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 (228Th) 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 the watch. The detector was removed after two days and the etch revealed that it had been overwhelmed by alpha-particle strikes: the detector surface was saturated with irresolvable overlapping alpha-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 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.

Table 1. Watch Data.

<table>
<thead>
<tr>
<th>Watch Details</th>
<th>Manufacture</th>
<th>Material of dial</th>
<th>Material of hands</th>
<th>Dial Colour</th>
<th>Hands Colour</th>
<th>Date of manufacture</th>
<th>Inferred Radium Content (kBq m⁻³)</th>
<th>CR39</th>
<th>RAD7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helvetia UK Military Wrist Watch</td>
<td>UK Military</td>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
<td>White</td>
<td>Black</td>
<td>1940</td>
<td>0.188</td>
<td>3.2</td>
<td>0.2</td>
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<tr>
<td>Swiss Military G.S.T.P.</td>
<td>Swiss</td>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
<td>White</td>
<td>Black</td>
<td>1951</td>
<td>0.250</td>
<td>3.2</td>
<td>0.2</td>
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<tr>
<td>US Military Pocket Watch</td>
<td>USA</td>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
<td>White</td>
<td>Black</td>
<td>1951</td>
<td>0.250</td>
<td>3.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Pocket Watch</td>
<td>USA</td>
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<td>Stainless Steel</td>
<td>White</td>
<td>Black</td>
<td>1960</td>
<td>0.375</td>
<td>3.2</td>
<td>0.2</td>
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</tbody>
</table>

Main Experiment

In the main experiment 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.

Analysis

The three results...

1. Extrapolation of the Newmark 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 of the actual radon concentration monitored in the 67 m³ room indicates that the zero-ventilation equilibrium concentration could exceed 10 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