GAMMA IRRADIATION FACILITY

Gamma irradiation is a process that uses Cobalt-60 radionuclide produced artificially in nuclear reactors to irradiate a variety of items using gamma radiation. A key characteristic of gamma irradiation is its high penetration capability and the fact that it can modify physical, chemical, and biological properties of the irradiated materials.

Gamma irradiation can be used for a broad spectrum of applications. Most commercial irradiators use gamma radiation for sterilization of health care products, pharmaceuticals, and horticultural products (for disinfestation, shelf life extension, pest control) and for material modification (such as polymerization, polymer crosslinking and gemstone color enhancement).

On the other side of gamma irradiation application spectrum are research facilities that provide high-fidelity simulation of nuclear radiation environments for testing materials and components that must function reliably in the presence of high radiation levels. These applications include space technology development, military systems vulnerability testing, nuclear reactor component development, nuclear fusion technology, and high-energy physics applications. For this reason, the US demand for gamma irradiation R&D has increased over the past 20 years.[1]

As a result, Sandia constructed the Gamma Irradiation Facility...

IPO

Sandia National Laboratories

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

U.S. DEPARTMENT OF ENERGY NNSA

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BACKGROUND

Sandia's Gamma Irradiation Facility (GIF), located in New Mexico's Tech Area V, is a radiological facility providing high-fidelity simulation of nuclear radiation environments for materials and component testing.[2] The Facility is used for space technology development, military systems vulnerability testing, nuclear reactor component development, high-energy physics applications and many other. Scientists can perform testing on objects as large as tanks or satellites and as small as microchips and bacteria for their ability to withstand damaging radiation environments that exist in space, in nuclear fission and fusion reactors, near stored nuclear materials, or during a wartime nuclear exchange.[3] Typical experiments at GIF include testing for electronic-component hardness, materials-properties testing, investigations of various physical and chemical processes, testing and radiation certification of satellite and weapons system electronic components, dosimetry calibration, and investigations of radiation damage to materials.[4]

Depending on customer need, a test can last seconds to months with gamma dose rates as low as tens of rads per hour to as high as 10 million rads per hour. (A rad is a unit for measuring absorbed doses of ionizing radiation by a material).[5] To further accommodate specific irradiation experiment needs, designers can customize GIF with configurable radiation sources that provide different geometries for the source array (e.g., point, planar, and circular); enable shielded windows for experiment observation during irradiation; install remote manipulators to facilitate experiment or source handling; enable pass-throughs in the shielding walls so that experiment power and instrumentation cables can penetrate the shield walls; engage a moveable wall in the large cell to provide access for large components; make use of removeable cell-roof-shield plugs that provide access for large and/or massive experiments; use an overhead bridge crane spanning the facility's high bay that can access the cells through the cell-roof-shield plugs; use dry experiment canisters for in-pool irradiation experiments; and perform experiments that can be heated or purged with air or other gases.[6]

> *"This Facility has capabilities that will help satisfy many of the nation's experimental gamma radiation needs for decades"*

BACKGROUND CONT'D

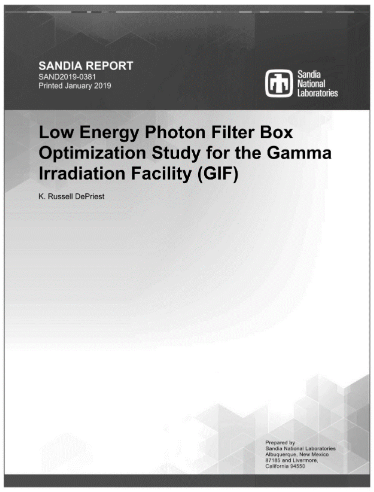
The Gamma Irradiation Facility is approximately 10,700 gross square feet and is comprised of a central high-bay laboratory with three concrete test cells for dry in-cell irradiations and two pools. In-cell dry facilities are large, shielded rooms in which irradiations are performed with high intensity gamma-ray sources. The in-cell dry testing facilities include two 10×10-ft cells; one cavernous 18×30-ft chamber that can accommodate large test objects (e.g., weapon assemblies, military vehicles, space equipment). The source pins made of radioactive cobalt-60, a source of high intensity gamma radiation, are arranged in source arrays, which are automatically raised into and lowered out of the chambers to deliver the desired dose of gamma radiation.[7] In addition, the facility has two pools containing demineralized water (18- and 25-foot-deep). The 18-foot-deep pool is used to provide radiation shielding for the submerged gamma sources and for source handling. The 25-foot-deep pool is used for testing without radioactive sources.[8] Typical experiments performed at these facilities include electronic component hardness, survivability, and certification tests for military and commercial applications; radiation effects on material properties; radiation effects on organic materials; and mixed environment testing (e.g., cryogenic conditions, heat, humidity, and radiation.) The in-pool wet facilities allow for radioactive sources to be held in an irradiation fixture in a deep pool of water where they remain stationary. Experiment canisters containing test units are immersed in the pool and positioned in preset locations in the irradiation fixture for a variety of underwater experiments (e.g., thermal- and radiation-effects studies, material aging tests).[9]

