on prismatic PCEA and pebble NGB-18)
  - Establish statistical unirradiated thermo-mechanical and thermo-physical properties
    - Characterize lot to lot and billet to billet variations
  - Establish irradiated thermo-mechanical and thermo-physical properties
  - Develop understanding of life limiting phenomena at high dose and temperature (e.g. irradiation induced creep)
  - Develop appropriate constitutive relations
  - Establish reliable predictive thermo-mechanical FEM model
  - Establish relevant ASTM standards and ASME design rules
- Evaluate processing route and raw material constituents influences on graphite

Overview of NGNP Graphite Program



Graphite – Irradiation Capsules



Graphite material property database

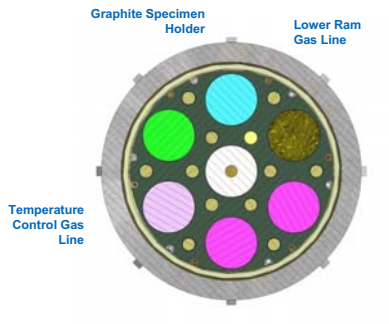
- *Irr. creep*
- *Thermal*
- *Mech.*

High Dose Tensile Irradiation Creep Studies are still under discussion

Graphite Status and Plans

- Completed final design of first graphite creep capsule (AGC-1). Insertion in ATR in spring 2009
- Procured graphite billets for follow-on testing
- Initiate AGC-2 sample pre-irradiation characterization
- Continue modeling and oxidation testing
- Support ASTM and ASME activities

AGC-1 Capsule



AGC-1 Assembly Mockup

Graphite PIE Facility Preparations

- ORNL's Low Activation Materials Design and Analysis Laboratory (LAMDA)
- INL's Graphite PIE Lab
- Full range of thermal, physical and mechanical testing capabilities
  - Perform measurements before and after irradiation to determine impact of neutron damage on thermomechanical and thermophysical properties

Summary

- Large R&D program needed to qualify fuel, materials and methods for NGNP
  - Preliminary results from AGR-1 are demonstrating excellent fuel performance albeit at lab scale
  - Safety testing of this fuel is anticipated in 2010-2011
  - Fabrication of UCO and UO_2 TRISO Fuel at industrial scale is underway as part of AGR-2 activities
  - Graphite capsule to begin irradiation this summer
  - Baseline characterization of unirradiated graphite is underway
- Results of pre-conceptual design studies are focusing the planned R&D
  - Outlet temperature now 750-800°C
  - Potential steam generator in primary system
- Better definition of NRC requirements and the associated NGNP licensing strategy is being established and will impact details of the anticipated future R&D activities