Measurement of Radon Emanation from Bubble Detector Tubing

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1. Introduction

During the fill of heavy water into the Acrylic Vessel (AV) and after it is full, the pressures inside and outside the Acrylic vessel must remain balanced. These pressures will be monitored by a bubble detector. The bubble detector components that goes into the SNO detector will be 4 separate 100 foot lengths of tubing, 2 inside the Acrylic Vassal and 2 outside the vessel.

From physics point of view, the 2 pieces of tubing installed inside the Acrylic vessel should not introduce more than 5% radioactivity of the intrinsic heavy water radioactivity. This report describes two different kinds of proposed tubing and measurements on their radon emanation rate. The Teflon tubing meets the design criteria and will be installed into the SNO detector for permanent pressure monitoring.

2. Experimental Procedure

The first investigated tubing was a Parflex Polypropylene (PP) tubing of 3/8 inch OD and 0.02 inch wall. Its has white colour with black printing on the outside wall. The second investigated tubing was a Teflon tubing of 3/16 inch OD and 0.030 inch wall, opaque. We cut the tubing into 9 inch long pieces and packed them into an empty PP column used to hold MnO_2 for radium assay. The column with tubing was then connected onto an electrostatic chamber. The electrostatic chamber was filled with nitrogen gas and a circulation pump forms a closed loop between the column and the electrostatic chamber and transports radon, emanated from tubing, into the electrostatic chamber.

The radon decay is then recorded and analyzed. The PP tubing was measured twice: one with the manufacturer's black product printing on the wall and one with the printing removed with Acetone. The Teflon tubing has not any printing on it and was measured only once. Background was measured with the same circulation loop without any tubing in the column.

The sequence of measurements was: PP tubing with printing; background 1; PP tubing without printing; background 2; Teflon tubing.

In these experiments, 20 feet of PP tubing and 50 feet of Teflon tubing was used. The reason for the length difference was because the Teflon tubing was smaller in size.

3. Results

Table 1 shows radon emanation results of three experiments, two for PP and one for Teflon tubing. The unit in the table is the number of radon emanated per hour and the number in the parenthesis is counting time for that sample.

Table 1. Radon Emanation Results

Rn / hr (counting time)	PP (20 feet) with printing	PP (20 feet) without printing	Teflon (50 feet)
Background	5.0±0.3 (264 hrs)	5.0±0.3 (264 hrs)	4.1±0.8 (47 hrs)
Gross	10.3±0.2 (213 hrs)	11.0±1.1 (87 hrs)	6.1±0.6 (213 hrs)
Net	5.3±0.4	6.0±1.1	2.0±1.0
For 200 feet	53.0±4.0	60.0±11	8.0±4.0

From the results, we can see that there is no difference for the PP tubing with or without printing on the wall. Also we can see that the Teflon tubing emanates 7 to 10 times (see (b) below) less radon than what PP tubing does.

4. Discussion

a. For an equivalent 10^{-14} g/g ^{238}U in the heavy water, 1000 tons of heavy water would produce 10^{-14} g/g * 10^9 g * (6.023*10^{23} / 238) * ln 2 / (4.5 *10^9 * 365.25 * 24) = 444.7 or nominally 450 radon per hour. The PP tubing would produce 53 or 60 Rn/hr, which is about 12 to 13 percent of the radioactivity from the heavy water. So it will not be suitable for use as bubble detector. The Teflon tubing will produce 8 radon per hour, which is less than 2 percent of that from the heavy water. The final decision was made to use Teflon tubing for the bubble detector.

b. Actually, the background measurement for the Teflon tubing was done in a hurry (for only 47 hours) and the error is large. We would rather use the background 1, which was just measured before the second PP tubing measurement. This indicates that the Teflon tubing would produce only one percent radioactivity of that produced by the heavy water.

c. Teflon is known to be a better material in terms of less radon emanation . Intensive investigations for all materials used for SNO detector and many other common materials has been done at Queen's University and the University of Guelph. If any SNO collaborator has concern about radon emanation from materials for use in the SNO detector they should seek advice from the two University groups. This may save some unnecessary work.