In addition to the irradiation testing facilities, low-bay ancillary spaces exist as the infrastructure for offices, setup laboratories, and mechanical and electrical systems.[10]

Alongside the primary facility, the Low-Dose-Rate Irradiation Facility (LDRIF) in the GIF annex offers gamma and neutron irradiation environments for long-duration testing of equipment, materials, and components at low dose rates. LDRIF includes two test cells and a setup/data acquisition lab and complements GIF by expanding the range of available gamma dose rates from six to nine decades.[11]

FACILITY DEVELOPMENT

In the late 60s, early 70s, Sandia constructed multiple facilities for gamma irradiation testing with funding from the Atomic Energy Commission (disbanded in 1974 and its functions were divided between the Nuclear Regulatory Commission (NRC) and Department of Energy (DOE)).[12] Then, in the early 90s, Sandia began exploring consolidating several of the gamma irradiation entities into a single, dedicated facility. In November 1995, DOE prepared a Final Environmental Assessment on the proposed construction of a singular facility at Sandia's New Mexico site. The new Facility was designed to enhance capabilities to assure technical excellence in nuclear weapon radiation environments testing, component development, and certification; reduce personnel radiological exposure to comply with regulations in accordance with DOE orders and standards; consolidate major gamma ray sources into a central, secured area; and reduce operational risk associated with the operation of GIF and the Low Intensity Cobalt Array in their then locations in Sandia's densely populated Tech Area I.[13] In 2001, Sandia conducted its first tests at the newly constructed GIF. The next major milestone took place in 2012, when Sandia began transitioning GIF from a Hazard Category 3 nuclear facility to a radiological facility by removing approximately 10k curies of non-certified cobalt-60 sealed sources.[14] More recently, in 2017, Sandia became a formal Nuclear Science User Facilities (NSUF) Partner and GIF was added to the NSUF User Facility List. Becoming an NSUF partner opened Sandia's capabilities to nuclear energy researchers, accelerating nuclear power research to address nuclear technology applications. In particular, NSUF partners can submit proposals to conduct research at Sandia's GIF and if selected, can visit and perform the research. The user facilities help researchers understand the effect of radiation on current and proposed reactor materials.[15] While successful, the Facility faces a significant obstacle: there is no domestic supply of cobalt-60. Current supplies come from a private Canadian company; however, new guidelines introduced by the Canadian government for the sale of cobalt-60 has affected GIF's ability to purchase the material. Various entities are working to resolve this.[16]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Sandia National Laboratories

Low Energy Photon Filter Box Optimization Study for the Gamma Irradiation Facility (GIF)

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RETURN ON INVESTMENT

Sandia's Integrated Partnerships Organization (IPO) has successfully established several Strategic Partnership Agreements (SPP) and one Cooperative Research And Development Agreement (CRADA), which utilize the Gamma Irradiation Facility.

ROI
Public Health
Nuclear Energy
Partnerships
Revenue

Strategic Partnership Agreements

National Security Research

Within tech transfer, Strategic Partnership Projects (SPP) Agreements facilitate the availability of Sandia's unique resources to private industry and individuals, state and local governments, colleges and universities, non-profit organizations, international organizations, foreign governments, and foreign companies to validate or improve technologies.[17] Sandia has multiple SPP agreements utilizing the Gamma Irradiation Facility and use dating from the 1990s to 2021.

Cooperative Research and Development Agreements (CRADA) foster mutually beneficial partnerships to facilitate cutting-edge research and development for ultimate commercialization. Sandia has one CRADA utilizing the Gamma Irradiation Facility.

LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

LDRD

The Laboratory Directed Research and Development (LDRD) program invests in high-risk, potentially high-payoff activities that enable national security missions and advance the frontiers of science and engineering. The LDRD program provides the flexibility to anticipate and respond quickly to future mission needs and to explore potentially revolutionary advances in science and technology.[18]

Over the past 17 years, six LDRD projects were conducted utilizing Sandia's Gamma Irradiation Facility.

