Rutherford Laboratory

Technical Leaflet

A13

LIQUID HYDROGEN TARGET SYSTEMS

Target Units and ancillary equipment

The basic requirement for all targets of this kind is to maintain a quantity of liquid hydrogen in a beam line for a long period with minimum containment material between the liquid and the beam. Since liquid hydrogen boils at -253°C a suitable design must incorporate heat shields which reduce to a minimum the migration of heat to the liquid; thus the normally rapid boil off rate is reduced, and containment of the liquid is possible. Target units have a reservoir to hold liquid hydrogen, surrounded either by a double walled liquid nitrogen jacket, or by a copper heat shield hanging from a liquid nitrogen container situated above the liquid hydrogen reservoir. The target flask hangs under the reservoir and is connected to it by a filling tube. Suitable boil-off and filling pipes are provided for each liquid container. Surrounding these items is a vacuum vessel which has thin windows adjacent to the target. A copper heat shield is attached to the nitrogen jacket, and surrounds the target flask, except in the region of the windows. Layers of "super-insulation" are wrapped in the vacuum interspace. These consist of aluminium coated "Mylar" or "Melinex" films (.0005" thick) interleaved with glass fibre paper. The vacuum vessel is pumped by means of a diffusion pump to less than 1×10^{-5} torr. before the filling procedure commences.

The target unit described above, and shown in figure 1 is connected by means of flexible hoses to a control panel to ensure a logical sequence of operations during the filling of the target unit. Operations include vacuum pumping of all interconnecting hoses, and purging with dry helium gas before transfer of liquid hydrogen into the target unit. The pumping trolley and electrical control panel are always positioned outside the "igloos" for reasons of safety. The electrical panel incorporates control equipment for vacuum pumps, vacuum interlocks, and vacuum gauge panels.

Liquid hydrogen is supplied in vacuum insulated "dewar" containers. Specially designed vacuum insulated transfer pipes ensure minimum boil-off rate during transfer of liquid hydrogen from the "dewars" to the target units.

Sizes and shapes of the target flasks vary according to the experimental requirements. A typical flask (axis horizontal), consists of a stainless steel cylinder 8 cms. diameter by 20 cms. long with flanges at each end. Mylar windows (.005" thick) are bonded to the flanges with epoxy resin and clamped. The Vacuum vessel windows are made in a similar fashion.

Thus, the experimental beam and subsequent beams scattered from the liquid hydrogen are disturbed only by very thin layers of material.

Safety

Safety considerations have been taken very seriously in the design and operation of liquid hydrogen target systems. In gaseous form, mixtures of hydrogen and air containing 4% to 74% of hydrogen by volume are explosive; and one litre of liquid hydrogen evaporates to 840 litres of hydrogen gas at normal temperature and pressure. The most elementary safety precaution is to ensure that explosive mixtures are not allowed to form. As a further precaution, all the equipment in which liquid hydrogen is used is contained within a tent or "igloo" of PVC sheeting built on light alloy framing. An extraction fan continuously exhausts the igloo to the atmosphere (approximately 60 changes per hour). Detecting equipment is also provided at the extract ducts to give warning of a $\frac{1}{2}$% Hydrogen mixture with air.

Electro-static discharges from clothing, shoes and "igloo" material; sparks from tools, nails in shoes, and improperly earthed equipment, are hazards apart from the more obvious danger from matches, etc. All personnel are provided with white cotton coats and anti-static footwear, and "igloo" floors are either covered with anti-static floor covering or are fully conductive. Special "reduced sparking" tools, and safety torch lamps are provided, as well as the more usual safety equipment.

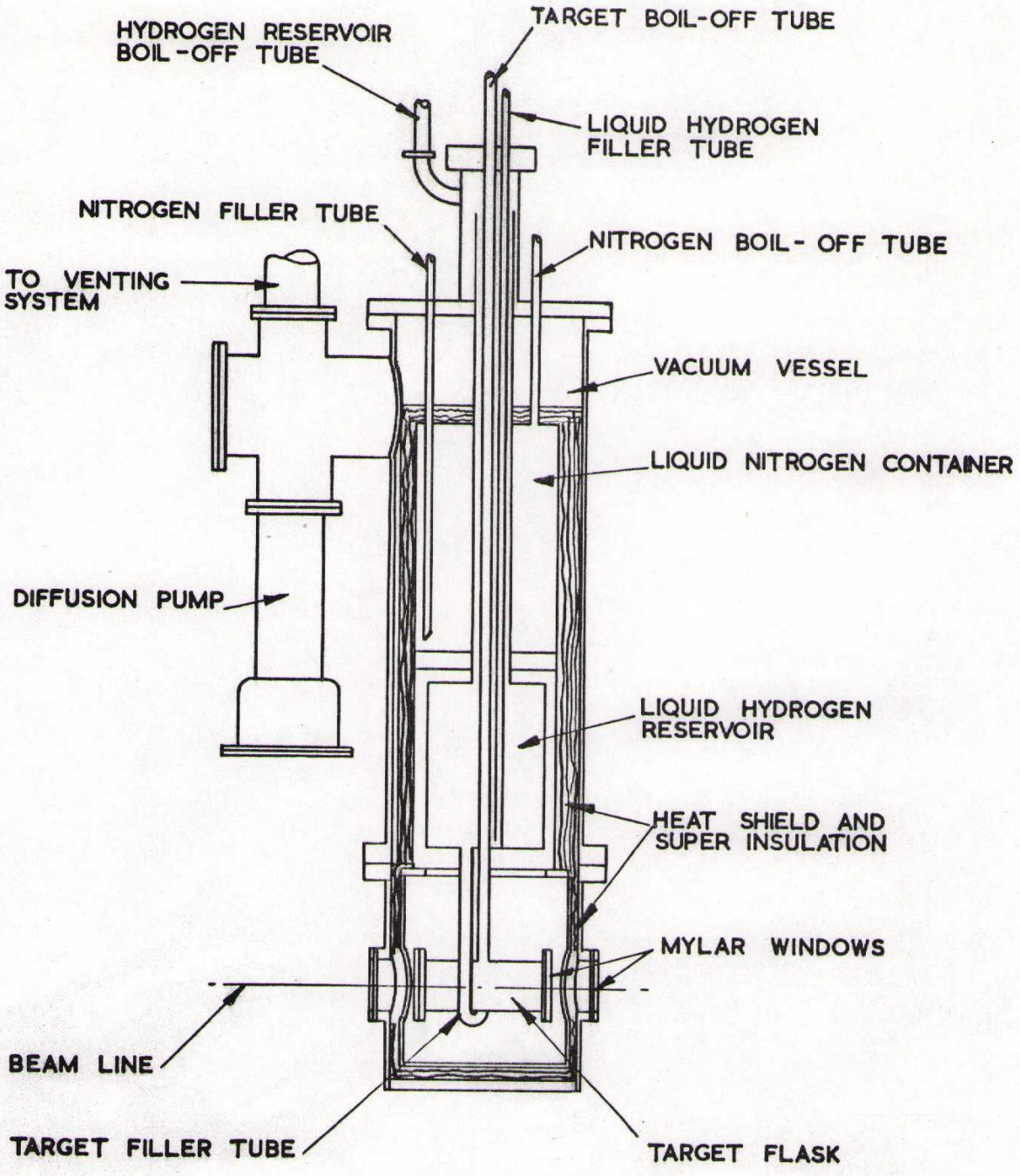

FIGURE 1. HYDROGEN TARGET AND RESERVOIR