

Radon Emissions from Radium-Dial Watches.

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Introduction – Context

Preliminary research during the latter half of 2011 has indicated that significant and potentially hazardous radon concentrations can arise from radium-dial watches stored in the built environment. Radium (²²⁶Ra) decays via alpha-particle emission to radon (²²²Rn); in addition, mesothorium (²²⁸Ra) and radiothorium (²²⁸Th) were also used in such watches and decay to thoron (²²⁰Rn).

Observation of such levels is largely unreported in the literature and our preliminary conclusion is that whilst collectors might be aware of the radiation hazard that arises directly from the radioactive material content of such watches, they are probably not aware of the large radon (and thoron) hazard that can arise, particularly if the watches are kept in a poorly ventilated room in a private house.

Sealed-Container Experiments

There were three sealed-container experiments.

In the first experiment, the Helvetia UK Military pocket watch (see Table 1) was placed in a sealed container (volume 7 L). A CR39 detector was placed in the container with watch. The detector was removed after two days and the etch revealed that it had been overwhelmed by α -particle strikes: the detector surface was saturated with irresolvable overlapping α -particle tracks, as shown in Figure 1. Similar results were obtained for other watches.

The second experiment was as the first experiment, for the same Helvetia pocket watch, but using a Sarad Doseman instead of the CR39 detector. The Doseman recorded an average radon concentration of 18.7 kBq m⁻³ over a 48 hour period.

In the third experiment, the less-active Newmark wrist watch (see Table 1) was placed in the same container with a CR39 detector and a RAD7 connected in a closed loop continuously monitoring the radon concentration. The CR39 detector was removed after 72 hours and the container resealed for a further 120 hours. The exponential increase of the radon concentration, with the step at 72 hours, is shown in Figure 2.

Watch Manufacture Details				Inferred Radium		
Make / Brand	Notes	Date	Origin	μ Ci	kBq	
Buren Grandprix / Bravingtons	UK Military G.S.T.P.	1930s	Swiss	1.000	37.000	P
Buren Grandprix / Bravingtons	UK Military G.S.T.P.	1930s	Swiss	0.688	25.438	P
Cyma		1940s	Swiss	0.563	20.813	P
Damas	UK Military G.S.T.P.	1940s	Swiss	0.313	11.563	P
Helevetia	UK Military G.S.T.P.	1930s	Swiss	0.938	34.688	P
Ingersoll Cadet	US "Dollar" Watch	1940s	USA	0.250	9.250	P
Ingersoll Radiolite	US "Dollar" Watch	1930s	USA	0.313	11.563	P
Ingersoll Waterbury	US "Dollar" Watch	1950s	USA	0.375	13.875	P
Ingersoll Triumph		1950s	UK	0.281	10.406	P
Ingraham Biltmore Radium	US "Dollar" Watch	1950s	USA	0.281	10.406	P
Ingraham Rex Radium	US "Dollar" Watch	1950s	USA	0.063	2.313	P
Moeris	UK Military G.S.T.P.	1940s	Swiss	1.063	39.313	P
Unsigned Military		1930s-40s	Swiss	0.750	27.750	P
Waltham	UK Navy	post 1941	USA	0.438	16.188	P
Westclox Pocket Ben		1950s	USA	0.188	6.938	P
Pocket Compass		1914-1918	Unkn'n	1.000	37.000	P
Arta	Liga Watch Factory	1949	Swiss	0.044	1.619	W
Avalon	Imp'd Swiss Movement	1960s	USA	0.063	2.313	W
Bulova (dial only)	US Military	1951	USA	0.313	11.563	W
Bulova (dial only)	US Military	1951	USA	0.188	6.938	W
Buren Eldis		1940s	Swiss	0.044	1.619	W
Buren		1950s	Swiss	0.125	4.625	W
Elgin		1960s	Swiss	0.031	1.156	W
Hamilton (dial only)		1920s	USA	0.031	1.156	W
Helvetia		1950s	Swiss	0.094	3.469	W
Ingersoll Triumph	Anglo-Celtic Watch Co.	1950s	UK	0.125	4.625	W
Ingersoll Wrist		1920s	USA	0.013	0.463	W
Ingraham St Regis Radium		1950s	USA	0.094	3.469	W
Moeris	UK Military A.T.P.	1940s	Swiss	0.875	32.375	W
Newmark		1950s	UK	0.063	2.313	W
Newmark		1950s	UK	0.188	6.938	W
Normandie		1940s	Swiss	0.125	4.625	W
Rodania		1950s	Swiss	0.094	3.469	W
Vertext		1940s-50s	Unkn'n	0.031	1.156	W
20 wristwatch hands		1930s-50s	UK	0.063	2.313	W

Key:
 G.S.T.P. General Service Timepiece/Temporary Pattern / General Service Tradde Pattern
 A.T.P. Army Time Piece
 P Pocket watch
 W Wrist watch

Table 1. Watch Data.

