Timeline for Cold War-era tritium production at Savannah River Plant (SRP, later Savannah River Site, SRS) (1950 – 1996)

Peter Lobner, 12 January 2020

The Savannah River Plant (SRP) was designed in 1950 primarily for a military mission to produce tritium, and secondarily to produce plutonium and other special nuclear materials, including Pu-238. Five dedicated production reactors were built at the SRP and began operation between 1953 and 1955: the R reactor (prototype) and the later P, L, K and C reactors. In 1955, the original maximum power of C Reactor was 378 MWt. With ongoing system improvements, C Reactor was operating at 2,575 MWt in 1960, and eventually reached a peak power of 2,915 MWt in 1967. The other SRP production reactors received similar system improvements. The increased reactor power levels greatly increased the tritium production capability at SRP.

The SRS reactors are described in detail in "The Savannah River Site at Fifty (1950 – 2000), Chapter 13, which is available at the following link: https://www.srs.gov/general/about/50anniv/Chapter%2013.pdf

In 1980, SRP was renamed Savannah River Site (SRS). SRS provided most of the tritium and a large percentage of the plutonium needed for the U.S. nuclear weapons program from 1953 through 1988. The prototype R Reactor was shutdown in 1964. The other four production reactors were shutdown between 1985 and 1988 after operating lives of about 30 years.

1950:

- Early 1950: The decision was made to build a new nuclear facility for tritium and plutonium production at a site to be selected.
- 25 July 1950: Letter from President Harry Truman requested DuPont's involvement in this new facility.
- 1 August 1950: Contract signed between the Atomic Energy Commission (AEC) & DuPont for construction and operation of the new facility.

- December 1950: Argonne Lab proposed the conceptual design for the production reactors. Argonne favored a heavy water reactor based on their operational experience with small heavy water reactors (i.e., CP-3 and ZPR-II) and the design of the larger CP-5. Argonne's conceptual production reactor design, designated CP-6, was accepted by the AEC and DuPont.
- 28 November 1950: Selection of the site at Savannah River was announced.

1951: Major construction was underway at Savannah River.

1952: Two heavy water (deuterium oxide, D_2O) production plants started operation in 1952 using the Girdler Sulfide (GS) dual-temperature fractional distillation process of hydrogen sulfide-water exchange to produce heavy water, which would be the coolant and moderator for the SRP production reactors that were under construction

- August 1952: After a failed startup attempt during the winter of 1951/52, the heavy water plant in Dana, Indiana started operation.
- October 1952: The Heavy Water Plant in SRP D Area started operation with the first of 24 GS units in October 1952.

SRP GS heavy water plant. Source: M. Ragheb, "Isotopic Separation and Enrichment," Jan 2007

1953:

- May 1953: All GS units at both heavy water plants (Dana and SRP) were operational.
- Spring 1953: A small plant was constructed in D Area to produce deuterium gas from heavy water by electrolysis.
    - Some deuterium would be used at the SRP Tritium facility where the tritium reservoirs for nuclear weapons were filled with a precise mixture of tritium and deuterium.
    - Some deuterium was sent to the Oak Ridge to be converted to the lithium deuteride for use in the secondary assemblies of thermonuclear weapons.
- Lithium target slugs manufactured at Oak Ridge Y-12 were shipped to SRP Building 320-M where they were cast into billets and manufactured into lithium-aluminum control rods for the SRP production reactors.
- Fall 1953: R Reactor (the SRP production reactor prototype) achieved initial criticality. It originally had a maximum power of 375 MWt. Near the end of its first fuel cycle, R Reactor was operating at about 640 MWt.

1954:

- P Reactor, L Reactor and K Reactor achieved initial criticality.

L Reactor. Source: The National Security Archives, The George Washington University

- June 1954: The first irradiated fuel and targets were discharged from R reactor. At this time, the lithium-aluminum alloy target rods ("producer rods") were used only in the septifoil (7-chambered) control rods in combination with cadmium neutron poison rods. Tritium production during this period was actually a byproduct of polonium production, which was done in septifoil (4-chambered) driver fuel and target assemblies.
- A second, larger deuterium plant was constructed in D-Area.

1955:

- First use of enriched uranium (5% U^{235}) "driver" fuel elements, with a quatrefoil (4-chambered) cross-section containing lithium-aluminum targets.
    - Quatrefoil elements improved tritium production.
    - Septifoil (7-chambered) lithium-aluminum control rods were still used.
- C Reactor achieved initial criticality in early 1955 with an original maximum power of 378 MWt.
- All five production reactors were operational in March 1955.
- October 1955: The first permanent tritium extraction and purification facility, Building 232-F in F Area, became operational.
    - The target slugs were melted to release gaseous tritium.
    - After melting, the tritium was purified by a process known as thermal diffusion.

The original SRP tritium extraction facility, Building 232-F. Source: SRS Archives

- Late 1955: The first shipment of tritium was made to the Atomic Energy Commission (AEC) for placement in reservoirs for nuclear weapons.

