Advanced Gas Reactor/TRISO Particle Fuel Re-Irradiation and Safety testing Experiment Performed in the NRAD Reactor and HFEF Hot Cell

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Post-irradiation examination (PIE) and safety testing of tri-structural isotropic (TRISO)-coated fuel particles from the second Advanced Gas Reactor (AGR) irradiation experiment, AGR-2, are in progress at the Neutron Radiography Reactor (NRAD) atthe Hot Fuels Examination Facility (HFEF) at the Idaho National Laboratory (INL). These fuels were irradiated for 559 effective full-power days in the Advanced Test Reactor; however, short-lived fission products with biological significance (such as I-131) decayed away before PIE cold be performed. The purpose of the re-irradiation is to generate short-lived I-131 (half life 8.0 days) and Xe-133 (half life 5.2 days) before heating tests in the Fuel Accident Condition Simulator Furnace (FACS) in the HFEF hot cell. There are three parts to the re-irradiation experiment. The first is to insert particles deconsolidated from irradiated fuel compacts into the NRAD reactor. Second is the heating test of the particles in the FACS. Third is the gamma spectroscopy of the furnace condensation plates, filters, and the fuel particles.

Intact TRISO coatings prevent fission product release. In order to study fission product release from the kernels, defects must be generated in the TRISO layers. Selected particles were cracked in order to damage all three TRISO layers and expose the fuel kernels. Inducing cracks in the particles to expose the kernels allows measurement of fission product releases from exposed kernels.

Components for Re-irradiation Experiment

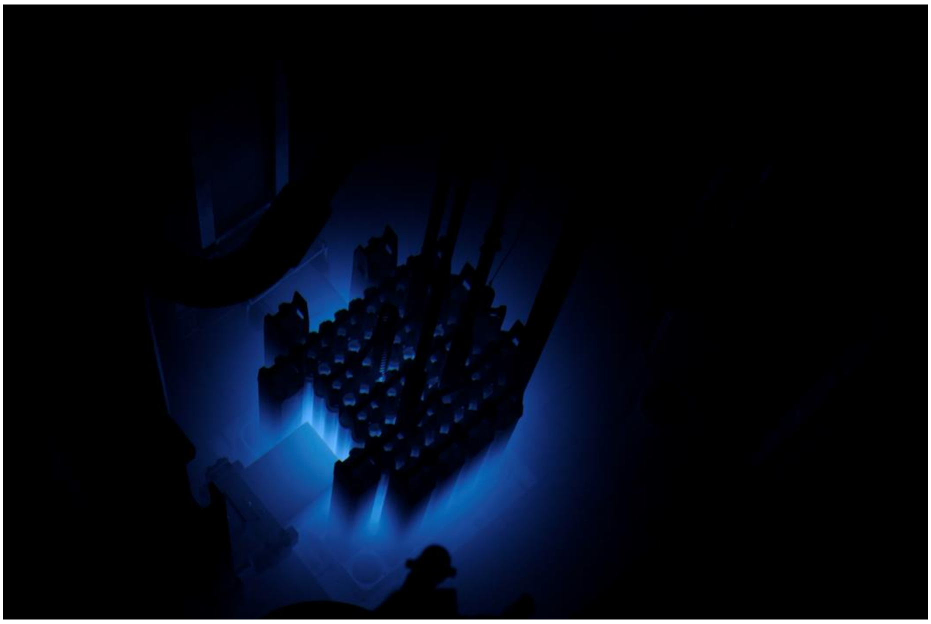

Figure 25: NRAD Reactor core

NRAD Reactor. The particles are placed into a titanium capsule and inserted into the wet tube C-4 SW core position of the NRAD reactor. The capsule is irradiated for up to 4 days of shift operation (8 hours at full power followed by 16 hours at zero power). At the end of the fourth irradiation period, the capsule is left in the reactor for a minimum 15 hours for decay time. The capsule is then transferred to HFEF and placed into the FACS furnace. Some particles were gamma counted in between re-irradiation in NRAD and loading into the furnace.

