HIGH CURRENT ENCAPSULATED TARGET SYSTEM FOR RADIOISOTOPE PRODUCTION

Wendy Ho, Shervin Bakhtiari, William Z. Gelbart, Nigel R. Stevenson
TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C., Canada, V6T 2A3

Abstract

Solid target systems for use with vertically oriented targets are currently used at TRIUMF for radioisotope production. In order to irradiate liquids, powders, and non-electroplatable materials using the newly developed encapsulated target, a new target system for use with horizontally oriented targets is being designed. This target station has a modular assembly consisting of a landing terminal, an irradiation chamber, a manipulator, and an actuator. Targets are pneumatically transferred between the station and the hot cells. The target is positioned in the irradiation orientation by a remotely controlled actuator, which also creates a concentric coolant circuit against the back surface of the target. Additional cooling is provided by a forced flow of helium gas over the top surface of the target. This target station can also be used for irradiation of regular solid targets. The paper discusses the detailed design of this target system and the current status of the project.

1 INTRODUCTION

Two isotope production cyclotrons (30 MeV TR30 and 42 MeV CP42) are operated by the Applied Technology Group at TRIUMF for MDS Nordion for medical radioisotope production. Remotely controlled solid target systems for use with vertically oriented targets are currently used with both cyclotrons to irradiate metallic, electroplatable materials with high melting point. Since there was an increased demand in the past few years to irradiate liquids, powders, non-metallic materials, materials that are hard to electroplate, and materials with low melting point, a new type of target system, called the encapsulated target system, is being designed.

The encapsulated target system is for use with horizontally oriented encapsulated targets, which are carefully designed so that the target material and its irradiated product are completely isolated from the rest of the system. Targets are pneumatically transferred between the hot cell and the target station. The target station, while still being based on the existing high current solid target system [1], incorporates several custom-designed modular subassemblies. The following sections discuss the design of the encapsulated target and the target station.

2 ENCAPSULATED TARGET

The encapsulated target is a bimetallic assembly that comprises a copper or silver central disc and a stainless steel ring. These two parts are silver soldered together to form one assembly. The target material is placed in a shallow recess of the central disc and a thin foil is electron beam welded to the periphery of the target. The encapsulated target is concentrically water-cooled and can withstand a 240 μA 30 MeV proton beam bombardment at a 12.5° angle. The thermal performance of the target has been analyzed using finite element analysis and experimentally verified.

Figure 1 shows the target with its plastic carrier, “rabbit,” in the background. For more information on the target construction, the target cooling configuration, and thermal analysis of the target, see Reference [2].

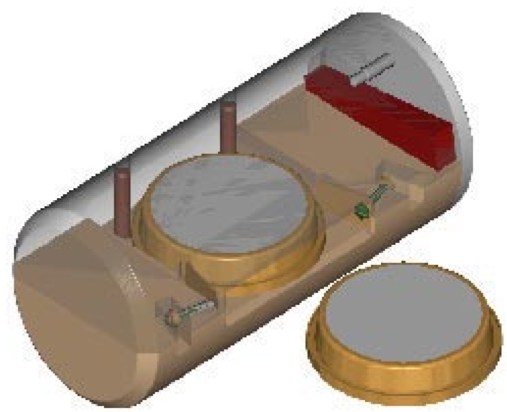

Figure 1. Encapsulated Target and Rabbit

3 ENCAPSULATED TARGET STATION

Figure 2 and 3 show the layout of the encapsulated target station. Since the encapsulated targets are irradiated in a horizontal position, a bending magnet is used to provide a 12.5° horizontal angle to the beam. Four modular subassemblies are mounted on an aluminum stand: a landing terminal, a vacuum/irradiation chamber, a manipulator, and an actuator.

