DRAFT DRAFT DRAFT DRAFT DRAFT

Radon Measurements on Box II at 6800 feet

V. Uras, H.W. Lee, D. Cluff, D. Hallman and A.B. McDonald

Nov. 5, 1993 SNO-STR-93-055

Emanation box I was a stainless steel box (approx. 18 inches by 18 inches by 2 inch) attached to the Urylon coating of the control room area at the 6800 foot level (SNO detector site). In sealing of this box to the Urylon, an extensive series of channels and holes were formed (as far as 2 feet away from the box) which took great effort to seal. The thickness of the Urylon could not be accurately determined and there was very little shotcrete radon permeating through into the box. A summary of the results is given in SNO-STR-93-037.

It was decided to put on a second box (II). This box would cover a thin (0.042 inch) membrane of Urylon against the shotcrete surface. In this way the amount of radon permeating through the Urylon would be sizable (and hence easily measurable) and by subsidiary measurements of the diffusion coefficient of Urylon at Elliot Lake (J. Bigu), a determination of the radon source strength of the shotcrete could be inferred.

Box II is a stainless steel 12 inch by 12 inch by 2 inch thick box. It covers a 8 inch diameter Urylon membrane.

The stainless steel traps (traps 1 and 2) containing the radon are sent to Queen's University to transfer the radon into ZnS scintillation cells and then counted.

Initial extractions on Box II showed that there was a large leak to mine air (the seal was broken when a bit of vacuum was applied to the box) as both trap 1 and 2 were very high in radon. The seal was eventually redone with silicone sealant which proved effective.

Sept. 29 Run

Box II was sealed for six days. The extractions on box II were performed in the mine on Sept. 29 and received at Queen's by bus on Sept. 30. There was some blockage of the trap near the end of the extraction in the mine. This may have been vapors from the silicone sealant.

Trap 1 was slightly under vacuum (about 735 Torr). The radon was counted from Trap 1 and it was determined that there was 19805 $\pm$ 821 radon atoms in box II.

Trap 2 was found to have 24.7 psi (absolute) of gas in it. The radon was counted from Trap 2 and was found to be equivalent to a background of 1387 $\pm$ 297 radon atoms.

The diffusion length of Urylon was measured to be 0.4 $\pm$ 0.1 mm. Hence for a piece of 0.042 inch thick Urylon, the radon flux through it probably comes to equilibrium in 8 to 12 days (J. Bigu). It is hard to determine analytically how close to equilibrium a

seal of six days reaches. Let us assume that it is 0.75 the way to equilibrium after a six day seal.

Then the net number of radon atoms in the box II was 18418 ± 873.

$P/\lambda = (18418 \pm 873) / 0.75$

where P is the number of radon per day permeating through the Urylon and λ is ln2/3.8 days.

so P = (4.52±0.21) × 10^3 Rn/day and the area of the Urylon is 0.03 m^2. Hence the radon flux through the Urylon is (1.51±0.07 × 10^5) × 10^5 Rn/m^2 day.

Using a diffusion length of 0.4 ± 0.1 mm means that 0.042 inch of Urylon attenuates the shotcrete radon flux by 22.0±13.4. Therefore the flux of radon from the shotcrete is (1.51±0.07) × (22.0±13.4) = (3.3±2.0) × 10^6 Rn/m^2 day
or (1.4±0.9) × 10^5 Rn/m^2 hr.

Oct. 13 Run

Box II was sealed 14 days and then the extractions were performed on Oct. 13 and received at Queen's Oct. 14.

Trap 1 had 19.7 psi (absolute) of gas in it. The radon was counted from Trap 1 and it was determined that there was 39616 ± 787 radon in box II. It was also determined that there was a very small leak (10^{-5} ml/sec) in the Swagelok connection at an elbow on Trap 1. This is not expected to significantly affect the results.

Trap 2 had 20.7 psi (abs) of gas in it. The radon was counted and was found to correspond to a background of 1896 ± 147 Rn atoms.

Then the net number of radon atoms in the box II was 37720 ± 801. After 14 days of sealing there should be an equilibrium number of radon in the box.

$P/\lambda = (37720 \pm 801)$

so P = (6.95±0.15) × 10^3 Rn/day and the area of the Urylon is 0.03 m^2. Hence the radon flux through the Urylon is (2.32±0.05 × 10^5) × 10^5 Rn/m^2 day.

The Urylon attenuates the shotcrete radon flux by 22.0±13.4. Therefore the flux of radon from the shotcrete is (2.32±0.05) × (22.0±13.4) = (5.1±3.1) × 10^6 Rn/m^2 day or (1.3±0.8) × 10^5 Rn/m^2 hr.

Oct. 29 Run

Box II was sealed 16 days and then the extractions were performed on Oct. 29 and received at Queen's Oct. 31.

Trap 1 had 23.7 psi (absolute) of gas in it. The radon was counted from Trap 1 and it was determined that there was 57000 ± 1000 radon in box II.

Trap 2 had 18.7 psi (abs) of gas in it. The radon was counted and was found to correspond to a background of 1400 ± 200 Rn atoms.

Then the net number of radon atoms in the box II was 55600 ± 1020. After 16 days of sealing there should be an equilibrium number of radon in the box.

$P/\lambda = (55600 \pm 1020)$

so $P = (1.02 \pm 0.02) \times 10^4$ Rn/day and the area of the Urylon is 0.03 m^2. Hence the radon flux through the Urylon is $(3.41 \pm 0.06 \times 10^5) \times 10^5$ Rn/m^2 day.

The Urylon attenuates the shotcrete radon flux by 22.0±13.4. Therefore the flux of radon from the shotcrete is $(3.41 \pm 0.06) \times (22.0 \pm 13.4) = (7.5 \pm 4.6) \times 10^6$ Rn/m^2 day or $(3.1 \pm 1.9) \times 10^5$ Rn/m^2 hr.

Summary

The results for the flux of radon from the shotcrete are

Sept. 29	$(1.4 \pm 0.9) \times 10^5$ Rn m^{-2} hr^{-1}	Radon not in equilibrium, blockage at end of run
Oct. 13	$(1.3 \pm 0.8) \times 10^5$ Rn m^{-2} hr^{-1}	small leak in Trap 1
Oct. 29	$(3.1 \pm 1.9) \times 10^5$ Rn m^{-2} hr^{-1}	

The largest remaining uncertainties are how efficiently radon is flushed out of the box and the uncertainty in the diffusion length. The efficiency for flushing radon out of the box and trapping onto a stainless steel trap has not been measured. At present it is assumed in our calculations to be near 100%.