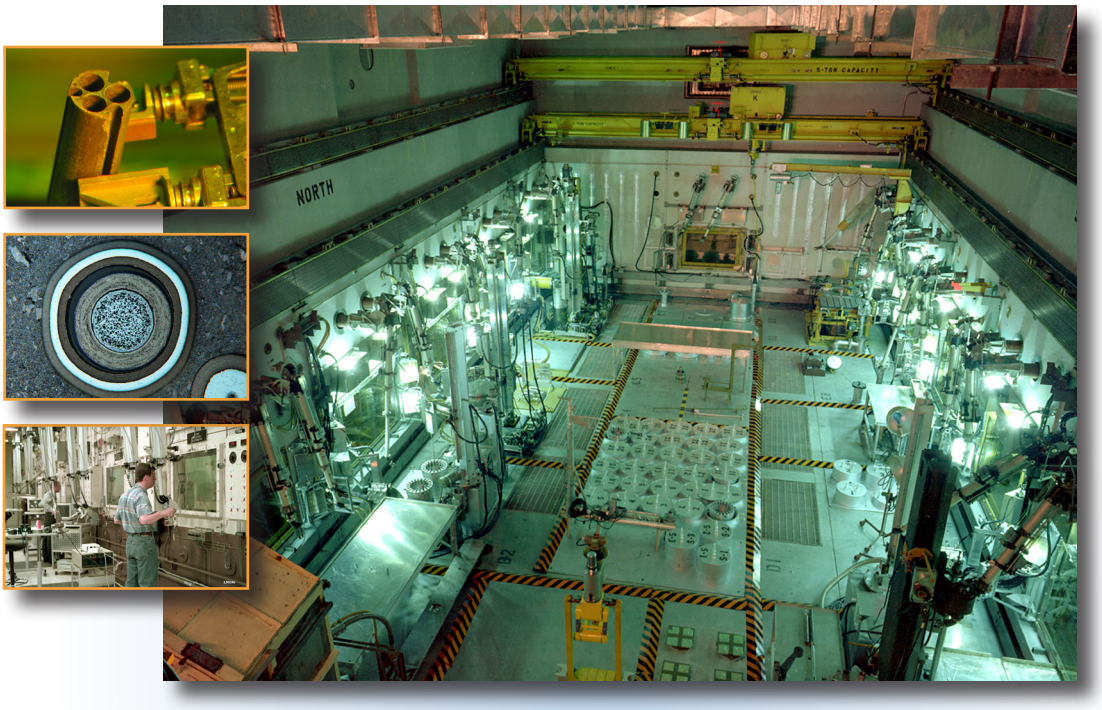

Post-irradiation examination of TRISO fuel provides essential data on fuel performance during normal operation and under accident conditions.

Post-irradiation Examination and Safety Testing

Next Generation Nuclear Plant

The Very High Temperature Reactor (VHTR) Technology Development Office Program is working to develop high temperature gas-cooled reactor (HTGR) technology that will meet the commercial needs of a wide range of industrial end users. Idaho National Laboratory (INL) manages the research and development of NGNP for the Department of Energy.

Post-irradiation Examination and Safety Testing

Post-irradiation examination (PIE) and safety testing are essential elements of the NGNP Fuel Development and Qualification Program. The PIE and safety tests provide data on the performance of the fuel during normal operation and postulated accident scenarios as a function of temperature, burnup, and neutron fluence. The primary focus is on assessing fission product retention of the fuel and characterizing irradiation-induced changes to the kernel and coating microstructures. The data obtained support the fuel fabrication effort by clarifying the important relationships between fuel processing, properties, and performance, and is also used to update and validate fuel performance models.

Fission metals retention of particles during irradiation

An important aspect of fuel performance is the potential release of metallic fission products from the fuel during normal operating conditions, which can have an impact on plant safety. Online monitors used during the test irradiation only measure fission gas release (krypton, xenon) and provide no information on fission metals. Information about fission metals release is obtained using several different approaches. The irradiation test capsule components are analyzed for fission metals that have been released from the fuel and

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NGNP Next Generation Nuclear Plant

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deposited on cold surfaces or on structural graphite during the irradiation. Fuel compacts are deconsolidated and the inventory of fission products released from particles but retained in the compact matrix is measured. Individual fuel particles are gamma counted, allowing the fraction of specific fission products (including cesium, silver, and europium) that have been retained in the particles to be determined.

