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REMOTE TARGETING SYSTEM FOR
ACCELERATOR PRODUCTION OF ISOTOPES

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Remote Targeting System for
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Abstract

A positioning mechanism for the manipulation of multiple targets in the beam line of a proton accelerator is described. The targets with integral forced-water cooling are placed in a helium atmosphere under a 10 meter water shield.

The Brookhaven LINAC Isotope Producer (BLIP) was designed to expose multiple targets to a beam of 200 MeV protons. The beam is pulsed up to ten times per second with a maximum of 10^{14} protons in a pulse. Protons striking the first target cause spallation reactions, which in turn degrade the beam in energy before striking the second target. The optimum energy at which reactions occur varies with the target material; moreover, the maximum cross section for spallation reactions requires proton energies between 50 and 150 MeV. The proper arrangement of various targets in the beam line for the preparation of selected isotopes primarily for medical and biological use is beyond the scope of this paper.

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It is sufficient at this time to indicate that ten separate target holders are provided. Each is independent and contains its own positioning and cooling system. The holder can contain a package with more than one target material, so that the total number of different targets exposed to the beam simultaneously can be 40 or 50, although it is more likely to be 10 or 15.

The targets are arranged in the holder between two thin stainless steel windows (0.013 cm). The water connections are at one side, and the passageways are narrow (0.10 cm) to provide high velocity water for heat removal (4 kW per target average). An exploded view of the target holder with two targets is shown in Figure 1. The windows are sealed by metal "O" rings held in place by a retaining ring screwed to the target holder. The use of organic sealing materials is precluded by the intense radiation field at the targets.

The pulsing action of the beam causes temperature spikes in the target. The Gaussian distribution of the beam protons causes a build up of centerline temperatures; therefore, thermal conductivity and melting point of the target determine its thickness. Axial heat conduction is the principal mode of heat removal to the cooling water, with the centerline heat flux maintained below incipient boiling by the

high-velocity cooling water. A nominal water flow of five gpm is provided to each target holder.

The facility is located at the end of a spur tunnel into which 90% of the total available 200 μ A current can be magnetically deflected. Nondestructive momentum analysis is performed in this tunnel on a portion of the beam for proper LINAC operation. This beam is then available for the preparation of isotopes by spallation reactions without disturbing normal AGS operation. The installation of the 34 ft high BLIP tank at the end of the LINAC spur tunnel is shown in Figure 2. An aerial view of the LINAC, AGS, and BLIP building erected over the tank is shown in Figure 3.

A plan view, Figure 4, of the end of the spur tunnel shows the beam line and the position of the targets. You will note that each target holder has a position along the beam line near the center line of the BLIP tank. In the vertical direction the targets and beam line are located two feet above the bottom of the tank. The 34 ft BLIP tank is eight feet in diameter and is filled with 12,000 gallons of water to provide radiation shielding mainly from 100 to 200 MeV neutrons. The water in the tank is separate from the water in the target cooling system, which is only 420 gallons.

The target holders are guided into their positions along the beam line by rectangular tubes. The proton beam is in

helium gas as it traverses the target irradiation chamber; therefore, the guide tubes are shaped so that they maintain a water seal on the chamber. The target holders pass down through the water seal and come up into the helium-filled chamber. A helium-water pressure balance system maintains a constant level below the chamber. The ten guide tubes, five on each side, attached to the irradiation chamber are shown in Figure 5 prior to being lowered into the BLIP tank. The view is axially along the beam line. The small tubing contains the wire cable for positioning the target holders.

The target drive system is a continuous-loop cable driven by an electric motor. Each target holder with its water cooling hose has a cable which carries it down into the beam line, where it strikes a stop. The slipping clutch on the motor indicates beam line position. The cables are driven by rubber covered friction wheels. Each motor has an operation point and annunciator position on the instrument panel to indicate the position of the target.

The targets are removed by reversing the motor and carrying the target holder out of the tank and into a lead shielded cave. The cave is equipped with several manipulator devices to disconnect water hoses, target holder, and insert target holder into a lead transfer cask. The 1½-ton cask is used to

transport the targets to the Hot Lab for chemical processing of the isotopes.

A schematic view of the equipment is shown in Figure 6. One of the ten targeting systems is shown for clarity. The continuous-loop cable drive system, the cooling water hose with its take-up reel, one of two target transfer caves, and the water cooling system are shown.

The 420-gallon-water cooling system consists of a single nominal 50 gpm pump, a heat exchange for removing 40 kW, a filter and a surge tank. Each target is fed from a common manifold and the return water from each guide tube is fed to the pump suction manifold. The target holders discharge cooling water directly into the guide tubes, which overflows into the suction manifold. The irradiation chamber must be kept under two atmospheres of helium pressure by the balance system to maintain the water level at the suction manifold.

The ten cooling water reels and hoses each are fed through flow switches that indicate a loss of flow. The cooling water temperature is recorded at the exit of each target, and the temperature difference across the heat exchanger recorded. (See Figure 7.) The water flow to the end window is controlled as well as tank liquid level. In

the interests of water conservation, the heat exchanger water is taken from the BLIP tank; and the Chem Beam Dump uses BLIP cooling water discharge. The tank water is removed at the rate of about 10 gpm to balance the rate of water fed to the beam tube end window. Any excess water flows to the building drain from an overflow at the top of the tank. An alarm connected to a liquid level probe will be activated if the tank water level drops more than two feet.

The helium-filled irradiation chamber has a water detection probe. If water is detected it will automatically switch off the LINAC beam to BLIP and shut the quick-closing valve in the beam line. A drain valve to a hold-up tank (not shown) under two atmospheres pressure opens to remove the water. A ruptured target holder window or a leak in the end window or a malfunction in the pressure balance system may be the cause. A third valve shuts off the cooling water supply to the targets.

Individual target holders are automatically retracted if the melting of a target causes a reduction in water flow rate. The flow switch and/or the exit temperature rise of the cooling water will trip the target retraction mechanism. Automatic operation of the target drive mechanism is provided since no operating personnel will be present.

The LINAC operates 24 hours a day, seven days a week, except for scheduled maintenance shut downs; therefore, a malfunction can occur at any time. This automatic type of operation permits targets to be exposed to the beam for a sufficient period of time to reach saturation of a particular isotope. The resulting yields of the isotope are thus greatly enhanced.

BLIP TARGET ASSEMBLY
(typical)

Figure 1 Exploded view of typical target assembly.

Figure 2 Placement of BLIP tank at end of LINAC spur tunnel.

Figure 3 Aerial view of AGS LINAC
and BLIP.

Figure 4 BLIP beam line.

Figure 5 Guide tube assembly prior
to insertion into BLIP
tank.

Figure 6 Isometric view of process equipment.

BLIP FLOW DIAGRAM

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Figure 7 BLIP flow diagram.