***Heating test in the FACS furnace*.** The particles are removed from the irradiation capsule and placed on a sample holder in the FACS. As the particles are heated to ~1600ºC, a helium sweep gas flows past the sample. The gas flows past a condensation plate that is attached to a cold finger. Condensable fission products such as I-131, Cs-134, Cs-137,Eu-152, Eu-154, and Ag-110m are collected on the plate. Condensation plates can be exchanged for new plates at predetermined times throughout the heating test. The sweep gas exits the furnace and flows through a silver zeolite filter and into an LN2 cold trap. Fission gases from the particles, such as Kr-85 and Xe-133, are collected in a charcoal canister (in the LN2 cold tarp) and are counted by High Purity Germanium (HPGe) detectors. The zeolite filter is later removed and counted (primarily for I-131) out of cell.

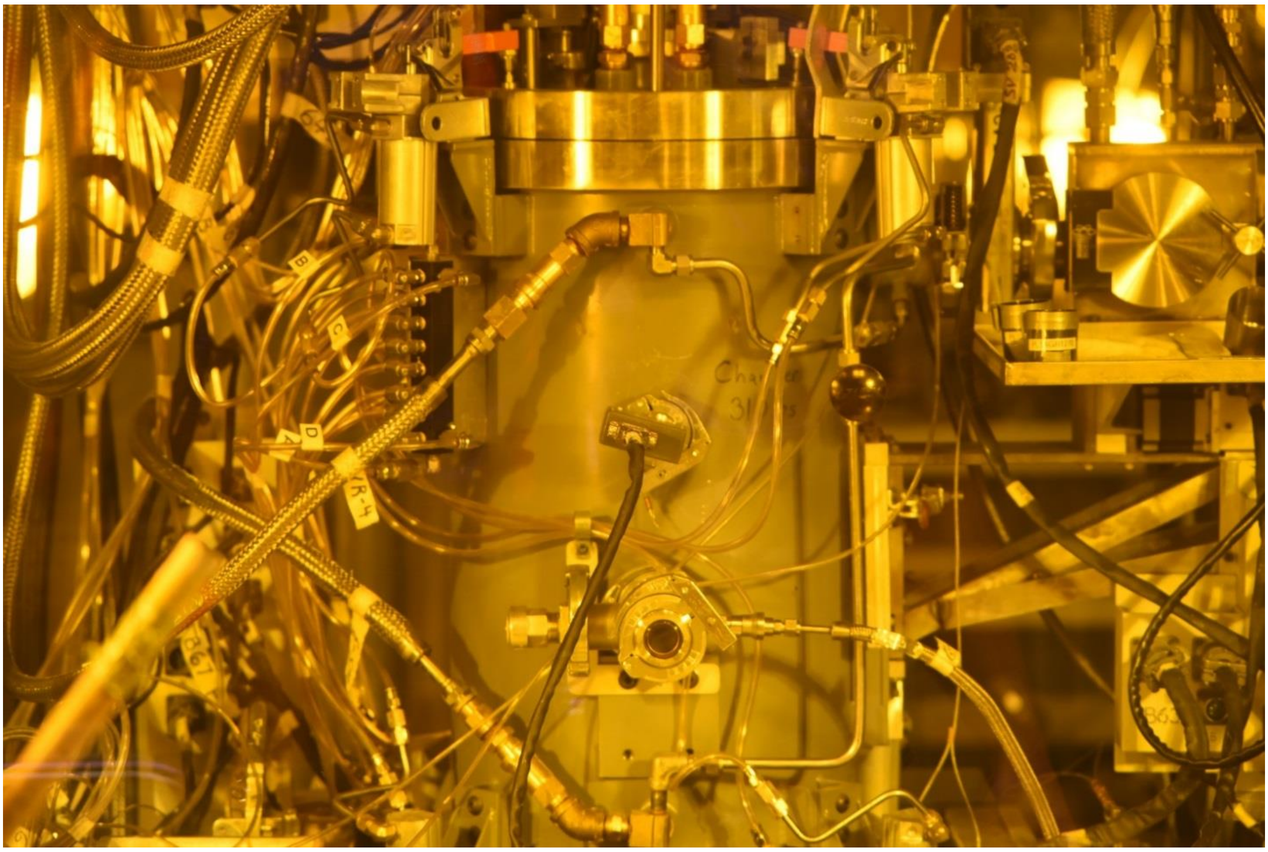

Figure 26: The FACS furnace.

