Facts from the Savannah River Site

ENVIRONMENTAL STEWARDSHIP • NUCLEAR SECURITY • SCIENCE AND ENERGY

Savannah River Tritium Enterprise

Background

"Savannah River Tritium Enterprise" (SRTE) is the collective term for the facilities, people, expertise, and activities at the Savannah River Site (SRS) related to tritium, which is an isotope of hydrogen and a key element of nuclear weapons.

Operated by Savannah River Nuclear Solutions for the National Nuclear Security Administration (NNSA), SRTE is an important contributor to the U.S. Nuclear Security Enterprise (NSE). The NSE has responsibility for maintaining a safe and reliable nuclear stockpile. SRTE prepares the nation's only tritium supply for our national defense and ships loaded containers called reservoirs to the Department of Defense, where they are installed in weapons. In addition, SRTE — in particular, the groups within the Savannah River National Laboratory (SRNL) that are part of SRTE — conducts related research and development.

SRTE's primary facilities occupy approximately 29 acres in the northwest portion of SRS' H Area, with additional space in SRNL's facilities. Operations began in 1955.

SRTE personnel have a long history of outstanding performance in safe, secure, disciplined, and compliant operations, consistently delivering high-quality products to our customers on schedule.

Missions

The SRTE performs five assigned missions that are vital to the United States' national security:

Tritium Supply

Tritium decays radioactively at the rate of 5.5 percent each year and must be replenished continually. SRTE accomplishes this by two methods.

- Recycling tritium from the reservoirs of existing warheads
- Extracting new tritium from Tritium-Producing Burnable Absorber Rods (TPBARs) that have been irradiated in a Tennessee Valley Authority (TVA) commercial light water reactor

Nuclear Stockpile Maintenance

SRTE helps to maintain the U.S. nuclear stockpile by supplying gas transfer systems (GTS), which ensure the performance of nuclear weapons. Reservoirs are loaded with a mixture of tritium and deuterium (a non-radioactive isotope of hydrogen), assembled, inspected, and packaged for shipment.

Gas transfer system function test

- **Gas processing:** Reservoirs returned from the Department of Defense contain three gases: the remaining tritium (T_2), deuterium (D_2), and helium-3 (the gas that forms when tritium decays). At SRTE, the gas mixture is pumped through a hydride bed to separate the helium-3 from the hydrogen isotopes. The T_2/D_2 gas is transferred to modern storage beds that occupy about 1/300th of the space required by old-style gas storage tanks. A Thermal Cycling Absorption Process (TCAP) is used to separate the tritium and deuterium.
- **Reservoir loading:** Before loading into the reservoirs, T_2 and D_2 are mixed to an exact ratio. When each reservoir is loaded to the correct pressure, its fill stem is pinched closed, then resistance welded to completely seal the gas into the reservoir.

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U.S. DEPARTMENT OF ENERGY

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- **Reservoir finishing:** Reservoir finishing consists of all operations necessary to ensure the loaded reservoirs are safe and meet Design Agency specifications. These include pinch weld evaluation; gas fill validation; fill stem trimming and polishing; leak detection; laser marking; surface defect inspection; and, in some cases, assembly of the reservoirs to squib valves, which are designed to release the gas in the weapon.
- **Packaging:** After reservoirs have been inspected and formally certified as acceptable for use in the weapon, they are packaged for shipment. The shipping packages used for tritium reservoirs are specifically designed to contain tritium in the event of a worst-case accident, and are periodically re-verified as acceptable for transportation.

Nuclear Stockpile Evaluation

In the absence of nuclear weapons testing, designers must rely on surveillance data to certify the reliability of U.S. nuclear weapons. Samples of nuclear weapons are removed from the stockpile, and their gas transfer systems are sent to SRTE for testing.

- **Function testing:** These tests provide confidence that the tritium gas delivery system will function properly should the weapon be used.
- **Environmental Conditioning:** The gas transfer systems may be subjected to one or more steps that simulate conditions potentially experienced during use, such as temperature extremes, vibration, acceleration, and dynamic shock.
- **Burst testing:** Metallographic evaluation and/or burst testing is performed to obtain valuable information about reservoir integrity, leading to safer designs.
- **Material characterization:** Studies are performed for different specimens of materials to document the effect of tritium on each material's physical properties.
- **Life storage:** Samples of reservoirs that had been loaded at least one year before the oldest reservoir of each type in the stockpile are kept in life storage to study the effects of aging. Some are subjected to elevated temperatures to accelerate the rate of tritium permeation into the reservoir body ("accelerated aging"). Life storage operations help to ensure the integrity of tritium-loaded reservoirs in the field.

Helium-3 Recovery

Helium-3, which is formed when tritium undergoes radioactive decay, is a precious commodity, valued between $2,000 and $2,500 per liter. SRS is the sole source of helium-3 gas in the United States because this is the only place in the Western world with the capability and expertise to recover, purify, and bottle this valuable gas. Its unique properties make it useful for several applications:

- It is particularly useful in neutron detectors used by the Department of Homeland Security at ports and border crossings to deter smuggling of nuclear materials.
- It is used to generate the coldest temperatures on earth, giving it unique value in scientific research.
- It is used for oil exploration, placing a neutron source and a He-3 neutron detector in exploratory wells to map formations containing oil, gas, and water.
- It can be used in medical imaging, since it is non-toxic and is not absorbed by the body.
- It is used in fusion research for future power sources.

Helium-3 recovery operations in SRTE

Research and Development

Technology plays a key role in the achievement of SRTE's missions — a role that will become even more essential as the NNSA moves toward a smaller, safer, more secure and less expensive Nuclear Security Enterprise. SRTE's facilities provide a capability not available anywhere else to safely perform research and development involving large quantities of tritium.