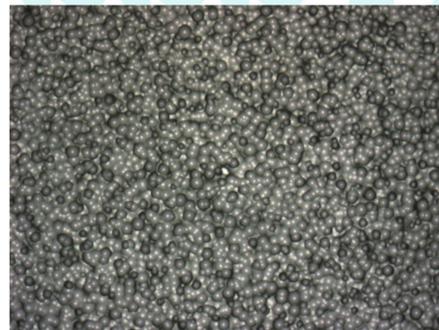


Fig 1. Overlapping α -particle tracks (x15). Helvetia UK Military Pocket Watch

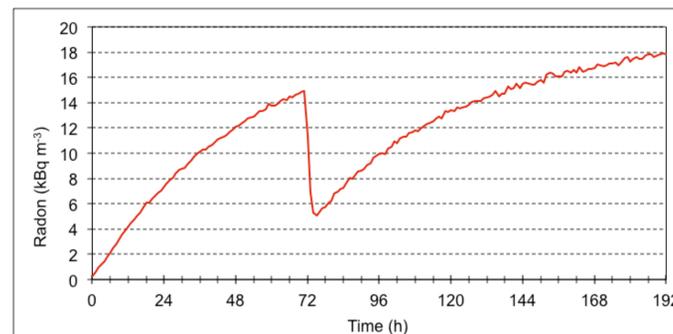


Fig 2. Radon Exponential Increase. Newmark Wrist Watch

Main Experiment

In the main experiments conducted to date, a set of radium-dial watches representative of a small private collection, was placed in a controlled access room, of volume 67 m³, that is continuously ventilated to the external environment. A ventilated room was chosen to minimise any health hazard that might arise from the radon emanations.

The radon concentration was monitored using a RAD7 placed adjacent to the set of watches. Two three-week records from May-July 2011 are shown in Figure 3.

The normal radon concentration at the maximum ventilation rate was ca. 10 Bq m⁻³. This rose to ca. 190-230 Bq m⁻³ following the placement of the watches in the room, again at maximum ventilation. When the ventilation rate decreased to a 'standby' setting, the radon concentration increased rapidly to ca. 2-3 kBq m⁻³, then decreased rapidly to the lower concentration when the ventilation rate returned to maximum.

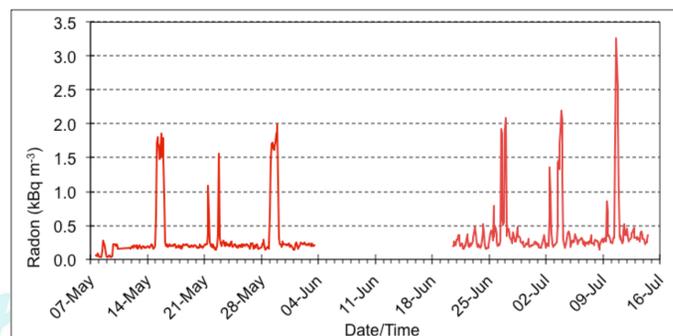


Fig 3. Radon Concentration in Room, May-July 2001.

Analysis

The three results...

1. Extrapolation of the Newmart wrist watch sealed-container experiment results indicates that the zero-ventilation equilibrium concentration in the 67 m³ room arising from the whole set of watches is on the order of 5 kBq m⁻³.

2. Calculation of the radon activity in the 67 m³ room based on the total inferred radium content (see Table 1) indicates that the zero-ventilation equilibrium concentration is on the order of 6 kBq m⁻³.

3. Monte-Carlo simulation using parameters derived from the actual radon concentration monitored in the 67 m³ room indicates that the zero-ventilation equilibrium concentration could exceed 10 kBq m⁻³, possibly 25-30 kBq m⁻³, in the effective sub-volume 'seen' by the RAD7.

All three figures are greatly in excess of the UK Action Levels; 200 Bq m⁻³ domestic, 400 Bq m⁻³ workplace.

Conclusions

The research has confirmed that there is also a risk to collectors from radon gas emitted from radium-dial watches. Routine radon concentrations of ca. 200 Bq m⁻³, i.e. the UK Domestic Action Level, peaking to over 3 kBq m⁻³, were recorded in this study: such levels represent a significant potential health hazard. Those peak levels accord with the estimated equilibrium concentration of ca. 5 kBq m⁻³ and 6 kBq m⁻³ derived from single-watch measurements and the inferred radium content respectively.

Also, it should be noted that the room volume of approximately 67 m³ is likely to be considerably larger than the volume of a typical private collector's storage space, implying higher concentrations would have been observed in such circumstances. There are considerable numbers of such watches that remain in circulation and these are readily collectible and are easily obtained through (online) auction sites such as eBay.

References

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- Baker, A.C., Toque, C., 2005. A review of the potential for radium from luminising activities to migrate in the environment. Journal of Radiological Protection, 25, 127-140.