



Fuel and Graphite Technology Development Status

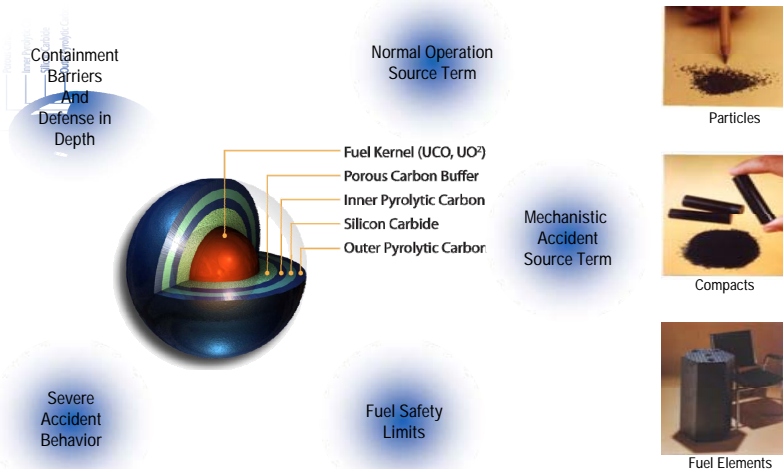
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Key Technology Development Areas

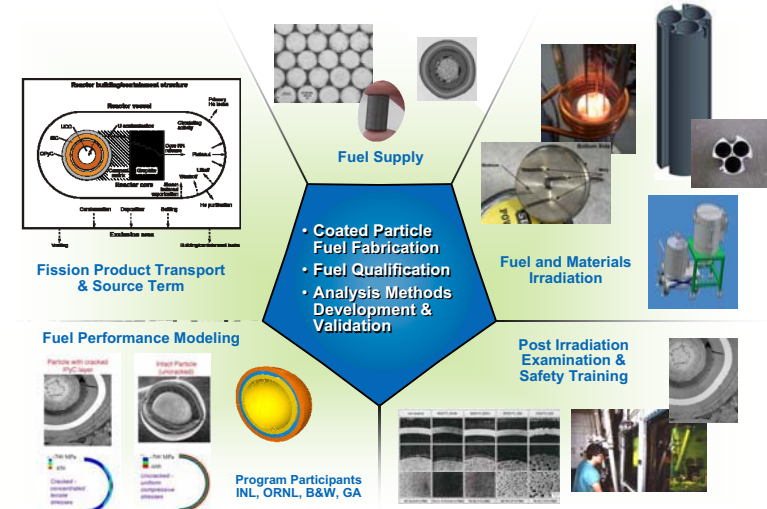


- Fuel Development and Qualification
- Source Term Qualification
- Graphite Materials Qualification
 - Structural (non-fuel) graphite
 - Ceramic composites (Cf/C and SiC/SiC)
 - Structural ceramics (Fused silica, SiC, alumina)
- High Temperature Material Qualification
 - Intermediate heat exchanger (IHX)
 - 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



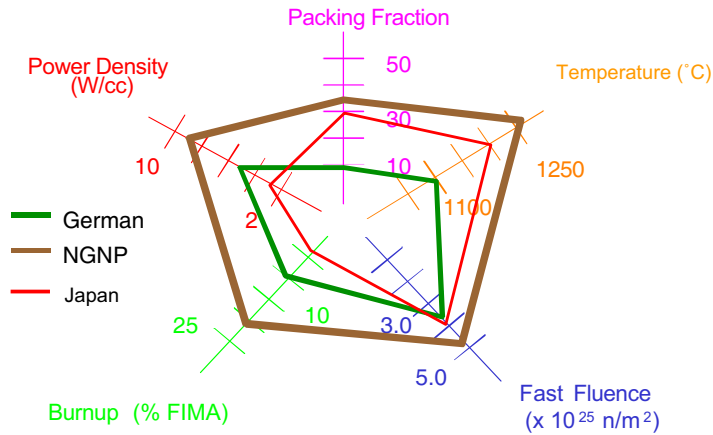
NGNP Fuel Program Elements



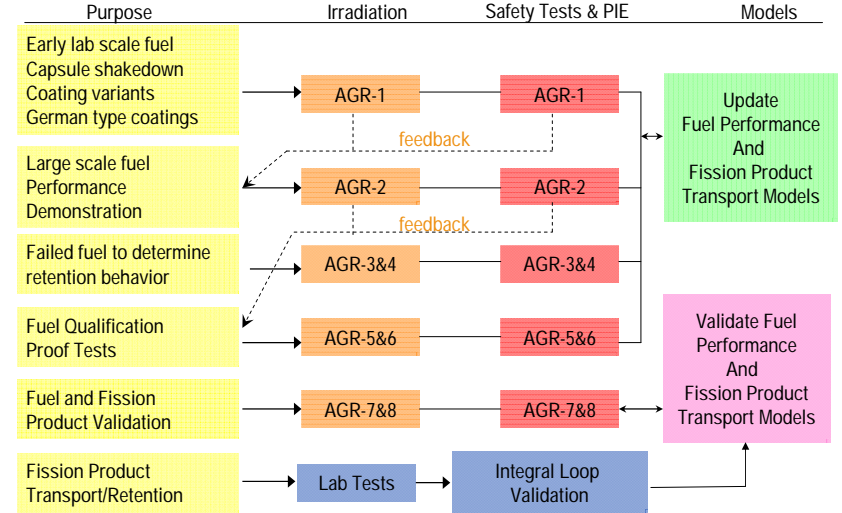
Performance Envelope for NGNP TRISO-coated Particle Fuel