To assure that NNSA's tritium missions are being well-served by research and development (R&D) initiatives, SRTE established a strategic Tritium R&D Steering Committee made up of senior management from the SRS Tritium Facilities, SRNL, and NNSA's nuclear security laboratories (Sandia National Laboratory and Los Alamos National Laboratory). The committee strengthens and coordinates the partnership among these entities to ensure the right R&D is being performed at the right time to assure mission success.

SRNL has been deeply integrated into the tritium missions since the site's early days. As a result of this integration, the laboratory provides leadership in research involving tritium processes, development of innovative new technologies, and support for the national security laboratories' GTS design and certification mission. SRNL enables SRTE to play a key role in the development of new reservoir designs by working with weapon designers to evaluate early designs using tritium to determine aging effects and ability to manufacture.

SRNL also provides valuable day-to-day support for tritium operations. In addition to ongoing activities, such as material characterization and life storage studies, SRNL participates in addressing emergent issues, such as corrosion, contamination, or other unexpected phenomena. Some of these issues could have the potential to cause extended facility shutdowns if not successfully addressed.

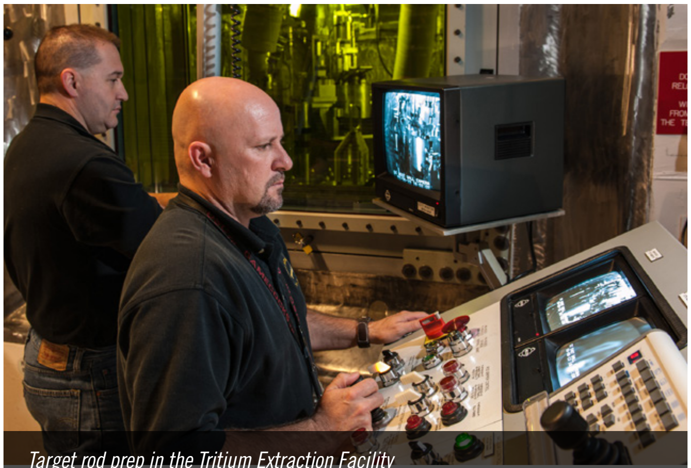
Much of SRNL's research and development applies 21st century advances to improve efficiency and reduce costs to match current tritium demands. Among these are a streamlined process for separating tritium from less valuable hydrogen isotopes; improved hydride technology for storing hydrogen; and a new process for making used hydrides safe for disposal. Many of their developments have been additionally deployed at other NNSA facilities, or in industry. *(continued)*

Aerial of the tritium facilities at the Savannah River Site

Facilities

Four process facilities are currently used to execute the Tritium missions. One is a Cold War-legacy facility built in the 1950s. The other three are modern facilities that utilize advanced technologies that have been developed over the years to greatly reduce cost, footprint, and the amount of tritium released to the environment.

- **H Area Old Manufacturing (HAOM) Facility:** The HAOM Facility, the largest and oldest process facility in the Tritium area, houses the assembly, inspection, and packaging processes. It has been expanded twice in its long history, most recently in 1984. Plans are underway for its replacement.
- **Tritium Extraction Facility (TEF):** TEF, which began operations in 2006, is where tritium is extracted from irradiated TPBARs.
- **H Area New Manufacturing (HANM) Facility:** The HANM facility was built in 1994, with space for potential future needs. Relocation of functions here allowed the deactivation of the 1955 Tritium Manufacturing Facility. In 2012, the Helium-3 recovery function was also relocated here from a stand-alone facility that had been operating for over 40 years. Other functions housed here include reservoir unloading, gas processing, reservoir loading, and gas transfer system surveillance.
- **Materials Testing Facility (MTF):** The MTF, built in 2004, houses laboratory functions relocated from the old Tritium Manufacturing Facility, including the life storage program and various metallurgical analysis capabilities.



Target rod prep in the Tritium Extraction Facility

Preparing for the Future

The 2018 Nuclear Posture Review noted that the U.S. needs both a marked increase in the production of tritium, as well as the recapitalization of the NNSA's nuclear weapons complex of laboratories and plants. SRTE is implementing plans to address both of those needs.

Increased Production Period

TEF is preparing to ramp up the number of annual tritium extractions to provide new tritium for the U.S. stockpile. After years in which TEF was only needed to conduct a single yearly extraction, in 2017 the facility performed three extractions. In 2019, personnel qualified and started up a second furnace in TEF, giving the facility two qualified furnaces for use in the extraction process. Over the next few years, SRTE will continue to increase the number of extractions, reaching eight per year in FY26.

At the same time that TEF is seeing this increased production, SRTE's other facilities are also in a period of increased production and recapitalization to meet vital national needs.

Strategic Reinvestment Period and Future Facilities

Both long-range and nearer-term measures are being undertaken to ensure that SRTE's facilities remain able to carry out their important missions.

A new Tritium Finishing Facility (TFF), to house functions currently in the 1950s-era HAOM, is in the works. The conceptual design, cost range, and schedule range have been approved. Preliminary design has begun, and early phases of construction are scheduled to start in 2021, with the facility expected to come on-line in FY31.

In the meantime, SRTE is initiating a Strategic Reinvestment Period (SRP) in early 2020 to ensure that TEF and HANM can continue to fulfill their missions successfully, and that HAOM can continue to meet out-year mission requirements until the TFF is brought online. This SRP will culminate in HANM revitalization projects in FY25 and FY27, with new equipment being installed while the old equipment continues to run to minimize system downtime and allow commitments to be met. Other elements of the SRP will include: upgrades to the HAOM HVAC system that began in FY20, TEF increased capacity and recapitalization, and an expansion of the Materials Test Facility.