Savannah River Tritium Enterprise

Background


The Tritium Extraction Facility began operating in 2007.

"Savannah River Tritium Enterprise" (SRTE) is the collective term for the facilities, people, expertise, and activities at SRS related to tritium, an isotope of hydrogen and a key component of nuclear weapons. SRTE's primary facilities occupy approximately 29 acres in the northwest portion of the Savannah River Site (SRS) H Area with additional laboratories in the Savannah River National Laboratory's facilities. Operations began in 1955. Currently operated by Savannah River Nuclear Solutions, LLC (SRNS), for the National Nuclear Security Administration (NNSA), SRTE is a key element in the U.S. Nuclear Security Enterprise (NSE), which is responsible for maintaining a safe and reliable nuclear stockpile. 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 is committed to continued excellence in the execution of four 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. This is accomplished by recycling tritium from existing warheads and by extracting tritium from target rods irradiated in nuclear reactors that are operated by the Tennessee Valley Authority (TVA). SRTE recycles, extracts and purifies gases to produce tritium that is suitable for use.
- *Nuclear Stockpile Maintenance* – SRTE helps to maintain the U.S. nuclear stockpile by replenishing gas transfer systems, which ensure the performance of nuclear weapons. War reserve reservoirs (stainless steel containers that meet rigorous quality specifications) are loaded with a mixture of tritium and deuterium (T_2/D_2) or an inert gas, finished, assembled, inspected, and packaged for shipment.

- *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 active stockpile, and their gas transfer systems are sent to SRTE for function testing. These tests ensure that the tritium gas delivery system will function properly should the weapon be used. Prior to or during function testing, the gas transfer systems may be subjected to one or more conditioning steps that simulate forces potentially experienced during use. Metallographic evaluation and/or burst testing are performed following the function test to obtain valuable information about reservoir integrity, leading to safer designs.
- *Helium-3 Recovery* – Tritium radioactively decays to helium-3, which has become a precious commodity. One reason for the tremendous growth in demand for helium-3 is its use in neutron detection equipment that is being installed all over the world to protect our nation and its allies from terrorism. SRTE recovers, purifies, and bottles this valuable byproduct of tritium, and is the sole source of helium-3 gas in the United States.

Facilities

Five process facilities are currently used to execute the Tritium missions. Two of these are Cold War-legacy facilities that were built in the 1950s and 1960s. The other three are modern facilities which utilize advanced technologies that have been developed over the years to greatly reduce cost, footprint, and the amount of tritium released to the environment. Tritium processing involves a number of key operations.

Tritium Extraction Facility (TEF) TEF provides the capability to extract tritium from Tritium-Producing Burnable Absorber Rods (TPBARs) that are irradiated in commercial light water reactors by TVA. The first extraction of tritium was successfully completed in January 2007. The size of the U.S. nuclear weapons stockpile has been greatly reduced since TEF was designed, which means the required tritium supply can be met via recycling of gas from unloaded reservoirs. This led SRS to develop its cost-effective "TEF Responsive Operations" strategy. Cross-trained personnel from other facilities are utilized to conduct one extraction per year, thereby maintaining facility readiness and extraction capability. This strategy saves the government $12 million per year.

An SRTE employee performs work in the Materials Testing Facility.

TEF consists of three major structures:

- **Remote Handling Building (RHB)**: In the RHB, the TPBARs are unloaded and the tritium gas is extracted. The RHB has a truck receiving area, cask decontamination area, TPBAR and waste preparation area, furnaces, and hot maintenance area, along with the associated gloveboxes for extraction pumps and tanks. It also includes an overhead crane and remote handling equipment.

- **Tritium Processing Building (TPB):** The TPB provides preliminary purification of the extracted gases. It houses the main control room, crane control room and miscellaneous rooms for gas analysis and radiation control activities.
- **Tritium Support Building (TSB)**: The TSB houses management and support staff, as well as change rooms, maintenance support areas and a loading dock.

Employees perform work in the H Area New Manufacturing Facility.

H Area New Manufacturing (HANM) Facility The design of the HANM facility, which was built in 1994, included space for potential future needs. In 2004, a project was completed that consolidated most of the remaining functions from the old (1955) Tritium Manufacturing Facility, allowing the old facility to be deactivated and placed in a cost-effective, long-term surveillance and maintenance mode. The HANM facility currently provides the following capabilities:

- **Reservoir unloading**: Gases are removed from returned reservoirs using a laser that is mounted on a mobile base and housed in its own secure enclosure. Operators use an alignment laser in back of the cutting laser, in conjunction with a video monitor, to ensure the cutting beam's alignment. The cutting laser beam is directed through a prism, and then passes through a series of containment windows before striking the stem of the reservoir. A series of pinpoint firings cut a hole in the stem of the reservoir, allowing gas to expand into the receiving tank.
- **Gas processing**: Reservoirs returned from the Department of Defense contain three gases: the remaining tritium, nonradioactive deuterium and helium-3 (the gas that forms when tritium decays). The three-component gas is pumped through a hydride bed to separate the helium-3 from the hydrogen isotopes. The separated tritium/deuterium (T_2/D_2) gas is transferred to storage beds that occupy about 1/300th of the space required by conventional gas storage tanks. To be useful, the T_2/D_2 must also be separated. A Thermal Cycling Absorption Process (TCAP) accomplishes this separation. The gas is cycled through a TCAP column using specific operating parameters. The two isotopes are drawn off separate ends of the column and fed into separate storage beds.
- **Reservoir loading**: Before loading into the reservoirs, T_2 and D_2 are mixed to an exact ratio. A mass spectrometer verifies that each tank contains the required mix for its intended reservoir. The blended isotopes are fed into an oil-free mechanical compressor system that compresses the gas to achieve the proper loading pressure. When each reservoir is loaded to the correct pressure, its fill stem is pinched closed using electrodes, and the stem is resistance-welded. This completely seals the gas into the reservoir, and the seal weld is inspected using non-destructive methods.
- **Gas transfer system surveillance**: As part of the nuclear weapons stockpile surveillance program, selected gas transfer systems (including reservoirs) are removed from the active stockpile and sent to SRTE for function testing. In these tests, a squib valve fires to open a hole in the reservoir fill stem, and surveillance specialists verify that the fill gas is delivered as expected. Prior to or during function testing, the gas transfer systems may be subjected to one or more conditioning steps that simulate forces potentially experienced during use, such as thermal extremes, vibration, acceleration and dynamic shock. Savannah River National Laboratory personnel provide essential support to these operations, including post function testing data analysis and report generation.

- **Helium-3 recovery**: In 2012,a new system for separating and capturing helium-3 was started up in HANM, relocating this important function from a stand-alone facility that had been operating for over 40 years. The relocation of this important function into a modern facility has paved the way for the deactivation and eventual retirement of the original facility. By-product gas is composed of helium-3, nitrogen, inert gases and traces of hydrogen isotopes.

H Area Old Manufacturing (HAOM) Facility The HAOM Facility has been expanded twice in its long history, most recently in 1984. At over 61,000 ft.^{2}, HAOM is the largest process facility in the Tritium area. The HAOM facility currently provides the following capabilities:

- **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, polishing, deburring and gauging; tritium leak rate measurement; 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.
- **Inert reservoir processing**: Some reservoirs require filling with gases other than tritium, such as argon. Because these “inert” gases are non-radioactive, they are processed in clean areas, separate from the tritium reservoirs.
- **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 recertified as acceptable for transportation in the HAOM Facility.

Materials Testing Facility (MTF) MTF, an 8,400 ft.^{2} laboratory facility, was built in 2004 as part of the same project that consolidated functions from the 1955 Tritium Manufacturing Facility into the HANM Facility. It provides the following capabilities, which are conducted primarily by Savannah River National Laboratory personnel:

- **Material characterization**: Studies are performed for different tritium-exposed specimens (e.g., metal hydrides, getter materials, polymers), to include physical properties data collection and metallographic examination.
- **Life storage**: Samples of reservoirs that are loaded at least one year in advance of 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.

Reservoir Reclamation Facility The Reservoir Reclamation Facility was a tremendous cost saver when it began operations in 1969, “paying for itself” within six months by enabling tritium reservoirs that were returned from the field to be reclaimed and reused instead of relying on new-built reservoirs. This facility currently provides two capabilities:

- **Reservoir reclamation**: Following unloading in the HANM Facility, some tritium reservoirs are sent to the facility, where their old pinch welded fill stems are removed and new fill stems are welded in place.
- **Burst testing**: As part of reservoir surveillance operations, some reservoirs are hydroburst tested to determine burst pressure and failure modes, providing valuable information about reservoir integrity.

Tritium Responsive Infrastructure Modifications (TRIM)

The TRIM Program is SRS' strategy to drive efficiency and revitalize the Tritium facilities for ongoing and new missions by FY2022. The two primary goals of the TRIM Program are to:

- Right-size and consolidate the SRTE production processes in the more modern facilities, while inserting new technology as applicable and appropriate
- Reduce the cost of operations and business processes within the SRTE

TRIM Program objectives include:

- Centralizing control of all Tritium operations in the HANM Facility (complete)
- Retiring the Helium-3 Recovery Facility (complete)
- Retiring the Reservoir Reclamation Facility
- Retiring the HAOM Facility

The TRIM Program is well-aligned with NNSA's Key Strategic Goals:

- Modernize the NNSA Infrastructure
- Strengthen the science, technology and engineering base
- Drive an integrated and effective Enterprise

Research and Development

The Savannah River National Laboratory (SRNL) has been deeply integrated with the other functions in SRTE since the earliest days, when both the laboratory and the Savannah River Site tritium enterprise were known by other names, As a result of this integration, the Laboratory provides leadership in research involving tritium applications, development of innovative new technologies, and valuable day-to-day support. Some SRNL researchers are based in SRTE facilities, with SRTE projects as their primary occupation. Other SRNL personnel also support other customers, further advancing SRTE's knowledge base through their participation in related projects

SRTE's facilities, in addition to supporting the nation's defense activities, provide a capability not available anywhere else to safely perform research and development involving large quantities of tritium.

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.

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 manufacturability. The Laboratory also performs research on hydride materials used for storing and handling tritium to predict and improve future plant operation.

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. Much of SRNL's research and development on behalf of SRTE 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 in solid form; 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.