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The APT Facility at SRS

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1.0 Introduction

In order to meet US tritium needs to maintain the nuclear weapons deterrent, the Department of Energy (DOE) is pursuing a dual track program to provide a new tritium source. A record of decision is planned for late in 1998 to select either the Accelerator Production of Tritium (APT) or the Commercial Light Water Reactor (CLWR) as the technology for new tritium production in the next century. To support this decision, an APT Project was undertaken to develop an accelerator design capable of producing 3 kg of tritium per year by 2007. The Los Alamos National Laboratory (LANL) was selected to lead this effort with Burns and Roe Enterprises, Inc. (BREI) / General Atomics (GA) as the prime contractor for design, construction, and commissioning of the facility. If chosen in the downselect, the facility will be built at the Savannah River Site (SRS) and operated by the SRS Maintenance and Operations (M&O) contractor, the Westinghouse Savannah River Company (WSRC), with long-term technology support from LANL. These three organizations (LANL, BREI/GA, and WSRC) are working together under the direction of the APT National Project Office, which reports directly to the DOE Office of Accelerator Production which has program authority and responsibility for the APT Project. This paper will briefly describe the APT facility, and then summarize preparation activities at SRS for APT.

2.0 Description of APT

The APT, which is shown schematically in Figure 1, is made up of four major subsystems which are described briefly below.

Fig. 1 APT Plant Layout

2.1 Accelerator System

The Accelerator System is based on a linear accelerator (Linac) design with the following subsystems:

- Proton injector to develop and maintain a continuous 100-mA current.
- Radio Frequency Quadrupole (RFQ) to focus and accelerate the proton beam to 7 MeV (kinetic energy).
- Coupled-cavity drift-tube Linac (CCDTL) to increase the proton beam energy to 100 MeV.
- Coupled-cavity Linac (CCL) to accelerate the proton beam to 211 MeV.

- Superconducting Linac (SCL) to accelerate the proton beam to its final energy of 1700MeV.
- High Energy Beam Transport (HEBT) to direct the beam to the Target/Blanket (T/B) beam expander.

The design is modular so that the portion of the accelerator up to 1030 MeV can be completed in stages to allow for changes in production goals.

2.2 Target/Blanket (T/B) System

The Accelerator System provides a proton beam which is expanded and directed to a T/B assembly shown in Figure 2. The T/B assembly consists of a tungsten clad neutron target surrounded by a blanket in which additional neutrons are produced in lead. The neutrons are thermalized by collisions in the lead and in light-water and are subsequently captured in He-3 to produce tritium.

Fig. 2 Target/Blanket Building

2.3 Tritium Separation Facility (TSF)

The TSF operates by extracting tritium from a tritium, hydrogen and He-3 mixture returned from the T/B System in a recirculating He-3 loop. The He-3, hydrogen and tritium mixture also contains impurities such as water, methane, ammonia and small quantities of radioactive material. Hydrogen isotopes are separated from the He-3 and sent to an Isotope Separation System where the tritium is separated from hydrogen. The He-3 is purified and recycled to the T/B assembly.

2.4 Balance of Plant (BOP) Systems

The BOP Systems support the integrated operation of the accelerator, T/B, and TSF, and provide the facility buildings that house them. The BOP System designs are driven by the required electric power input, the generated waste heat to be removed throughout each facility and the need to handle radioactive materials remotely.

3.0 Implementation of ISM

In order to insure safe, reliable, low risk and cost effective operation of the design, Integrated Safety Management (ISM) principles are being applied from the beginning of the project. These principles (line management responsibility for safety; clear roles and responsibilities; competence commensurate with responsibilities; balanced priorities; identification of safety standards and requirements; hazard controls tailored to the work; operations authorization; and involvement) are central to the cost-effective integration of safety into every aspect of design, construction and operation of the project and facility. Safety goals are being captured and integrated into the project/facility operational procedures and the technical baseline documentation.

4.0 Environmental Program

The APT project has taken an aggressive approach by implementing an environmental program early in the design process, where most pollution and environmental provisions can be designed in. Most of this is being done on a voluntary basis by the Project and will result in environmental releases well below any regulatory concern. In this way, many of the mandatory permitting requirements are either eliminated completely or are vastly simplified. Pollution Prevention (PP) principles are serving as the `common thread' for implementation of the APT Environmental Program.

Based on a complete evaluation of environmental impacts, the following conclusions are documented in the EIS (Environmental Impact Statement) for APT:

- Impacts of APT on air, surface water, land, plant/animal life, and groundwater are far below all regulatory limits/guidelines and within SRS norms for workers and the public.
- In most cases <5% impact on SRS infrastructure such as traffic, roads, utilities (except electric power), and waste storage, treatment disposal facilities.

A site selection process that carefully avoided impingements on ecologically sensitive areas was utilitied to select the preferred site. In addition, APT wastes have been carefully characterized and are manageable. The majority of the waste can be disposed in existing facilities at SRS.

5.0 O&M Design Support

Participation in the design process by SRS staff knowledgeable in the conduct of O&M ensures that the design will meet the SRS site standards for Conduct of Operation and Conduct of Maintenance. In addition, it will result in a design which will be easier and more cost effective to operate and maintain, provide early indication of opportunities to improve these site standards to better accommodate the new accelerator technologies, and provide an early training opportunity.

