# Evaluation of the Impact to the Safety Basis of Research Conducted in Production Facilities at Y-12

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## INTRODUCTION

This paper describes the unique challenges to maintaining the integrity of the safety basis during the conduct of nuclear research in existing production facilities at the Y-12 National Security Complex. It reviews lessons learned in the performance of advanced radiation measurement evaluations performed using the Nuclear Materials Identification System, Advanced Portable Neutron Imaging System, and other radiation detection and measurement systems in the Nuclear Detection and Sensor Testing Centers (NDSTC) inside operating facilities at Y-12.

The NDSTC was established in 2009 to provide the U. S. Department of Energy (DOE) and the nuclear detection community with locations for performing radiation measurements with both enriched uranium (EU) and depleted uranium (DU), in many different configurations, with and without a variety of shielding and reflecting materials.

The NDSTC, when used for evaluating large quantities of EU, is housed in a Category 2 nuclear facility at Y-12. Nuclear material operations in this facility include assembly, disassembly, product certification, quality evaluation and storage of weapons components. Measurements are conducted in areas dedicated for NDSTC operations as well as in operating storage areas. Operation of the facility, including the NDSTC, is evaluated in documented safety analyses, including fire hazard analyses, criticality safety evaluations, safety analysis reports and technical safety requirements.

## METHODOLOGY

The NDSTC uses various deuterium-tritium or deuterium-deuterium neutron generators, as well as sealed Californium-252 ($^{252}$Cf) sources to perform active neutron interrogation of fissile targets consisting of 161-type castings (EU and DU), canned subassemblies, various reactor fuel elements, and other miscellaneous shapes and masses, some of which are stored in a production facility, and some of which are supplied by the organization performing the measurements. The active interrogation equipment emits radiation that induces fissions in the target materials. Radiation detectors are placed at various positions adjacent to the targets to observe and measure the resulting radiation. The measurements are used to determine the "unique radiation signatures" of various materials for nuclear safeguards, arms control and nonproliferation, counter terrorism, and other applications.

In some experiments a reflector is positioned contiguous to or close to the target. The reflector components may be constructed of plastic (polyethylene), steel, depleted uranium, lead, water (contained in metal or plastic), or a combination of these materials.

The safety analysis for NDSTC was completed in four phases. The first phase assessed installation and initial testing without a fissile material target. The second phase involved operation of the Radiation Generating Device with one fissile target without any reflectors. The third phase evaluated operation with targets and a stack of steel and polyethylene blocks that provided reflection and shielding. Lastly, operation was evaluated with the use of "simulant materials" as shields and reflectors.

Three separate Unreviewed Safety Question Determinations (USQDs) evaluated NDSTC operations. The first USQD, evaluating installation and initial testing without a fissile material target, found no interference with Criticality Accident Alarm System operability due to increased radiation levels and added shielding. Although no unreviewed safety question was identified, recommendations were made to require Fire Hazards Analysis (FHA) of combustible materials and Criticality Safety Evaluation (CSE) of targets that contain fissile material.

The second USQD evaluated operation of the NDSTC with targets, reflection, and shielding. The scope of the review included the Nuclear Criticality Safety (NCS) limits and requirements as documented in the CSE, restrictions documented in the FHA, as well as the results of the hazard identification and screening documented in the facility safety analysis report. No unreviewed safety question was identified.

The third USQD evaluated the use of additional simulant materials used primarily as shields or reflectors during operation. No unreviewed safety question was identified.

The hazard screening concluded that the RGDs that produce neutrons for interrogation of materials do not require further analysis. The neutron generators are exempt under Paragraph 3.c.(1) and (5) of DOE Order 420.2B because they will not be modified, are acceptable for industrial applications, and are operated at a very low voltage (90kV). According to the vendor, this neutron generator and a similar but larger neutron generator are used by organizations that include Clear Path Technologies, SAIC, Northrop Grumman, Pennsylvania Transit Authority, and Baylor University Medical College. Since the neutron generator does not require further analysis, the resulting radiation hazard is controlled by plant safety programs rather than through controls that are derived from the safety analysis. The radiation hazard from the Californium sealed source is also controlled through plant programs. The plant safety programs that apply to the neutron generators and Californium source are radiation protection, control of radiation generating devices, and sealed source control.