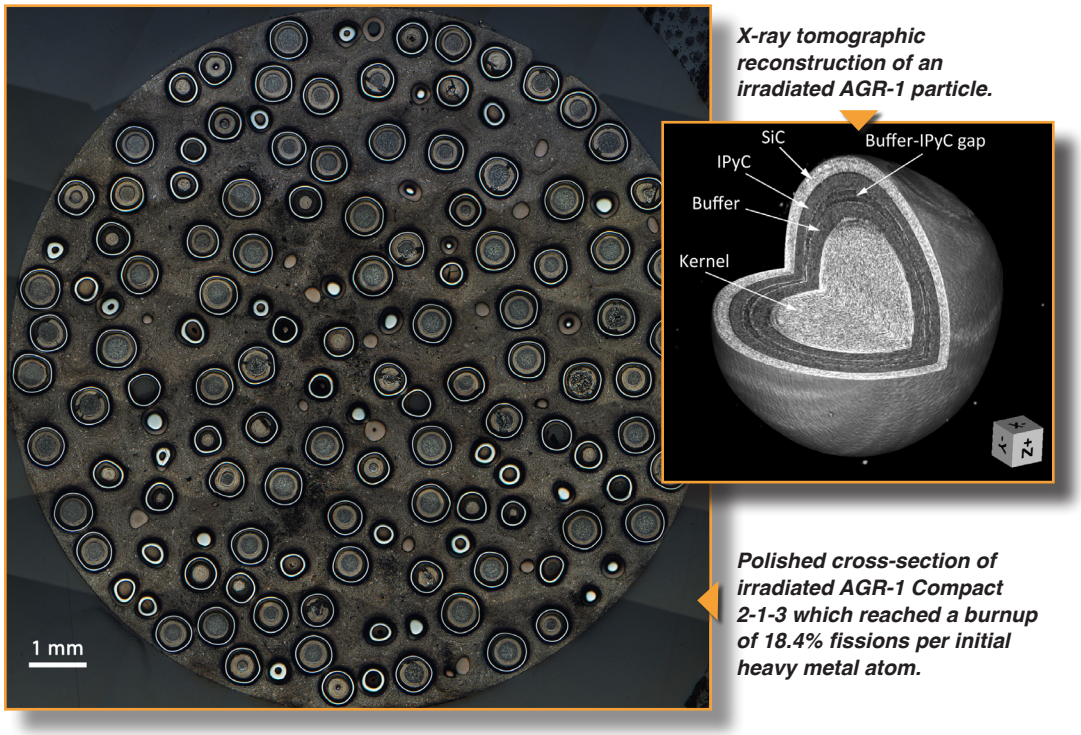
Fission product retention under high temperature accident conditions

The ability of the particle coatings to retain fission products during postulated accident scenarios is tested using dedicated furnaces that can heat the fuel specimens in inert helium or air/steam gas mixtures and measure the time-dependent fission product release. These safety tests provide verification of the fuel particle coating integrity and demonstrate that the fuel is of sufficient quality to meet reactor design requirements.

Microanalytical characterization of irradiated fuel

The irradiated fuel kernel and coating layer cross-sections are analyzed using optical and electron microscopic techniques. This provides data on kernel porosity, kernel migration, coating damage or crack propagation, and any changes to coating microstructure that occur during irradiation which might affect the integrity of the coating layers. Microchemical characterization of the particles is also performed to study the migration of fission products from the fuel kernel through the coating layers during irradiation and post-irradiation accident tests. This data provides information on fission product mobility within the coated fuel particles (important for understanding fission product release behavior) and can reveal chemical reactions of fission products with coating layers which could compromise the coating integrity.

An important aspect of the PIE is identification of specific particles that exhibit elevated fission product release–either during the irradiation or during safety tests–which could indicate coating layer failures. This requires a combination of special tools, first for identifying compacts and then for isolating individual particles of interest. A number of advanced microanalysis techniques can then be utilized to characterize the particle microstructure in detail in order to better understand the causes of coating failures, promoting the fabrication of particles with improved properties.



X-ray tomographic reconstruction of an irradiated AGR-1 particle.

Polished cross-section of irradiated AGR-1 Compact 2-1-3 which reached a burnup of 18.4% fissions per initial heavy metal atom.

For more information

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