TECHNOLOGY DEVELOPMENT FOR THE ACCELERATOR PRODUCTION OF TRITIUM*

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Abstract

The Engineering Development and Demonstration (ED&D) program for the Accelerator Production of Tritium (APT) project provides critical data necessary for a plant built on schedule and within budget. The ED&D program is based on prioritized design data needs, and is driven by a formal systems-engineering approach. This paper describes the current role of the project for the U.S. defense program, the ED&D process, the functional areas where ED&D activities are underway, key ED&D activities, and how the technical data from the ED&D program are used.

1 INTRODUCTION

The APT Core Technology Plan (CTP) [1] delineates a program of ED&D activities that support design and construction of the APT facility. The goal of the ED&D programs is to provide critical data necessary for the APT to be built on schedule, based on a demonstrated technical foundation and avoiding costly over design.

1.1 APT Named Backup Tritium Supply Option

On December 22, 1998, Secretary of Energy Bill Richardson announced that the commercial light-water reactor program will be the primary tritium supply option for the United States. The Secretary designated the APT as the "backup" technology for tritium supply. As such, APT will prepare a preliminary design package for the plant, and will complete the essential technology development to support that design. A reduced ED&D program is still necessary. Details of the modified program scope and schedule are still being evaluated by the Project.

1.2 APT ED&D Program Driven by DDNs

The ED&D activities are driven by formal, articulated Design Data Needs (DDNs). The DDNs are identified by the APT design team and transmitted to the APT Technology Office, where they are evaluated and prioritized. The evaluation criteria include several factors:

- Can reasonable extrapolations be made from existing data?
- Is a new measurement needed?
- Is it possible to provide the data within budget and time constraints?

In some cases, the result of this evaluation is to require a more conservative plant design to compensate for the unavailability of supporting data. When appropriate, a test program is then undertaken to provide the necessary data. This formalized, systems-engineering approach to evaluating the DDNs has led to the establishment of an extensive engineering development program aimed at reducing technical, as well as cost and schedule, uncertainties.

2 THE ED&D PROCESS

2.1 The Systems Engineering Approach

A systems-engineering approach, illustrated in Figure 1, identifies and resolves cost, scope, and technical risk issues related to design requirements.

APT program objectives are translated into goals, requirements, and functions that must be met by the design. During the design process, DDNs are identified by the relevant design leaders whenever the existing database is insufficient to fully support a design. At that time, an assumption is made, then confirmed or modified, based on the outcome of the ED&D program. If the completed design meets performance goals and adequate performance is achieved, the design process is complete. If the outcome of the ED&D activity does not support assumptions made earlier that were required to proceed with the design, the design must be modified and new DDNs must be formulated and addressed.

2.2 ED&D Activity Areas

There are four major areas where ED&D activities are underway:

- *The Low Energy Demonstration Accelerator (LEDA):* to fabricate and operate a linac that produces a high quality, ~10-MeV, 100-mA, continuous-wave proton beam.
- *High-energy RF linac technology:* to develop and test component prototypes for normal conducting and superconducting high-energy linac structures (cavities, cryomodules, power couplers, etc.). Included are activities in development and

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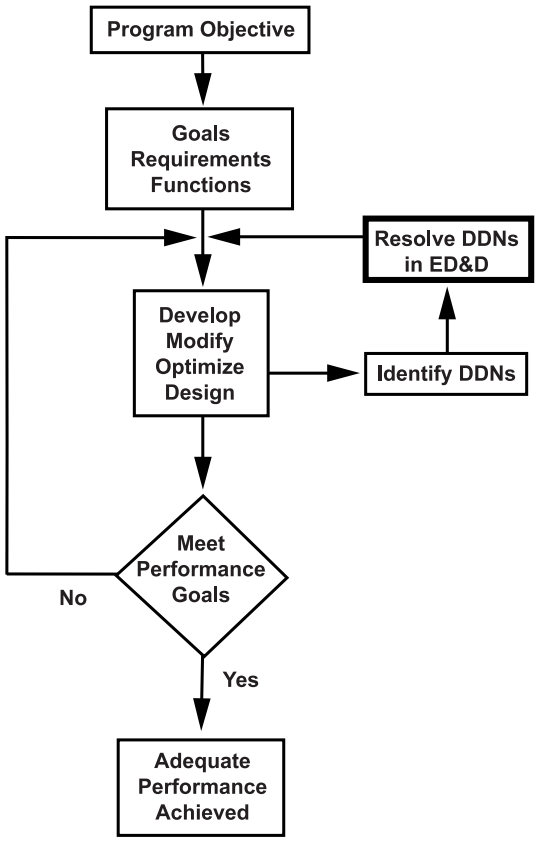

Figure 1. APT design approach

enhancement of RF power systems and high-energy beam transport components.