Experienced O&M personnel provide input to trade studies and Reliability, Availability, Maintainability, and Inspectability (RAMI) analysis. The O&M group has incorporated key SRS site practices and lessons learned from accelerator and other nuclear operations into a comprehensive set of O&M Requirements for use by the design teams. O&M personnel also participate on numerous working group teams focused at specific design needs. One of these, the O&M Working Group, which has experienced O&M members from throughout the APT team, focuses on all aspects of operating strategy from design input through start-up planning, training and procedures. Finally as the design evolves, O&M personnel will continue to visit, and become familiar with, other operating accelerator facilities to ensure O&M planning is reflected in the design and that lessons learned are fully understood and incorporated.

The O&M group is also responsible for developing staffing and training plans for eventual operation of the facility. A variety of variables must be evaluated, with RAMI as the key factor. Maintenance philosophy is also very important. Some accelerator facilities continue to operate with short outages for minor repairs until a major maintenance requirement forces the facility to shut down. Other accelerator facilities have an effective predictive maintenance program and routine outages for repairs in hopes that an unexpected major shutdown is avoidable. As part of this process, SRS has developed detailed changeout procedures including timing for several of the major scheduled maintenance operations. Since this is a production facility with a predetermined deliverable, it must attain its stated nameplate availability. Based on an evaluation of all these variables and reviewing staffing at other accelerator facilities, the O&M organization will determine an adequate staffing level. In addition, a training plan will be developed to qualify operators and maintenance personnel.

6.0 Infrastructure

The APT site infrastructure support includes: road and rail access; Domestic Water; Sanitary Sewer; Process Water; temporary power; telecommunications, and preparations for full power operation. Designs for modifications to these systems have been developed. These will support both the temporary construction and permanent plant operational needs.

Providing for the electrical requirements for the APT has encompassed two areas of concern. First, the APT's interface to the SRS electrical grid had to be examined to ascertain if the gird could support a load of the magnitude of the APT (400 to 500 MW). Secondly, the electricity must be procured at a reasonable cost from an assured supply.

The Savannah River Site is tied to the South Carolina Electric and Gas (SCE&G) utility system through three 115kv tie lines. Also crossing the plant are two SCE&G 230kv lines as pictured in Figure 3. A 2400 MW nuclear generating station is located in close proximity to SRS. A study conducted by SCE&G and General Electric was completed in 9/96 which determined that the grid would support the APT loads and would only require minor modifications to meet load flow and voltage stability requirements.

Figure 3. SRS Electrical Interface

Preliminary load forecasts were completed in late 1996 which determined a peak load of 500Mw for the 3kg accelerator. Exeter Associates was contracted to analyze electrical market forecasts and the interest of open market suppliers to provide power for the APT. This study which was issued in October of 1996 projected that electricity could be procured for an estimated cost of $25/MWhr from an open market rate. Subsequently, negotiations with SCE&G have resulted in a MOU that was signed 5/98, which documents a commitment by SCE&G to provide marketing services for the APT to allow it to have access to low priced market based electricity.

7.0 Core Competence

As the APT operator, WSRC must master the technologies necessary for reliable operation; cryogenics; rf power and control; vacuum system; beam diagnostics; and accelerator physics, to name a few. Limited or no experience in these areas exists now at SRS. To develop these capabilities, a three-phased approach has been adopted. In Phase 1, which will continue until the decision on tritium production technology is made, WSRC personnel will be placed in the design and prototyping teams at LANL and the prime contractor. This supports these efforts and begins the acquisition of technology. More than twenty SRS personnel are now assigned to LANL, with a major portion of these personnel assigned to support the development of the Low Energy Demonstration Accelerator (LEDA), the prototype of the APT Linac up to 20 MeV. SRS personnel are assigned to each of the major design authority areas with senior SRS personnel assigned the Lead for TSF and the BOP.

In addition, SRS is providing direct support to several of the ED&D (Engineering Development & Demonstration) program through the involvement of the Savannah River Technology Center (SRTC). Foremost of these is the support of APT Materials Program where SRTC has provided strong leadership in formulating the Program and has fabricated many of the test modules for irradiation in the LANL accelerator facility (LANSCE). SRTC is also supporting the development of remote handling techniques for T/B components and the optimization of tritium processing and handling technologies for APT applications. In addition, SRTC and the Westinghouse Safety management Solutions (WSMS), a subsidiary of WSRC, are providing extensive support in safety analysis and preparation of the Preliminary Safety Analysis Report.

In Phase 2, detailed plans will be developed for each of the key core competency areas and critical resources will be identified and capabilities established, either through selective hiring or through special training in addition to on-the-job experience. In Phase 3, these personnel will support the prime contractor in the completion of construction, startup, commissioning, and turnover of the facility. This strategy will build the well-trained and highly-experienced technical organization necessary to support all facets of the APT operation.

8.0 Conclusion

The Accelerator Production of Tritium project will bring exciting new technologies and opportunities to the Savannah River Site. Enthusiasm for this opportunity for continued service in support of national defense is high among contractor personnel, DOE staff and the surrounding communities, and all look forward to a favorable decision and an early start to construction.

Reference

1. "Accelerator Production of Tritium Conceptual Design Report", LA-UR-96-4847 (March, 1997).