Gamma Spectroscopy in the HFEF Out of cell Gamma Counting Stations (HOGS)

Throughout the run, condensations plates are transferred out of the HFEF hot cell and over to the HOGS. The HOGS consists of 2 shielded HPGe detectors that communicates with an ORTEC DSPEC-502. The DSPEC-502 contains two complete spectrometer electronics, including detector high voltage, amplifier, and an analog-to-digital converter. The information is then sent to a Data Acquisition computer. After the heating test is complete in the FACS, the zeolite filter and particles are counted as soon as possible so that the short-lived fission products (i.e. I-131 and Xe-133) are not lost through decay.

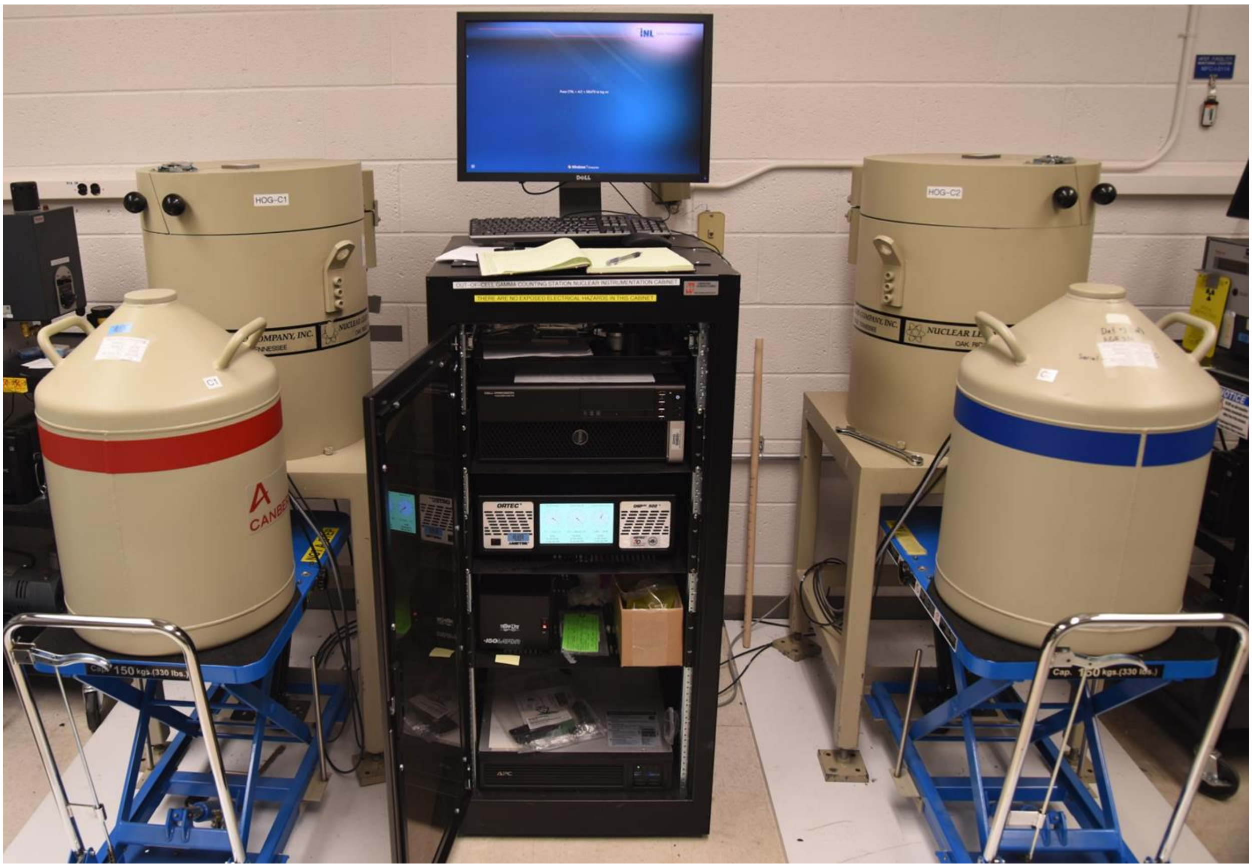

Figure 27: The HOGS

Conclusion

The unique ability the INL has to use the NRAD reactor to generate short-lived isotopes in previously-irradiated fuels, heat the fuel to simulated accident temperatures in the FACS, and analyze the components in the HOGS in a limited time frame gives the AGR program a better understanding of how these isotopes behave in the fuel under accident scenarios.