BEAM PLUG FOR RADIATION SHIELDING PENETRATIONS

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Abstract
A beam line plug has been designed to fill the cylindrical hole formed by beam lines which pass through radiation shielding walls. The plug consists of multiple steel discs held together along their cylindrical axis by a steel cable forming a flexible snake-like structure. Other disc materials including laminates may be used to solve a variety of radiation shielding problems. When the beam line is to be used, the plug is pneumatically withdrawn into a vertical extension of vacuum line that is connected through a 90° bend to the beam line. Upon release, the plug is reinserted by pneumatic action. The beam plugs being used at the Brookhaven Three-stage MP Tandem Van de Graaff Facility are 7.6 cm diameter and provide 80 cm equivalent thickness of steel to fill penetrations through a 120 cm thick concrete wall. Fast-neutron measurements at the shielding wall surface show that the beam plug is indistinguishable from concrete shielding. A description of the beam plug mechanism, failsafe features, test results, and performance data is presented.

Fig. 1 Beam Plug for Radiation Shielding Penetrations.

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The vacuumed housing for the beam plug (Fig. 1) consists primarily of an elbow and straight tube sections which are fabricated from standard stainless steel tubing. The elbow was formed by a commercial tube bending company using available tools and dies. A horizontal section of tube was welded to the heel of the elbow to provide the beam entrance port. The inside diameter of both the elbow and the vertical tube is 3.2 mm larger than the inside diameter of the horizontal section which penetrates the shielding wall. Additional clearance in the elbow compensates for distortion which occurs during the bending operation. A 6.4 cm long, tapered section provides a smooth transition between the two different inside diameters. All sections are flanged and sealed with elastomer "O" rings and Varman clamps. The vacuum housing is supported in a steel box of square cross section which provides horizontal and vertical screw adjustments for initial alignment. The void between the plug and box is filled with steel balls. Concrete blocks fill the opening between the box and the poured concrete shielding wall.

The steel discs of the moving plug are separated by steel balls and are held together by a spring-loaded stainless steel cable. This provides the combination of stiffness plus flexibility required for passage through the elbow. The steel discs are lubricated with molybdenum disulphide which was applied and baked by a commercial vendor.

The vacuum seal for the sliding actuator shaft consists of three sets of conventional chevron (V-ring) seals. The space between the inner two seals is differentially pumped and the other space is used to retain the lubricant. All of the differential pumping ports are connected to a common manifold and mechanical vacuum pump. The pneumatic actuator, chevron vacuum seal, and flexible plug assembly can be replaced without disturbing the shielding blocks or beam tube alignment by removing the Varman clamp on the bottom vertical joint.

The beam plug is actuated by a commercial air cylinder and solenoid valve. With a 20 psig air supply, the plug can be withdrawn in about 19 seconds and inserted in 7 seconds. With proper cushioning of the actuator the speed could be increased. Loss of electrical power inserts the plug fully while loss of air supply inserts the plug 2/3 of the way by gravity. Two magnetic reed switches, located outside of the vacuum housing, provide position indication. As shown in Detail A of Fig. 1, the upper steel disc is split to capture a cylindrical permanent magnet which actuates the switches.

**Test and Operation**

A prototype beam plug was assembled to a 150 l/sec ion pump and cycled over 2000 times. This test demonstrated that the plug could be cycled rapidly without stalling the ion pump and that the service life of the unit was adequate. Fig. 2 shows pressure fluctuations for a line which has been in service for over a year. The pressure improves when the beam plug is inserted because the plug effectively seals the beam pipe from higher pressure at the switching magnet.

A total of eight plugs are presently in operation. Except for some early seal failures, most of the units, including the oldest, have been trouble free.

A beam plug is installed on each beam line at the Brookhaven Tandem facility to prevent direct beam or secondary radiation from being accidentally introduced into an occupied target room. Fig. 3 shows eight beam plugs which penetrate into three separate target rooms. Under normal operating conditions every beam plug in a target room must be in the inserted position when the room is opened to personnel working in the area. The beam plugs will be interlocked with the shielding doors as part of the target room radiation safety system.

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**References**

2. Electrofilm Inc., Cherry Hill, New Jersey 08034.
3. Lubricant I part by volume molybdenum disulphide powder to 4 parts Apiezon-N vacuum grease.