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ELEVATED RADON AND THORON CONCENTRATIONS FROM NATURAL RADIOACTIVITY IN BUILDING MATERIALS

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Rio Algom had measured working levels in excess of 20 mWL in ground floor units of one of their new apartment buildings under construction. Since the building was nearing completion Rio Algom requested DSMA-Acres' assistance in locating the routes of radon entry.

We made measurements in the ground floor apartments which gave radon concentrations as high as 6.9 pCi/l and apparent working levels of 100 mWL when the apartment doors were closed. (Table 1). Almost without exception the working level was much higher than would be expected from the observed radon levels even at equilibrium, as illustrated by the equilibrium fractions.

It was noticed that adjacent apartments had similar working levels. Was this because the transfer rate between apartments was so high that the entire ground floor behaved as one large room, or was each apartment unit independent of its neighbours? A transfer rate test was conducted to answer these questions.

Sulphur hexafluoride (SF_6), a tracer gas, was released in unit 105. Air samples were taken in unit 105 and the adjacent unit 106 over a period of 10 hours. The samples were analysed on a Gas Chromatograph equipped with an Electron Capture detector and results plotted. (Figure 1).

A numerical analysis of the changes in SF_6 concentration in units 105 and 106 gave an estimated transfer period of 70 hours or a rate of approximately 2cfm. This very small transfer rate told us that each apartment unit behaved independently of adjacent apartments and so the similar WL's in the apartments was the result of similar radon supply rates into each apartment.

The change in SF_6 concentration in unit 105 also gave an estimate of the ventilation period which was a surprisingly long 23 hours per airchange or a rate of approximately 8 cfm. This ventilation period was longer than any previously measured in houses by a factor of 2.

We repeated the ventilation test in a third floor apartment. (Figure 2). The ventilation period here was 29 hours per air-change. The main reasons for these long ventilation periods was that the apartment doors and windows all fitted tightly, and the weather was generally calm during the period of measurements.

The long ventilation periods suggested that very small radon supply rates would produce the observed working levels. It was strongly suspected that the natural radioactivity of the building materials contributed a major portion of the radon gas observed.

Working level and radon concentrations were measured in second and third floor apartments (Table 2) and found to be comparable to those found on the ground floor. This showed that the WL's measured in the ground floor apartments were not entirely due to the entry of soil gas containing radon. The only source possible in the upper floor apartments was the building materials.

To calculate if the observed radon concentrations in these apartments agree with what could be expected from the natural radioactivity of the concrete and other building materials, we carried out a mass balance calculation as shown in Figure 3.

We considered only the poured concrete floor and ceiling of an apartment unit as a significant radon source for the block walls were not of local materials. The measured radon flux rate from the concrete was 560 $pCi/hr/m^2$, the equilibrium radon concentration expected under these conditions was 7.8 pCi/l.

The equilibrium radon concentration was comparable with the levels we had observed in the apartments confirming that building materials were the source of the radon. It is important to note that the concrete itself had normal radio-activity. The radon flux rate of 560 pCi/hr/m^2 was slightly higher than average for local concrete but not unusual. The radon production rate of concrete dust was measured and found to contain the equivalent of 0.3 pg emRa/g, which is comparable to the level measured in local sands and aggregates.

The working levels expected from the observed radon concentration would normally be 30 to 40 mWL. The observed working levels, however, ranged from 50 to 100 mWL. (Table 1 and 2). This suggested that thoron daughters (^{220}Ra) were contributing to the alpha activity of the filters used to estimate working level.

Air filters used to measure working levels in the apartments were kept for at least 12 hours after counting, and were then recounted to estimate the contribution to the alpha activity on the filters from thoron daughters. (Table 4).

Thoron daughters interferences was as high as 23 mWL of the apparent working level. This contribution from thoron daughters was high compared to an average interference of less than 2 mWL seen in houses. The corrected working levels were all within the range expected from the measured radon concentrations.

The ventilation period in a similar apartment unit in a building where the mechanical ventilation system was operating was 4 hours. In this building radon and working levels were low, as would be expected from the mass balance.

