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SUMMARY: LIQUID METAL TARGETS

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Of the three liquid metal spallation target projects (SNQ, SIN, TRIUMF), the one at TRIUMF is the only one operating at present. New results or major changes, however, have not been reported of the TRIUMF target.

The other two projects, SNQ and SIN, are both in the conceptual stage. The variants primarily discussed at the liquid metal target meeting were both vertical cylindrical targets of a liquid eutectic mixture of lead and bismuth (LBE).

The SNQ project presented by Hoffmann, Piesche and Wild is designed for a proton beam of 1.1 GeV, 5 mA and an r.m.s. diameter of 5 cm. This high beam density, thought to be required by the pulsed neutron mode of the SNQ source, would make the use of a beam window rather hazardous. The window-less version presented on the last ICANS meeting, in which the beam enters the target vertically from the top through a free, conical LBE surface created by an appropriate nozzle, has been developed further. Flow calculations and measurements on a new LBE test circuit show that such a free surface can be generated and kept stable. An alternative version has been considered in which the LBE is pumped around a horizontal bend in such a way as to present a free surface to the proton beam near the centre of inside of the bend where a small section of the wall of the LBE channel is removed. This version would simulate the geometry of the wheel target which is the reference design for the SNQ.

For the SIN project (nominal beam characteristics: 0.6 GeV, 1.7 mA, 10 cm r.m.s. diameter), a new target concept has been developed in which the proton beam enters a vertical LBE target from the bottom through a beam window. The target is a vertical cylinder of 20 cm diameter and about 3.5 m height. The LBE is circulated by natural convection and is cooled by an internal heat exchanger thus eliminating the need for a complex external primary LBE circuit. Calculations for stationary and start-up flow in the target have shown that proton beams of up to 2 MW, even if switched on instantanuously on to a stationary target, will not produce LBE temperatures above 500 °C. Preliminary studies indicate that it is possible to insert uranium fuel rods into the LBE target to boost neutron production. The feasibility of a beam window has been ascertained by several preliminary results of proton irradiation at LAMPF (800 mAh/cm2 on pyrolitic carbon, 400 mAh/cm2 on inconel), SIN (60 mAh/cm2 on reactor graphite) and TRIUMF (50 mAh/cm2 on stainless steel) which indicate, that a suitable beam entrance window would hold up for at least several thousand hours in the proposed beam density of 20 μA/cm2. Thermal strains and pressure stress in the window were shown to be well below limiting values.

An important aspect of liquid metal target operation is the emission of radioactive gases and vapors from the liquid metal surface. Preliminary data presented by Hellwig show that for an LBE temperature of 325 °C the activity released by mercury isotopes and their decay products is ten times higher than that of all other spallation and fission products in LBE exept possibly of Po. The exact amount of released Po activity is still under investigation but will still be dominated by the Hg activity. This is true to an even larger degree at lower LBE temperatures.

In general developments presented at this conference have shown that liquid metal LBE targets are thermodynamically stable and reliable in both the natural and forced convection versions. If the detailed problems of beam windows and handling of released radioactivity are solved successfully, which appears now to be possible, such targets would be inhearently safe due to their simplicity and large thermal capacities.

The examples presented show the wide choice of target geometries and source requirements that may be covered by liquid metal targets, ranging from powerful pumped versions for extremely high power densities above 10 kW/cm^3 to relatively cheap, simple natural convection concepts for moderate power densities of a few kW/cm^3.

In order to further substantiate the present promising predicitons for liquid metal target performance, the following studies seem to be particularly urgent for the immediate future:

- detailed, full scale radiation damage and associated corrosion tests on potentially suitable window materials with 500 - 1000 MeV proton beams in the dose range of 100 - 1000 mAh/cm^2

- LBE flow and corrosion tests including simulated beam heating

- determination of the release of radioactive spallation products and particularly of polonium from LBE, and concepts for handling this contamination

- concepts for the inclusion of uranium into liquid metal targets

The results of these studies would provide the basis on which to determine definite concepts and basic design parameters for future high power spallation targets.