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Title: SAFETY OF SPALLATION SOURCES IN THE ACCELERATOR PRODUCTION OF TRITIUM

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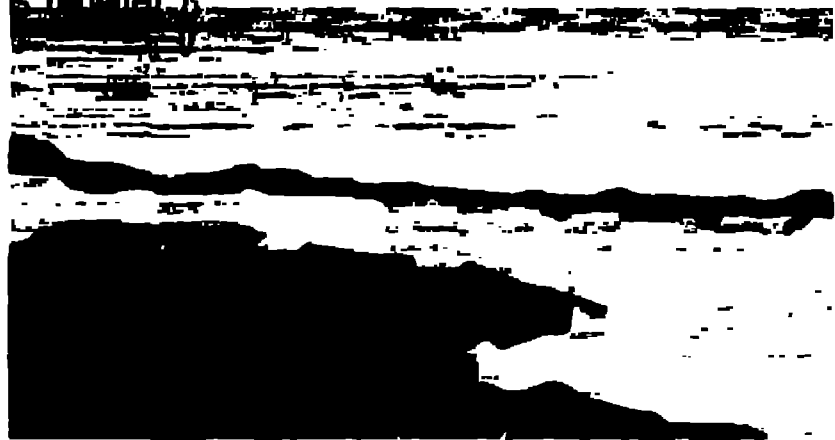
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**Safety of Spallation Sources in the Accelerator Production of Tritium**

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The Accelerator Production of Tritium (APT) project will employ a high power proton accelerator to generate neutrons in a spallation target for the production of tritium. This paper will describe major attributes of the safety of this facility.

The spallation target has been designed to maximize the production of tritium, which includes minimizing the nonproductive structures and coolant in the path of the proton beam. This results in a system design that has critical performance requirements during normal operation and accident conditions. While a spallation target has no fissionable material, there is a buildup of radioactive material from neutron activation and spallation products. When the proton beam is shut down, the power falls very quickly to residual heat levels that are <1% of the full power value

The authorization basis for APT is expected to be approved by United States Department of Energy (DOE) on the basis of the DOE system of orders and regulations. To follow the DOE requirements for APT, the preparation of a Safety Analysis Report (SAR) will be required. The SAR documentation will be based on evaluating the hazards following the methodology of DOE-STD-3009-94 , "Preparation Guide For U.S. Department Of Energy Nonreactor Nuclear Facility Safety Analysis Reports." Preliminary hazards analyses have been performed for the accelerator, the target/blanket (T/B), the tritium extraction facility, and the balance of the plant. From the point of view of risk to the public, the T/B has the most significant radioactive inventory and potential release mechanisms.

Accidents have been identified along with potential prevention and mitigating systems. In this paper we will describe the major accident sequences. Emphasis will be placed on examining the systems behavior of the target blanket protection systems.

The APT target uses short, small diameter (0.32 cm diam. x 20 cm) tungsten rods in tightly packed bundles. The bundles are placed in a short segment of stainless steel tubing. Ten bundles are arranged horizontally to resemble a ladder with the vertical legs of the ladder providing supply and return for the coolant. There are 10 ladders in the target (Fig. 1).

The hazards for the T/B are dominated by events leading to damage and target cooling system breach. The primary accidents with the potential to cause these consequences are loss-of-coolant-accidents (LOCAs) and loss-of-flow-accidents (LOFAs).

There are two classes of LOCAs. The first occurs in the external piping for which case the tungsten neutron source remains flooded and the decay heat is removed by the residual heat removal (RHR) system.

For the second class of LOCA, which is inside the cavity with a break low in the ladder, there are several mechanisms that could cause the liquid to be lost in a rung or rungs. During accident conditions, the safety systems design objective will be to keep the tungsten from drying out. The LOCA mitigation under these conditions will depend on a cavity flood system and the RHR system. This case will prove to be the most challenging to analyze, and experimental work may be required.