Since the mechanical ventilation system was not yet operating in the new building, small fans were temporarily installed in

selected units to produce a ventilation period of a few hours. Working levels and radon gas concentrations were reduced significantly in these units. (Table 5). The working levels were below 20 mWL and the radon concentrations were below 3 pCi/l. It was concluded that as long as the mechanical ventilation system in apartment building was operating, elevated radon, thoron and working levels would not be observed.

The apartment building did not have a radon supply problem. It was the long ventilation periods in individual apartments combined with the natural radioactivity of the building materials that produced the high WL's observed.

TABLE 1

TYPICAL WL AND RADON MEASUREMENTS IN GROUND FLOOR APARTMENT UNITS

UNIT NO.	WORKING LEVEL (mWL)	RADON (pCi/L)	EQUILIBRIUM FRACTION
104	71	6.7	1.1
105	56	4.0	1.4
	95	6.9	1.4
	100	6.9	1.4
	70	3.8	1.8
	61	4.9	1.2
106	59	6.2	0.95
	74	4.8	1.5

TABLE 2

TYPICAL WL AND RADON MEASUREMENTS
IN UPPER FLOOR APARTMENT UNITS

	WORKING LEVEL (MWL)	RADON (PCI/L)
SECOND FLOOR	46	2.2
	43	3.8
THIRD FLOOR	57	1.8
	53	7.5

TABLE 3

MASS BALANCE

AT EQUILIBRIUM

$$C_E = \frac{\text{SUPPLY RATE}}{\text{LOSS RATE}} \text{ pCi/LITRE}$$

SUPPLY = SURFACE AREA X RADON FLUX RATE

= 200 M^2 X 560 pCi/H/M^2

= 112,000 pCi/H

LOSS RATE = VOLUME X (VENTILATION RATE + DECAY RATE)