1956:

- A second tritium extraction and purification facility, Building 232-H, was built in H Area and became operational in late 1956. Today, this facility remains in operation and is known as the H Area Old Manufacturing (HAOM) Facility.

1956 – 1964: Reactor power level was incrementally increased as reactor and cooling system design and operating changes were implemented.

- For example, C Reactor rated power levels were: 378 MWt (early 1955), 877 MWt (Dec 1955), about 1,400 MWt (1956), 2,250 MWt (1957), 2,575 MWt (1960), and peaked at 2,915 MWt (1967).
- Design and operating changes that enabled this dramatic increase in power level included the following:
    - Higher fuel slug surface temperature was permitted with no cladding damage (1956).
    - Additional primary coolant heat exchangers were installed to handle the greater heat load (1956).
    - Reactor coolant flow distribution was optimized (1956).
    - Higher-capacity heavy water circulating pumps were installed to provide better heat transfer from the reactor core (1957).
    - Par Pond was built to serve as a water source for R and P Reactors, allowing a greater supply of river water for the other three reactors (1958).
    - Larger capacity river water pump impellers and additional pumps at Par Pond were installed to increase secondary coolant flow (1960).
    - Reactor tank (primary system) pressure was increased by 5 psi to increase thermal margin (1963 – 1964)

1957:

- A sufficient stockpile of heavy water had been accumulated.
    - Production at the Heavy Water Plant in D-Area was reduced by 2/3, mostly for reconcentrating heavy water that had become diluted during operation.
    - The Dana heavy water plant in Indiana was closed. During its five years of operation, the Dana plant produced 1,200 to 1,500 tons of heavy water.
- The production of solid target slugs ended late in 1957 after tubular targets had been introduced.

1958:

- Tritium recycling began at Building 232-H in August 1958.
- The original tritium extraction process line in Building 232-F was closed in the autumn of 1958. The building was dismantled in 1994 to 1997.

1958 to 1963: R, P, L, K and C reactors were operating and producing tritium and other nuclear products.

1963: High-efficiency filters were installed in all reactor building ventilation systems to remove particulates, and charcoal beds were installed to remove radioiodine in the exhaust airflow.

1964: R Reactor was shut down due to lack of demand. It was never restarted.

1968: L Reactor was shut down for upgrades. It was not restarted for 17 years.

Late 1960s: The Building 238-H Reclamation Facility began operation, enabling reuse of some tritium reservoirs from nuclear weapons.

1970s: P, K and C Reactors were operating and producing tritium and other nuclear products.

1982: The remaining part of the Heavy Water Plant in D Area was shutdown in January 1982. During its 30 years of operation, the D Area plant produced over 6,000 tons of heavy water.

1985:

- L Reactor was restarted after being shut down for 17 years, since 1968.
- C Reactor was shut down and never restarted, likely due to cracks detected in primary system components.

1986: Construction of the Replacement Tritium Facility began.

1988: K, L and P Reactors were shut down and maintained for possible restart.

1989: Savannah River Plant (SRP) was renamed Savannah River Site (SRS) on 1 April, 1989. Westinghouse Savannah River Company took over from DuPont as the operating contractor.

1990: In May, Secretary of Energy James Watkins announced that K Reactor would be returned to service by December 1990, and that P and L Reactors would follow in March and September of 1991.

- These plans were delayed and revised to comply with South Carolina water quality standards and Consent Orders that required thermal mitigation for all reactors and other facilities.
- A cooling tower was required for any reactor being restarted.

1990 - 1992:

- A cooling tower was built for K Reactor.
- P Reactor was permanently shut down in February 1991.

K Reactor with its new cooling tower, circa 1993. Vogtle nuclear power plant cooling towers are visible on the left horizon. Source: SRS Archives, negative 93-1340-17.

1992:

- K Reactor was operated briefly, and for the last time, on 8 June 1992, with the cooling system connected to a new cooling tower.
- Non-radioactive operations began at the Replacement Tritium Facility.

1993:

- L Reactor was permanently shut down in April 1991.
- K Reactor was placed in “cold-standby”, but with no planned provision for restart as the Nation's last remaining source of new tritium production.
- Later in the year, R, P, L, and C Reactors were declared “excess” by DOE, with no further production mission.
- Tritium was introduced into the Replacement Tritium Facility and preliminary radioactive operations began.

1994: The Replacement Tritium Facility, now known as the H Area New Manufacturing (HANM) Facility, began production operation, and continues in operation today.

1995: The Heavy Water Plant in D-Area was dismantled.

1996:

- K Reactor was placed in shutdown condition and never restarted. It was later reconfigured as the K Area Complex (KAC) for the handling and interim storage of our nation’s excess plutonium and other special nuclear materials (SNM).
- The L Reactor was reconfigured as the L Area Complex (LAC), which provides underwater storage of spent nuclear fuel from a variety of domestic and international research reactors.