Loss-of-flow-accidents will be in the anticipated events category with a frequency of  $10^{-4}$ /yr. The normal protection for these events will be to trip the beam, and then heat will be removed by the RHR system via either forced flow or by natural circulation. A concern is a LOFA with a failure to trip the beam. In a safety-grade, two-out-of-four logic protection system, the

unreliability would be in the range of  $10^{-4}$  to  $10^{-6}$ . The probability of the LOFA without a beam trip will therefore still be in the range of credible events. It will be a design requirement that the beam trip have two separate beam trips that are completely independent, that rely on diverse conditions to detect a beam trip condition, and that affect the trip of the beam in diverse ways.

### **Challenges**

The design of the APT system is a challenging effort but will not require a departure from standard engineering practice. The design of the safety features is proceeding in concert with the design for normal operation. The principles involved are well understood, but the uniqueness of the design introduces many system interrelationships that require thoughtful analysis and design.

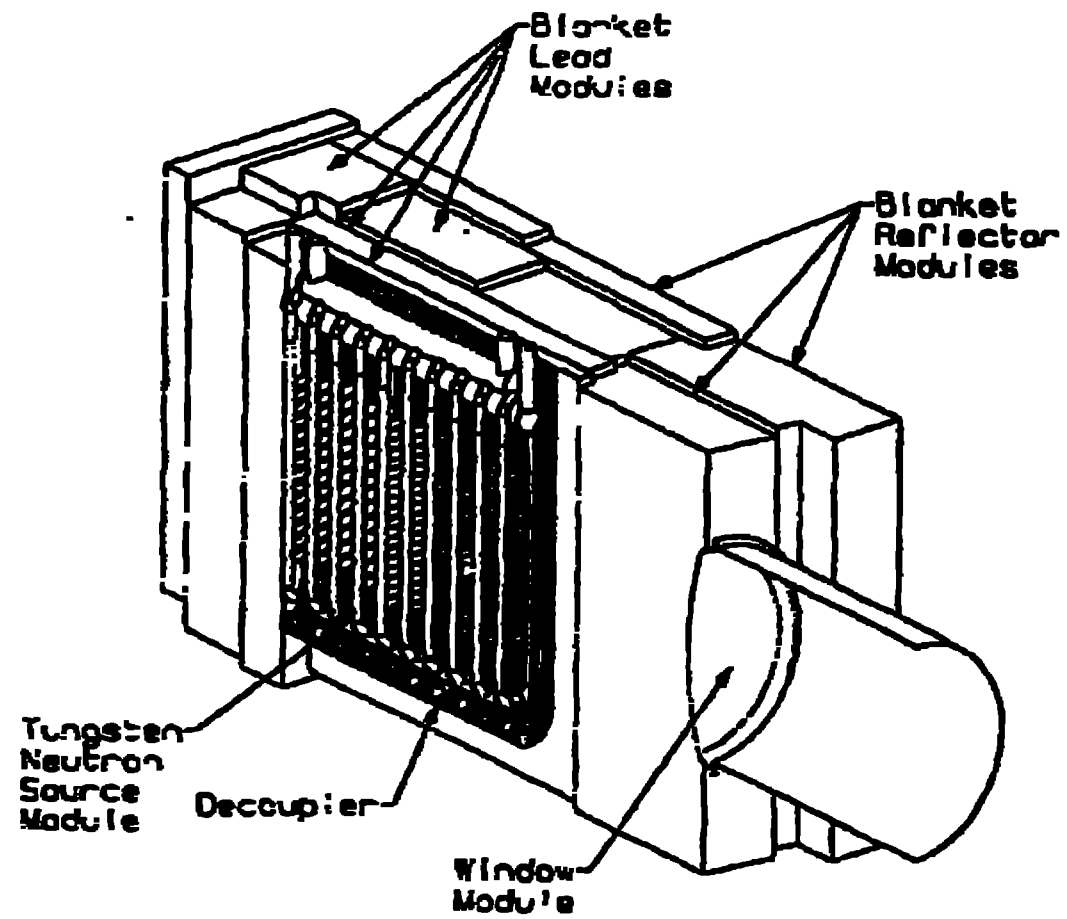


Fig. 1. APT Target/Blanket Design