= 300 M^3 X (1/25 H + 1/132 H) X 1000 LITRE/M^3

= 14,000 LITRE/H

C_E = 7.8 pCi/LITRE

TABLE 4

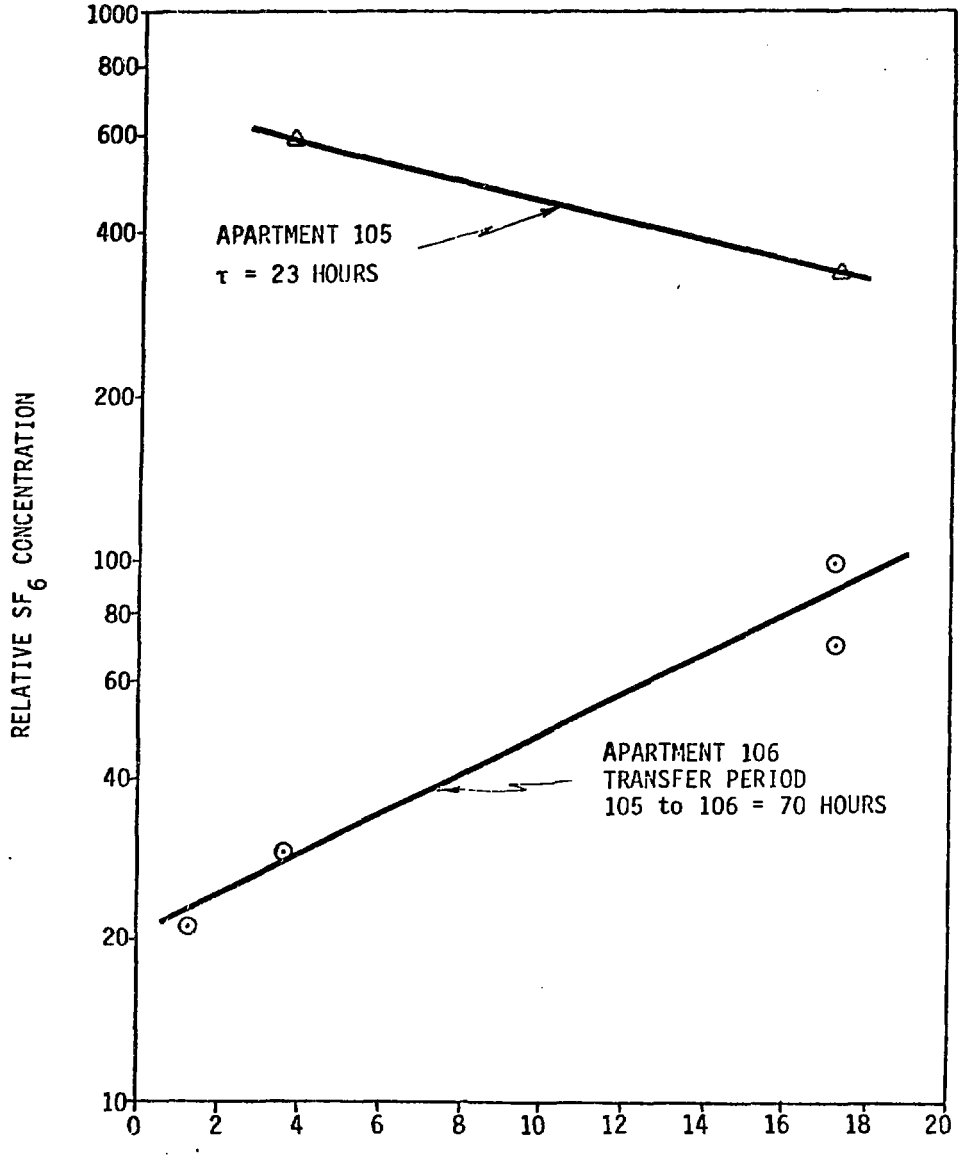
THORON INTERFERENCE WITH WL ESTIMATE

Apparent WL (mWL)	Thoron Contribution (mWL)	True WL (mWL)	% Over Estimate
38	11	27	40
46	17	29	60
25	7	18	40
34	12	22	55
34	23	11	210
43	9	34	25
53	20	33	60

TABLE 5

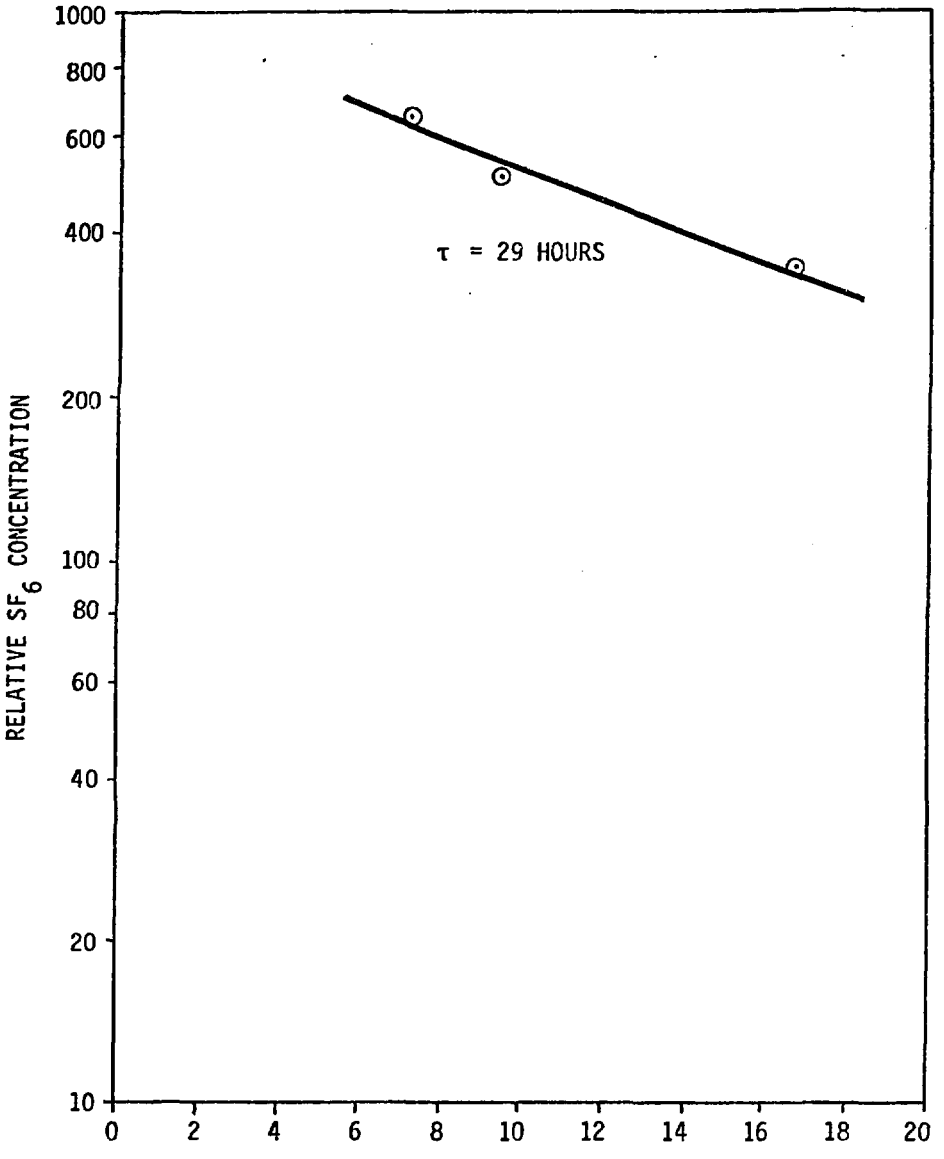
WL AND RADON MEASUREMENTS
IN GROUND FLOOR APARTMENT UNITS
AFTER INCREASING VENTILATION