The CSE was revised to document credited controls for interaction, mass, moderation and reflection associated with NDSTC operation. The FHA was revised to document restrictions related to combustible reflector materials. The SAR was revised to document the results of the hazard screening.

An Experiment Review Board (ERB) was established to provide an integrated approach to reviewing and approving active interrogation and passive detection experiments at the NDSTC. The mission of the ERB is to ensure planned experiments are accomplished in accordance with approved site procedures and guidelines. In support of NDSTC experiments, the ERB provides a formalized review of experiment requests and plans, and evaluates experiment objectives against applicable facility safety and security approvals; and other site procedures, policies and guidelines.

An ERB charter[1] was developed to document the purpose of the ERB, general roles and responsibilities, membership and structure, experiment plan/request acceptance criteria, and required training. ERB membership is selected by the production facility operations manager, and includes, as a minimum, a chairperson and one representative from NDSTC management, facility operations (may be the chairperson), criticality safety, facility safety, radiological control, safeguards and security, the design authority representative, and the systems engineering manager.

An experiment request (copy attached) was also developed, and includes the scientific background or aim of the experiment, identification of any RGDs or radioactive sources not integral to an RGD to be used, identification of any special nuclear materials to be supplied by Y-12, facility requirements, hazardous and non-hazardous materials to be used, safeguards and security requirements, and identification of all support personnel requiring access to the Y-12 site.

The Y-12 ALARA committee approved the initial startup of the NDSTC with a hold point afterwards to review survey data and compare against the dose estimates to determine if additional controls are warranted. After initial startup and testing were completed, the dose estimates and associated controls for the NDSTC were updated and reviewed again. After discussion, the committee approved operation subject to the controls being formalized either in an operating procedure or checklist with the addition of a requirement for the radiological engineer to check doses on a quarterly basis.

Portable shielding in the form of water-filled, steel reinforced polypropylene containers is used for occupational safety. Approximately 19 containers are used, each containing approximately 120 pounds of polypropylene and 300 gallons of water. Containers may be stacked two high.

Administrative controls include limiting the time of operation and total operating hours, restricting facility access while operating, providing area neutron monitoring, and conducting initial startup radiation surveys to establish boundaries.

In addition to area neutron monitoring, personnel entering the operating area are issued thermo luminescent dosimeters (TLDs) in a different color than their standard TLD. With these controls, the estimated maximum individual annual dose is 2 millirem for "unmonitored personnel," 17 millirem for neutron monitored personnel, and 80 millirem for the operator. The estimated annual collective dose is 944 person-millirem. An

emergency scram switch was also installed to shut off the neutron generator. Also, a committee was appointed for review and approval to use the neutron generators in the operating facilities.

## RESULTS

The analysis of the safety of NDSTC operations in a production facility identified important controls for maintaining the integrity of the safety basis during the conduct of nuclear measurements. Additionally, a checklist was developed to ensure all precursor activities and notifications are made prior to the start of measurements. A proactive approach was implemented to address employee concerns about neutron dose cancers.

Although production has priority over research, building personal relationships among NDSTC staff and operations staff improves cooperation. Demonstrated technical competence by NDSTC staff also improves trust among facility operations staff.

The resulting NDSTC measurements are used to determine the "unique radiation signatures" of various materials for nuclear safeguards, arms control and nonproliferation, counter terrorism, and other applications.

## REFERENCES

[1]Y/NSP-780, *Nuclear Detection and Sensor Testing Center (NDSTC) – Experiment Review Board (ERB) Charter, February 2011.*

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