PUBLIC IMPACT

COLLABORATION WITH OTHER NATIONAL LABS

Subjecting nuclear weapons components and other electronic systems to a range of radiation types is an essential element of Sandia's experimental capabilities and the Lab's support of DOE's science-based stockpile stewardship mission. When a nuclear weapon sits idle in the stockpile, its fissile materials give off a continual, low-level buzz of radiation, primarily gamma. Over time, this exposure can damage the weapon's electronic components. GIF has conducted multiple experiments and joint research of these processes with other DOE National Labs.[18]

HIGH-ENERGY PHYSICS RESEARCH

Hostile radiation environments can be experienced in space by weapons, satellites, and spacecraft with damaging effects to their electronics. They also exist in high energy physics, and nuclear fusion application (e.g., Large Hadron Collider, International Thermonuclear Experimental Reactor, SLAC National Accelerator Laboratory). GIF conducted numerous experiments in support of high-energy physics applications and NASA's interplanetary missions.[19]

Sandia scientist Maryla Wasiolek operating a gamma irradiation cell where the NIST cable irradiation experiment took place.

NUCLEAR ENERGY

The National Institute of Standards and Technology (NIST) used Sandia's GIF to perform aging experiments on electric cables used in older nuclear power plants. NIST tested several types of cables to ensure their continued safe performance for extended periods of time. This three-year experiment was the longest ever conducted at GIF and simulated 80 years of exposure to low-dose rate radiation to replicate cable exposures found in the nuclear power plants. Ensuring the safety of components used in nuclear power plants is just one example of how GIF helps perform testing critical for national security.[20] GIF also support nuclear energy research through Nuclear Science User Facilities network.

MEDICAL EQUIPMENT STERILIZATION

Sandia's GIF also participated in R&D related to the sterilization of medical equipment but does not conduct sterilization activities on a commercial scale.[21]

In 2020, Sandia collaborated with the University of New Mexico (UNM) Health Sciences Center (HSC), in an LDRD, using GIF to analyze the efficacy of gamma sterilization of personal protective equipment (PPE). Filtration properties of new and gamma-sterilized PPE were compared by analyzing various physical, electrostatic, and morphology parameters. Recommendations were then proposed for reusing gamma-sterilized PPE.[22]

In 2020, Coca-Cola and Oak Ridge National Lab collaborated to fill a gap in COVID-19 testing supply chains by converting one of Coca-Cola's bottling facilities to make tubes for COVID-19 test kits. Sandia contributed to this collaboration by using its GIF to inform the development of protocols for sterilizing the test tubes. Specifically, Sandia performed R&D to find the right level of gamma radiation to sterilize the tubes without damaging the components, the plastic, or the tubes' seals. Sandia's protocols were shared with medical sterilization facilities around the country receiving tubes from Coca-Cola to sterilize.[23]

SOURCES

1 PI Maryla Wasiolek
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GAMMA IRRADIATION FACILITY

A radiological facility providing high-fidelity simulation of nuclear radiation environments for materials and component testing. GIF is used for space technology development, military systems vulnerability testing, nuclear reactor component development, high-energy physics and many other applications.

> *This Facility is an international asset and has capabilities that will help satisfy many of the nation's experimental gamma radiation needs for decades*

The Gamma Irradiation Facility consists of:

- *A Central High-Bay Laboratory*
    - *In-cell dry facilities*
    - *In-pool wet facilities*
- *GIF Annex*
    - *Low-Dose-Rate Irradiation Facility*

Return on Investment:

- *Furthering national security research and development*
- *Multiple partnership agreements*
- *National Security Nuclear Energy Missions*

1960/70s
Sandia constructed multiple facilities for gamma irradiation testing with funding from the Atomic Energy Commission

1990s
Sandia began exploring consolidating several of the gamma irradiation facilities into a single, dedicated facility

1995
DOE prepared a Final Environmental Assessment on the proposed construction of the facility

2001
Sandia conducted its first tests at the newly constructed Gamma Irradiation Facility (GIF)

2012
GIF transitioned from a Hazard Category 3 Nuclear Facility to a Radiological Facility

2020
Sandia collaborated with Oak Ridge National Lab on COVID-19 testing supply chains for Coca-Cola by using the GIF to inform the development of sterilization protocols