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A LOW COST METHOD TO SAFELY VENT RADIOACTIVE GASES FROM THE COOLING SYSTEM OF A HIGH POWER BEAM STOP

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In a recent report[1], M. Awschalom suggests venting into the atmosphere the H_2 and O_2 produced by radiolysis of target box cooling water. He correctly concludes that the quantity of H^3 produced could be safely and legally vented directly into the atmosphere. Large quantities of short-lived radionuclides (C^{11}, N^{13}, O^{14}, O^{15}) are produced by spallation of the oxygen in the cooling water, and will be carried out of solution by the H_2 and O_2 evolved by radiolysis. The resulting gas will be far too radioactive to be released directly into the atmosphere. It is, however, quite practical to hold the evolved gas long enough to allow the short-lived activities to decay by the necessary 6 to 7 orders of magnitude. (The required decay factors were derived from Federal Regulations[2] and CERN guidelines[3]).

The critical radionuclide will be C^{11}, which has the longest half life (20.4 minutes). To allow this activity to decay by 7 orders of magnitude requires a holding time of

$$T_{hold} = t_{1/2} \times \log_2 10^7 = 20.4 \text{ min} \times 23.3 =$$
$$474 \text{ minutes} = 7.9 \text{ hours}$$

before being released.

The volume of the holding tank is of course also proportional to the rate at which gas is evolved. Awschalom[1] calculates that 1% of the hadronic interactions and 5% of the total track length occur in the cooling water in an idealized beam dump. We must estimate the thermal power deposited <u>directly</u> in the cooling water by ionization. About half the beam power is deposited in the dump by electromagnetic cascades from π°'s; the fraction deposited directly in the water is calculated from the path lengths in water and weighted by the radiation lengths of water and iron:

$$f_{\pi^\circ} = \frac{0.05}{36}\left[\frac{0.05}{36} + \frac{0.95}{1.8}\right]^{-1} = 0.0026$$

About a quarter of the beam power is deposited in the dump by ionization of charged hadrons and electrons below the critical energy, this fraction scales as the densities of iron and water:

$$f_{ion} = \frac{0.05 \times 1}{0.95 \times 7.8 + 0.05 \times 1} = .0067$$

Thus we may conservatively assume that no more than 1% of the beam power is directly deposited in the water, or a power of

$$1 \times 10^{13} \text{ p/sec} \times 3 \times 10^{11} \text{ ev} \times 1.6 \times 10^{-19} \text{ C} \times 0.01 =$$
$$4.8 \times 10^{3} \text{ watt}$$

Measurements made at SLAC[4] indicate that H_2 is evolved at 0.3 liters per megajoule of energy deposited in the water. The H_2 and O_2 mixture is evolved at 1.5 times this rate. The rate of gas evolution is then

$$1.5 \times 0.3 \frac{\ell}{\mathrm{MJ}} \times 4.8 \times 10^{-3} \frac{\mathrm{MJ}}{\mathrm{sec}} \times 3600 \frac{\mathrm{sec}}{\mathrm{hr}} = 7.8\ \ell/\mathrm{hr}.$$

The required holding tank has a volume of 7.8 ℓ/hr x 7.9 hr = 62 liters. To ensure that no gas is released without being held for the required cooling period, I propose that the "holding tank" be made of a long tube through which the gas flows before being vented. One hundred twenty meters of 1" I.D. tubing has the required volume and will fit nicely in a 55 gallon drum.

There is a slight safety hazard involved in storing this explosive mixture. The hazard can be minimized by the proper use of flame arresters on the gas vent, and by filling the remaining space in the drum with sand or other energy absorbing material.

To monitor the quantities of radioactive gas being released, the gas should be passed through a flow meter and ionization chamber just prior to being vented.

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REFERENCES

1. Miguel Awschalom "Estimate of the Radioactivity Produced in the Cooling Water of a Target Assembly and its Handling", TM-408A (2/73).
2. U.S. AEC Manual Chapter 0524, Annex A.
3. K. Goebel, "Radiation Problems Encountered in the Design of a Multi-GeV Research Facility", CERN-71-21, p. 4 (9/71).
4. D. R. Walz and E. J. Seppi, "Radiolysis and Hydrogen Evolution in the A-Beam Dump Radioactive Water System", SLAC-TN-67-29 (10/67).