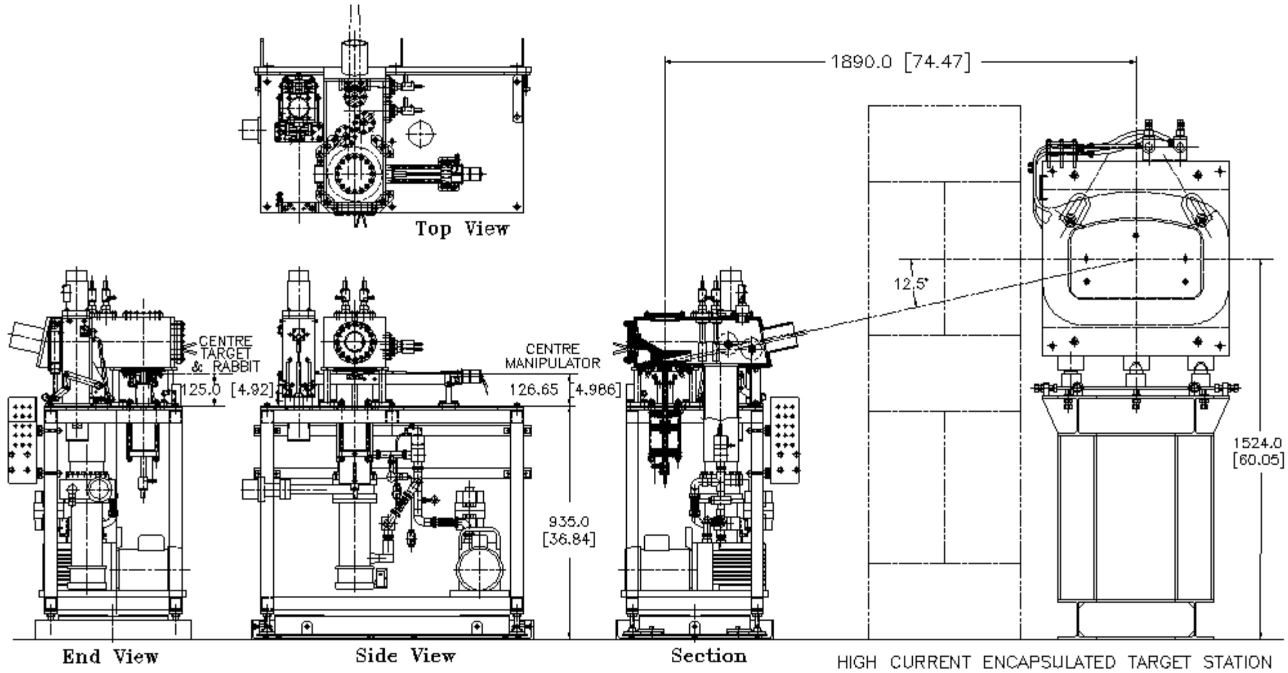

Figure 2. High Current Encapsulated Target Station

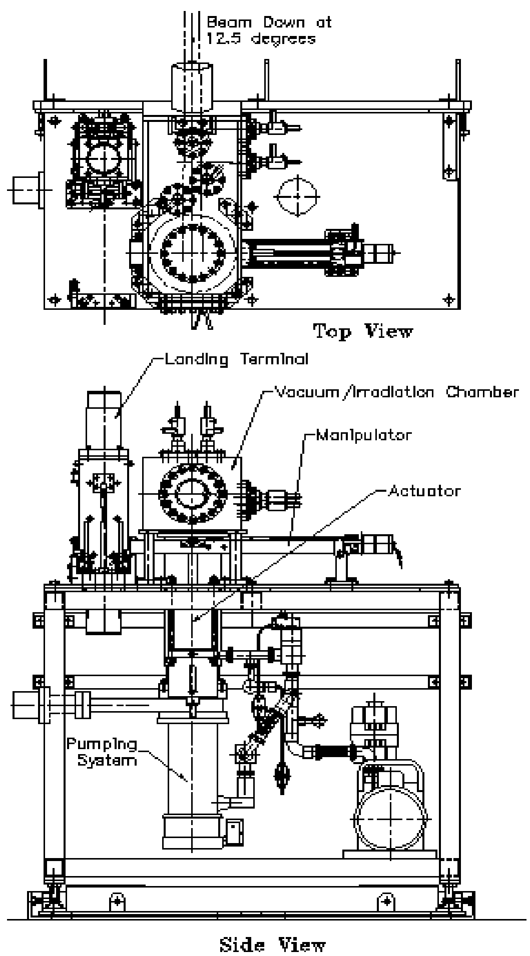

Figure 3. Side View and Top View of the Encapsulated Target Station

During operation, the target (in its plastic carrier called "rabbit") is transferred from the hot cell to the target station via a pneumatic transfer system. When it arrives at the target station, it is brought to a soft landing and oriented in the required way by a dynamic braking and magnetic orientation system inside the landing terminal. Dynamic braking system utilizes the pressure build up at the closed-end of the landing terminal and a reverse air flow injected into the receive housing of the landing terminal to slow and bring the rabbit to a "soft landing". Magnetic orientation system simply takes advantage of the attraction/repulsion of opposite/similar magnetic polarities to orient the rabbit.

Once the door of the landing terminal fully opens, the manipulator can advance forward to retrieve the target from the rabbit. Figure 4 shows a solid model of the manipulator. The manipulator grabber removes the target from the rabbit and pulls it along the manipulator guide until the target is directly underneath the target flange of the vacuum/irradiation chamber. The manipulator grabber then disengages from the target and an actuator (see Figure 5) lifts the target off the manipulator guide and pushes the target against the target flange for irradiation. The actuator head fits inside the target and creates a concentric water coolant circuit against the back surface of the target [2]. At the same time, the target, mounted on the actuator head, seals the vacuum/irradiation chamber. Additional cooling is provided for the top surface of the encapsulating foil of the target by a forced flow of helium gas that is incorporated into the design of the target flange. The helium also cools a fixed foil window placed between the target and the vacuum/irradiation chamber.

