

Brookhaven National Laboratory (BNL) Hot Cell Renovation

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1. Abstract / Introduction

Brookhaven National Laboratory and Merrick & Company are executing a project to renovate an existing, vacant hot cell facility to support the Medical Isotope Research & Production (MIRP) program. The primary mission of the MIRP program is to prepare certain commercially unavailable radioisotopes for distribution to the nuclear medicine community and industry and to perform research to develop new radioisotopes desired by nuclear medicine researchers. In order to support the MIRP program operations at BNL, a suite of three hot cells and two adjacent ready rooms have been selectively demolished, decontaminated, and redesigned for their new medical isotope production mission. Renovation activities have included the removal of radiologically contaminated equipment and the replacement of the hot cell telemanipulators and viewing windows. In order to renovate the hot cells for their new mission, a clean room vestibule space has been designed for material and personnel entry to the prep rooms, and the HVAC system has been redesigned to achieve ISO 5, 6, and 7 air cleanliness by particle concentration. Additional design considerations and elements have been employed to achieve an aseptic processing condition and monitor this condition for validation of aseptic processing of the product.

2. Brookhaven Radioisotope Production

Medical Isotope Research and Production (MIRP) Program

The primary mission of the Brookhaven National Laboratory (BNL) Medical Isotope Research and Production Program is to prepare certain commercially unavailable radioisotopes for distribution to various stakeholders including the nuclear medicine community, industry, and researchers at universities and national labs. Additionally, they perform research to develop new radioisotopes desired by nuclear medicine researchers and industry. In conjunction with this mission, the group also performs irradiations for non-isotope applications, sells by-products, and explores opportunities for new products and radioisotope applications.

BNL operates one of only a few high-energy high current particle accelerators in the United States. This accelerator, the Brookhaven Linac Isotope Producer (BLIP), produces the needed radioisotopes using precisely controlled beams of charged particles which are aimed at small puck shaped targets. The protons produced by the accelerator can be precisely degraded to a wide range of energies ranging from 202 million electron volts (MeV) and 165 μ A intensity down to whatever energy is needed to produce the desired isotopes. In the United States, this capability is unique to BNL.

The BNL Isotope Program is capable of producing the radioisotopes listed in Table 1.

Table 1. Radioisotopes Available from Brookhaven National Laboratory.

Radioisotope	Main Use
⁸² Sr	⁸² Rb daughter for cardiac viability and Coronary Artery Disease studies
⁵⁵ Fe*	Source for X-ray detectors as well as environmental/agricultural tracer
⁶⁵ Zn	Environmental, agricultural and medical tracer
⁸³ Rb	Calibration source for neutrino detector experiments
⁸⁶ Y	PET quantitative imaging studies
⁶⁷ Cu	Therapeutic for cancer therapy
⁷ Be	Post-detonation nuclear forensics, tracer for atmospheric/soil studies

The U.S. Department of Energy Isotope Program (DOE IP) provides stewardship over the Brookhaven Linear Isotope Producer (BLIP) Facility at BNL, the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL), and hot cell facilities for processing isotopes at Oak Ridge National Laboratory, BNL, LANL, and several other facilities.

3. Merrick & Company

Nuclear Services and Technology

Merrick has provided nuclear engineering services since 1983. We custom design nuclear equipment, systems, and facilities. Hot cells, gloveboxes, custom enclosures, and in-cell equipment design represent our primary business in Merrick's Nuclear Services and Technology business unit. We design hot cells and remote handling equipment for fuel research, post irradiation examination, medical isotope production, nuclear weapons support facilities, neutron research facilities, and advanced science facilities requiring high-energy shielding. We understand how to design your facilities for functionality, operability, and maintainability. Whether enhancing capacity, increasing efficiency, modernizing technology, improving safety, or renovating facilities, our team of trusted experts provides the right solution, allowing our clients to realize the greatest value.

4. Brookhaven/Merrick Hot Cell and Laboratory Renovation Project

Hot Cell Renovations

The objective of the Brookhaven/Merrick hot cell renovation project was to renovate an existing, vacant hot cell facility to support the Medical Isotope Research & Production (MIRP) program and enable the processing of medical isotopes for cancer diagnostics and therapies.

The suite of three hot cells identified for renovation in this project were originally constructed in 1958 and served as test cells for the fuel cladding material of reactor fuel rods used in BNL's High Flux Beam Reactor (HFBR). BNL's HFBR also once provided radioisotopes, but the reactor was permanently closed in 1999. At that time, the metallurgical operations within these hot cells ceased and the hot cells were vacated. Now these hot cells have been selectively demolished, decontaminated, and redesigned for their new medical isotope production mission. Renovation activities have included the removal of radiologically contaminated ductwork and a fume hood used to ventilate the hot cell and ready room operations. Additional equipment has also been removed from the hot cell areas including hot cell viewing periscopes, work surfaces, hot cell partitions, mechanical pass through and supplemental shielding mechanisms, a bridge manipulator, a jib manipulator, a bridge crane, pneumatic hoists, and electrical equipment.

Some equipment within the hot cells including telemanipulators, hot cell viewing windows, and a remotely operated manipulator crane has been replaced to support the new hot cell operations. Utility isolations, necessary to ensure worker safety during the decontamination process, for a 60-year old facility were challenging due to the lack of accurate documentation. Additionally, the initially high contamination levels ($> 750,000$ dpm/ 100 cm²) inside of the hot cells restricted access during the design and work planning phases of the project. In order to renovate the hot cells for their new medical isotope mission, an additional clean room vestibule space was also designed and configured for controlled entry of material and personnel into the prep rooms leading to the hot cells. The HVAC and electrical systems were also redesigned to achieve the necessary ISO 5, 6, and 7 air cleanliness by particle concentration.



Figure 1 BNL Hot Cells During Renovations

Aseptic Hot Cell Processing

In addition to the standard radiological and confinement challenges associated with hot cell design and construction, this project added the challenges of aseptic hot cell processing.

Designing and constructing for the processing of medical isotopes requires careful consideration of the requirements and guidance established by the Food and Drug Administration (FDA), European Union (EU), Good Manufacturing Practices (GMP), and other regulatory requirements. Potential contaminant loads from the process and the controlled environments must be identified and mitigated in aseptic processing to minimize the risk of viable and non-viable contaminants. It is important to establish and employ validated processes and procedures in each step of the processing of the pharmaceutical ingredient to ensure that these risks are mitigated. Further, the processing must also be monitored for viable and non-viable contaminants to ensure that the systems in place to minimize these risks are performing as expected at rest and in operation. The design and construction of the classified spaces must also consider the ability to clean the spaces to the requirements of the aseptic processing environment. For hot cell operations, this requires an emphasis on remote cleanability and the isolation of areas which cannot be remotely cleaned from the process area.

Radioisotope Processing

The radioisotope processing conducted within the renovated hot cell suit at BNL will be production of alpha emitters to support clinical trials. Currently thorium targets are irradiated at the Brookhaven Linac Isotope production facility and then shipped to Oak Ridge National Laboratory for processing and distribution. The upgrade of these hot cells will enable production to occur at Brookhaven and allow for increased quantities to be produced and distributed. The facility will further enable the program to meet the guidelines established by the FDA for Active Pharmaceutical Ingredient (API) production.