Radar plot of five key parameters of fuel performance



Overview of NGNP Fuel Development and Qualification Program Activities



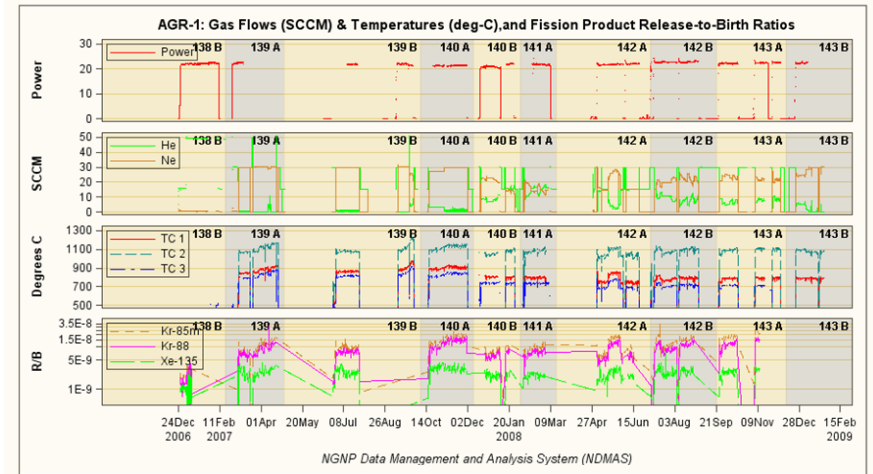
AGR-1 Irradiation Conditions After 413 EFPD (Preliminary Data)



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	2.9×10^{-8}
5	13.4	2.42	94.4	1121	985	2.7×10^{-8}
4	14.5	2.65	97.1	1177	1044	1.7×10^{-8}
3	14.6	2.69	98.3	1122	988	2.1×10^{-8}
2	14.2	2.53	96.7	1133	995	2.1×10^{-8}
1	12.8	2.16	85.7	1171	1037	1.7×10^{-8}

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

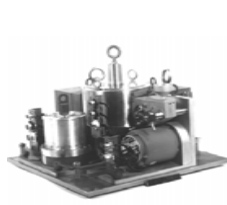
AGR 1 Capsule 4 Measurements



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 (2000°C 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 packing 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



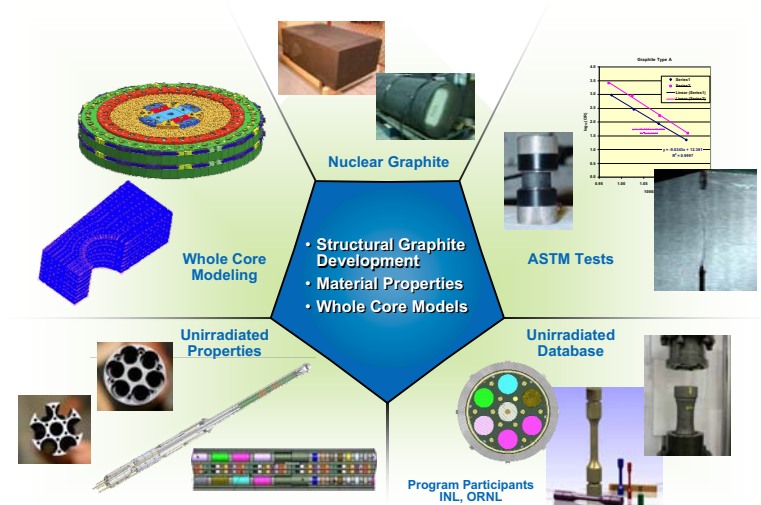
Objectives of Graphite Program



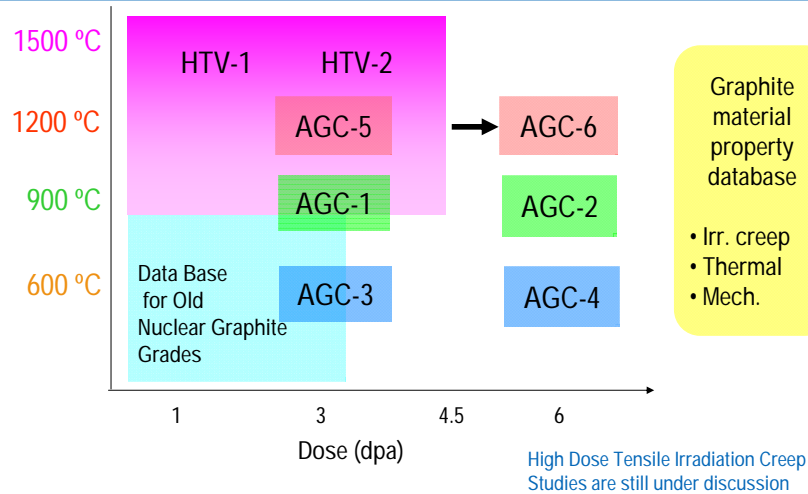
- Qualify new grades of graphite anticipated for future VHTRs (PBMR, NNGP) to demonstrate in-reactor behavior at least as good as that used in former German and U.S. gas reactors. (NGNP is focusing on prismatic PCEA and pebble NGB-18)
 - Establish statistical unirradiated thermo-mechanical and thermo-physical 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 NNGP Graphite Program



Graphite – Irradiation Capsules



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



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 NNGP
 - 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 UO₂ 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 NNGP licensing strategy is being established and will impact details of the anticipated future R&D activities