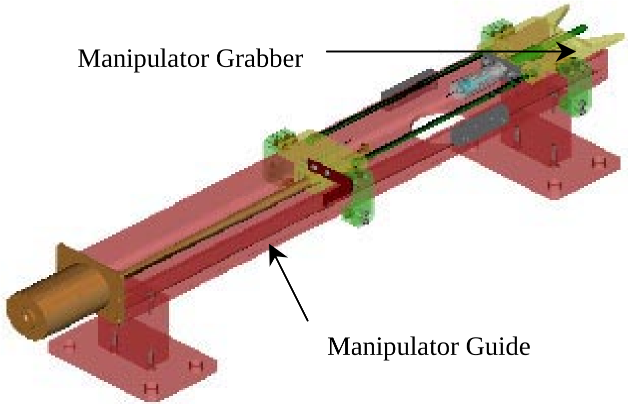

Figure 4. The Solid Model of the Manipulator

The vacuum/irradiation chamber is pumped down before the beam is put on the target. After the target irradiation and the vacuum/irradiation chamber venting, the actuator lowers the target back onto the manipulator guide, and the manipulator grabber engages the target and inserts it into the rabbit. The target in its rabbit is then sent back to the hot cell for processing.

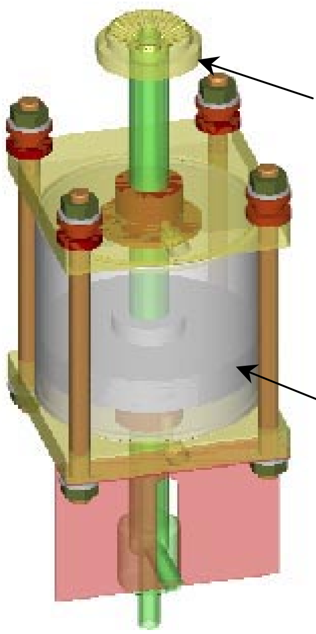

Figure 5. Solid Model of the Actuator

An industrial programmable logic controller will control the complete operational cycle, as well as all interlocks. A complete target change from the end of an irradiation on a target to the start of the beam on the subsequent target will take about 25 minutes.

4 RADIATION HARDNESS

The encapsulated target system follows the existing design of the high current solid target system which aims for minimizing downtime caused by radiation damage to system components. The component materials and locations are carefully chosen with respect to the beam and the target. For example, the pneumatic cylinders (of the landing terminal and the actuator) are fitted with graphite pistons and rod seals. Metal O-rings are used to seal the vacuum/irradiation chamber (except the target flange.) Elastomer O-rings on the targets are used only for one irradiation. Electrical isolation is achieved by hard anodizing on aluminum or polyamide plastic components. All these materials (as well as others chosen for electrical wiring, water connections, etc.) have been tested under actual operating conditions of the solid target system and proved their radiation hardness and suitability for this application.

5 CONCLUSION

The feasibility study of the encapsulated target by investigating its thermal performance using finite element analysis and actual target surface temperature measurements via embedded thermocouples during irradiation is completed [2]. The preliminary design of the encapsulated target station has also been recently completed. Detailed design is currently in progress and once it is completed and finalized, the construction of a prototype encapsulated target system can commence.

6 REFERENCES

[1] Gelbart, W. Z., Stevenson, N. R., Johnson, R. R., Nortier, F. M., Orzechowski, J., Cifarelli, F., “High Current Radioisotope Production with Solid Target System,” Proceedings of the 1993 Particle Accelerator Conference, P. 3099-3101

[2] Bakhtiari, S., Gelbart, W. Z., Ho, W., Stevenson, N. R., “Encapsulated Target for Isotope Production Cyclotrons,” Proceedings of 1997 Particle Accelerator Conference

[3] Gelbart, W. Z., Cifarelli, F., W. Ho, “The Design of the High Current Encapsulated Target System,” TRIUMF Design Note TRI-DN-95-30

[4] Gelbart, W. Z., “Electron Beam Welder for Target Material Encapsulating,” TRIUMF Design Note TRI-DN-89-25

[5] Nortier, F. M., Stevenson, N. R., Gelbart, W. Z., “Investigation of the thermal performance of solid targets for radioisotope production,” Nuclear Instruments & Methods in Physics Research Section A, 1994, P. 236-241