- *Target/Blanket (T/B) performance and Materials Studies*: including measurements of n/p and T/p; radiation damage effects from high-energy, high-flux proton and neutron irradiation; and radiation transport-code data development and/or enhancement.
- *Tritium Separation Facility (TSF) studies:* to determine tritium-processing and separation efficiencies under conditions expected in the APT plant.

2.3 Identified Key Activities

Key ED&D activities identified by the above process include:

- Demonstrate 100-mA proton beam at 100% duty cycle through the LEDA Radio Frequency Quadrupole (RFQ).
- Demonstrate 100-mA proton beam at 100% duty cycle through a Coupled Cavity Drift Tube Linac (CCDTL) section of LEDA to a final energy of ~10MeV.
- Determine proton/neutron irradiation effects on T/B materials.
- Develop and/or improve radiation transport codes and nuclear data libraries.
- Develop and confirm engineering design data for separating tritium from ^{3}He and hydrogen.
- Confirm five-cell β=0.64 superconducting cavity manufacturability and cavity performance; fabricate and test a cryomodule for the β=0.64 cavities.
- Confirm manufacturability and performance of the 210-kW coupler and RF window assembly for SC cavities.
- Determine performance, reliability, and failure modes of the new high-energy beam transport (HEBT) raster expander prototype.
- Determine performance and manufacturability of key RF distribution components, including waveguide switch, phase shifter, and waveguide valve.
- Determine performance and operability of beam diagnostics for measuring transverse intensity distribution in the linac and HEBT. Included are flying wire profile and gas fluorescence diagnostics.

3 ED&D PROGRAM RESULTS

The ED&D program provides technical data on the performance of all critical components of the APT facility.

3.1 Utilizing ED&D Program Data

ED&D data results will be compared with requirements given in the Preliminary Design Package (PDP) and the System Design Descriptions. These data will be utilized to establish confidence in the design, in the predicted plant availability, and to reduce cost when the data warrants design simplification. Thus, if at a later date the Department of Energy decides to build the APT plant, the facility will be built correctly the first time, on schedule, and without recourse to costly over-design. These results should also speed the commissioning process and ensure that full capacity production is attained on schedule.

3.2 Justifying the ED&D Program

The ED&D program is expected to provide the needed data within the projected schedule and resources. Specific schedules for delivery of data and descriptions of the needed data are contained in the DDNs. The total cost of the ED&D program is on the order of 10% of the project cost, and is considered a very good investment.

The ED&D will be judged a success when the data produced warrants design simplifications allowing reduction of design margins and cost. Present-day contingency estimates for the project greatly exceed 10% and it is expected that ED&D data will justify reduction of those contingencies by more than the cost of data production.

Even results that do not simplify the design or reduce cost are considered important and successful if they firmly establish performance, thus validating design and certifying cost within the existing contingencies.

Nevertheless, there is technical risk in some APT components that warrant careful attention. It is possible some results could be disappointing and may require design changes that increase cost moderately beyond the existing contingencies or cause moderate schedule slips.

4 CONCLUSION

With the Department of Energy's selection of the APT as the backup tritium supply option, the decision was made to carry the APT development to the stage that a PDP could be generated. To accomplish an adequate PDP, the technology development described in the CTP must be completed to support the preliminary design. While that means that not all of the identified ED&D activities will be completed, the essential technologies will be developed and tested to support the PDP. The CTP will be revised to reflect the changing scope required to support the PDP. The development of LEDA and the superconducting technologies continue to be major activities within the ED&D program. The current schedule calls for the ED&D activities to be completed by the end of Fiscal Year 2002.

5 REFERENCES

1. APT Core Technology Plan, Los Alamos National Laboratory Report, APT-CTP-002, August 2, 1997.