



Neutron Radiography Reactor (NRAD) core in the water-filled tank beneath the Hot Fuel Examination Facility main hot cell.

Neutron Radiography Reactor

Neutron imaging, irradiation

The Neutron Radiography Reactor (NRAD) is a 250-kilowatt Training, Research, Isotopes, General Atomic (TRIGA) research reactor that first went online at Idaho National Laboratory (INL) in 1977. Similar to an x-ray, neutron radiography provides more comprehensive information about the internal condition of irradiated nuclear fuel than any other nondestructive technique. At INL, neutron radiographs can significantly reduce the time and cost to examine irradiated fuel samples by allowing researchers to see inside samples to evaluate their performance and identify features or flaws that may require further study.

The reactor is situated beneath the Hot Fuel

Examination Facility (HFEF) to provide neutron radiography capabilities for examining nuclear fuels and materials at HFEF. It has two neutron beams for neutron imaging, providing researchers with a critical nondestructive tool to conduct post-irradiation examination of nuclear fuel and material samples.

Multiple INL nuclear fuels research and development programs routinely evaluate irradiated fuels using NRAD. A neutron beam routing east from the reactor enters the East Radiography Station directly beneath the main hot cell in HFEF. Highly radioactive samples within the hot cell can be lowered down an elevator into the neutron beam for imaging. A second beamline routing north

to the North Radiography Station provides radiography and three-dimensional tomography capabilities of non-irradiated and transient irradiated specimens. Highly radioactive samples within a cask can be examined at the North Radiography Station using a sample elevator that connects to the cask. Additionally, INL researchers are developing plans to establish neutron diffraction capabilities for nuclear fuels and materials using the north beamline. This capability will involve scattering neutrons in a sample to determine the structure of the material.

For neutron radiography of highly radioactive samples both dysprosium

and cadmium-covered indium foils are irradiated in the neutron beam, then transferred to a film cassette with ordinary X-ray film and allowed to decay overnight to form the image. The dysprosium foils, used for thermal neutron radiographs of low-enriched fuels and thin structural materials, produce excellent detail, but specimen thickness and fuel enrichment are limited. The indium foils are used for epithermal neutron radiography of highly enriched fuels and thicker structural materials. Epithermal neutron radiographs do not show as much specimen detail, but are useful for thicker specimens and more highly enriched fuels. In many cases, both foils are used to understand the internal

geometric condition of irradiated nuclear fuels.

NRAD can perform small-scale material irradiation tests or activation experiments in one of two irradiation locations within the reactor core. Irradiation/activation experiments may be placed in either the dry irradiation tube positioned at the edge of the reactor core (neutron flux of 2.1×10^{12} n/cm²-s), or in the wet tube located in the center of the reactor core (neutron flux of 5.2×10^{12} n/cm²-s). Quick access to the adjacent HFEF hot cell makes NRAD a unique irradiation capability that allows characterization of short-lived fission products in irradiated nuclear fuels such as TRISO and molten salts.

BASIC CAPABILITIES

- Nondestructive post-irradiation examination of irradiated, non-irradiated and transient-irradiated samples using two separate neutron beam lines.
- Neutron film and digital radiography using the transfer method (insensitive to gamma-rays).
- Neutron tomography of lightly irradiated samples (<1 R/h).
- Neutron diffraction (in development).
- Low flux in-core irradiation with adjacent access to hot cells.

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy.

FOR MORE INFORMATION

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INL staff and visiting experts in front of the open door to the NRAD reactor room.