Radon in the Acrylic Vessel

H.W. Lee SNO-STR-94-028
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There has been a suggestion (Moorhead, Bonvin, et al) that in the five months that the acrylic vessel is dry (before fill) that we attempt to assay the 222Rn inside. This would, in principle, tell us how much radon is coming from dust that is on the inside surface of the vessel. The following are some numbers to consider:

Volume of vessel 1000 m3

Area of inside surface 452 m2

Initial number of radon (per m3) in the vessel

Assume mine air is 2 pCi of radon per liter. If we clean the dust out of the mine air, we might get 0.002 pCi per liter
This translates to 3.5 x 10^4 Rn atoms per m3.

Expected level of radon from dust on the surface

The aim is 0.2 microgram per cm2 of dust (White book page 77)
We have measured (X. Zhu, WET Lab) 50 Rn per hour coming off of one gram of mine dust.

Hence the rate at which radon comes off the dust in the vessel is 0.2 x 10^-6 x 50 x 4520000 cm2
= 45 Rn per hour.

The equilibrium number of radon is then 45 * 3.8d * 24hr/(ln2) = 5860 Rn atoms in 1000 m3 or 5.9 Rn per m3.

Required Reduction factor of radon from the air

3.5 x 10^4 / 5.9 = 6 x 10^3
i.e. we have to get the air radon down by a factor of 6 x 10^3 before we can see the radon from the dust in the vessel !

Reduction factor if one waits for radon in the air to decay

3.8 days	factor 2
26.6 days	factor 125
38 days	factor 1000

A procedure to measure the radon

1. Get the cover gas system working for the inside of the acrylic vessel and make sure there are absolutely no leaks.

2. Flush with 2 times the volume (2 x 1000 m3) with nitrogen gas from liquid nitrogen boil-off. This will reduce the level of air radon and reduce the oxygen and water vapor inside the vessel. If stratification of the nitrogen could be arranged, then this flush

should be very effective.

Wait 52 days for the air radon to decay by a factor of 10^4.

3. Wait 2 more weeks for the air radon to die to 0.1 of the level of radon from dust.

4. Extract 20m3 of gas (mostly nitrogen) in the acrylic vessel At a flow rate of 5 liter/min this will take 66 hours.

5. If there is less than 140 radon atoms extracted (47 counts in one day of counting) then the dust level is acceptable. If the radon level is high, we have about 8 weeks left to find out why and fix it.

Summary

In principle assaying the radon is a sensitive technique to determine the total dust on the vessel and the five month window to do this is attractive. We first need a reduction of 6 x 10^3 in the radon from the air. Waiting for the air radon to decay away is possible but some nitrogen gas flushing is useful (it buys time should the 5 months be shortened or we have delays in the radon measurement). A 2 times volume flush requires about 3300 liters of liquid nitrogen (about 10 dewars with the associated transportation and handling costs). We have to be careful where we vent the nitrogen from the vessel flush.

Extracting the radon from 20 m3 of gas in the acrylic vessel will take 66 hours. This is time limited by the maximum flow rate we can put through a radon trap and still have good trapping efficiency. We could parallel five to ten radon traps together.