UNIT NO.	WORKING LEVEL (mWL)	RADON (pCi/L)	EQUILIBRIUM FRACTION
105	16	1.9	0.8
	6	1.7	0.4
	11	2.2	0.5
	12	1.3	0.9
106	16	2.1	0.8
	4	1.5	0.3



TRANSFER PERIOD APARTMENT 105 to 106

FIGURE 1



VENTILATION PERIOD APARTMENT 308

TABLE 2

Elevated Radon and Thoron Concentrations From Natural Radioactivity in Building Materials

Questions/comments:

K. Cliff : The ventilation rates appear to be remarkably low.

In discussing ventilation rate measurements with our building research people, they indicated that they experienced problems with small leakages of SF_6 from sealed containers stored near the survey sites. They had to store the SF_6 containers about 3 miles downwind.

D. Smith : Our containers were stored about 5 miles away.

K. Cliff : Was the building occupied at the time of survey?

D. Smith : No, this was before the building was completed.

K. Cliff : It is unlikely that the occupants would be comfortable at these air exchange levels as odors etc. would be somewhat oppressive.

D. Smith : The building was not completed or occupied so the mechanical ventilation system that would normally pressurize the corridors was shut down.

K. Cliff : In talking with Arthur (Scott), he gives me the impression that he believes plate out is a major removal mechanism. Equilibrium fractions in excess of 1 would suggest that this isn't so.

A. Scott : Equilibrium fractions in excess of 1 were due to the presence of thoron daughters. If you correct for this, the equilibrium fractions become remarkably reasonable figures of .6, .7.

Since the building was recently constructed, the humidity was likely quite high due to water coming out of concrete. Also, plastering work was being done upstairs.

R. Eaton : How do you release your SF_6?

A. Scott : We fill two 5 ml. cells with SF_6 and pull the stops out to release it.

R. Washington : Did you check the half-life of thoron? Did you confirm that it is approximately 11 hrs.?

A. Scott : No, we waited 4 hours and counted.

R. Washington : Your results can be seriously affected if the second readings happen to be on alpha emitters of much longer activity such as uranium dust. I suspect that in most homes and buildings around uranium mining communities, there is a good deal of air-borne dust containing appreciable amounts of uranium.

A Scott : Some of the filters were left 48 hours by mistake and counted. The count rate was very low.

A. George : We did make measurements in uranium mines, and the question of uranium dust didn't seem to be a problem, so I don't expect it would be a problem indoors in houses.

D. Morley : We are doing SF_6 measurements also and are measuring air exchange rates of 29 hours.

A. Scott : We have measured some air exchange rates less than 29 hours.