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RECENT MEASUREMENTS WITH THE O RING STACK

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The O ring stack is a test object that was constructed to measure the diffusion of Rn through O rings. It contains 20 sections that consist of a sandwich of a circular polypropylene disk and an O ring (see drawing WPS-D-D-6102, sheets 1 to 3). The Rn source is underground air which contains approximately 3 pCi/liter. Experiments are carried out by first evacuating the stack, waiting a few days for Rn flow equilibrium to the interior to be established, and then cryopumping the gas from the interior of the stack to a liquid nitrogen cooled trap. This extracted gas is then transferred to a Lucas cell and counted.

The O rings in the stack are listed in Table 1.

Table 1: O rings in the O ring stack.

Parker number	Quantity	ID (inch)	Thickness (inch)
153	2	3.487	0.103
235	20	3.109	0.139
218	3	1.234	0.139

When all the O rings in the stack were made from urethane, the rate of Rn entry to the internal vacuum was measured to be 720 atoms/day (see 'On Rn Diffusion through Urethane and Polypropylene', SNO STR-96-013). To verify that the measured Rn entered the stack from the outside, and not by emanation, the stack was placed in a sealed plastic bag filled with nitrogen gas. Ten days later, the measured rate of Rn entry was 50 times lower than when air was on the outside of the stack.

On 9 October 96, the 20 number 235 urethane O rings in the stack were replaced with rings made from butyl rubber supplied by N. Tanner. The other rings were urethane and were not changed. The stack was then leak checked using a helium mass spectrometer.

The leaks were found at a sensitivity of [illegible]
-liters/sec. After about 10 minutes with He on the outside the stack, the mass spectrometer baseline began to rise slowly, reaching 1.1 x 10**(-8) mbar-liters/sec after 45 minutes. This response is indicative of slow He diffusion through the elastomers.

Five extractions with exposure times of a day or more were made and the measured rates of Rn entry are given in Table 2.

Table 2: Results of extractions when most O rings in the stack were made from butyl rubber, but some were made from urethane.

Extraction Date	Exposure Time (days)	Rn entry rate (atoms/day)
16 Oct	5.98	269 +/- 13
17 Oct	0.92	115 +/- 26
21 Oct	3.95	123 +/- 10
25 Oct	3.99	81 +/- 10
6 Nov	12.00	72 +/- 8

Several additional extractions with exposure times of 1-2 hours were also made; their results are consistent with the values given in Table 2, but have a large error because of the very short exposure time. An additional extraction with zero exposure time was made to determine the background of the extraction apparatus. All procedures were identical to the other extractions, except the valve at the exit of the stack was kept closed. Its result was an effective entry rate of about 10 Rn atoms per day, small compared to the entry rate in any of the extractions.

As indicated in Table 1, the rate of Rn entry to the stack was high in the first extraction, gradually decreased in the next two extractions, and finally reached a value of 76 +/- 6 atoms/day. The high rate in the first extraction is probably due to residual Rn that was absorbed and slowly released by the stack components during the approximately five hours that were required to change the O rings and the stack was open to the mine air.

The total length of O ring during these measurements was 195 inches of butyl and 33.5 inches of urethane. If it is assumed that all the Rn observed in these measurements arose from diffusion through the O rings, then, simply scaling the all urethane rate by the fraction of O ring length that was urethane, the 5 remaining urethane rings are expected to give an entry rate of 720 x 33.5/(33.5 + 195) = 106/day. The observed rate is thus consistent with all the Rn coming through the urethane rings, with a negligible contribution from other sources.

Immediately after this series of measurements was completed, the stack was disassembled. The ends were welded so as to eliminate the need for the two number 153 O rings, a spoolpiece was removed to eliminate one of the number 218 rings, and the two other number 218 rings were replaced with rings made from butyl rubber (appropriate lengths of number 235 rings were cut and glued together). Four extractions with exposure times of more than a day have been made and the results are given in Table 3.

Table 3: Results of extractions when all O rings in the stack were made from butyl rubber.

Extraction	Exposure Time	Rn entry rate

Date	(days)	(atoms/day)
19 Nov	3.89	519 +/- 30
22 Nov	2.97	68 +/- 13
25 Nov	2.96	20 +/- 5
2 Dec	7.00	8 +/- 4

The first extraction has an anomalously high rate, probably again due to Rn that diffused into the surfaces during the nine days that the stack was open to the mine air. The rate gradually decreased during the next two extractions, and has now reached a value that is consistent with background extractions from the vacuum system.