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Confidential

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date : 08 April 2015

reference : 912887/15.132054 C&S/GdW/VL

subject : Thoron exhalation measurement and dose assessment for a concrete building material

Introduction

In this document the findings from a thoron exhalation measurement and thoron dose assessment are reported. Measurement of the thoron exhalation is performed on a concrete building material - code 5850 - using the protocol described by De With et al.[1]. Based on the experimental findings the annual effective dose from thoron is estimated for a typical Israeli room constructed with this type of concrete.

Thoron exhalation measurement

Principles of the method

The test setup is derived from the test arrangement used for measuring the radon exhalation rate from building materials. This arrangement and the required test procedures are described in the Dutch standard NEN 5699[2]. For the determination of the thoron exhalation rate, the test setup is adjusted and equipped with an active thoron Si-detector (RAD7; Durridge Company, Billerica, MA, USA). The detection is based on an alpha spectrometry technique and determines the thoron concentration from thoron's short-lived progeny nuclide, ^{216}Po. The Si-detector is added to the test setup together with an active drying unit. In addition, the exhalation chamber is equipped with an additional internal fan to ensure uniform mixing of the exhaled thoron. For accurate climate control, the exhalation chamber is equipped with an electronic temperature control, which is set at 20^{o}C . The chamber, with a volume of 32 L, is purged with nitrogen with a flow of 300 mL·min^{-1} and 50% relative humidity. Data acquisition of temperature, humidity, flow rates, and thoron concentration is done continuously. A picture of the test setup is presented in Figure 1 followed by a schematic view in Figure 2.

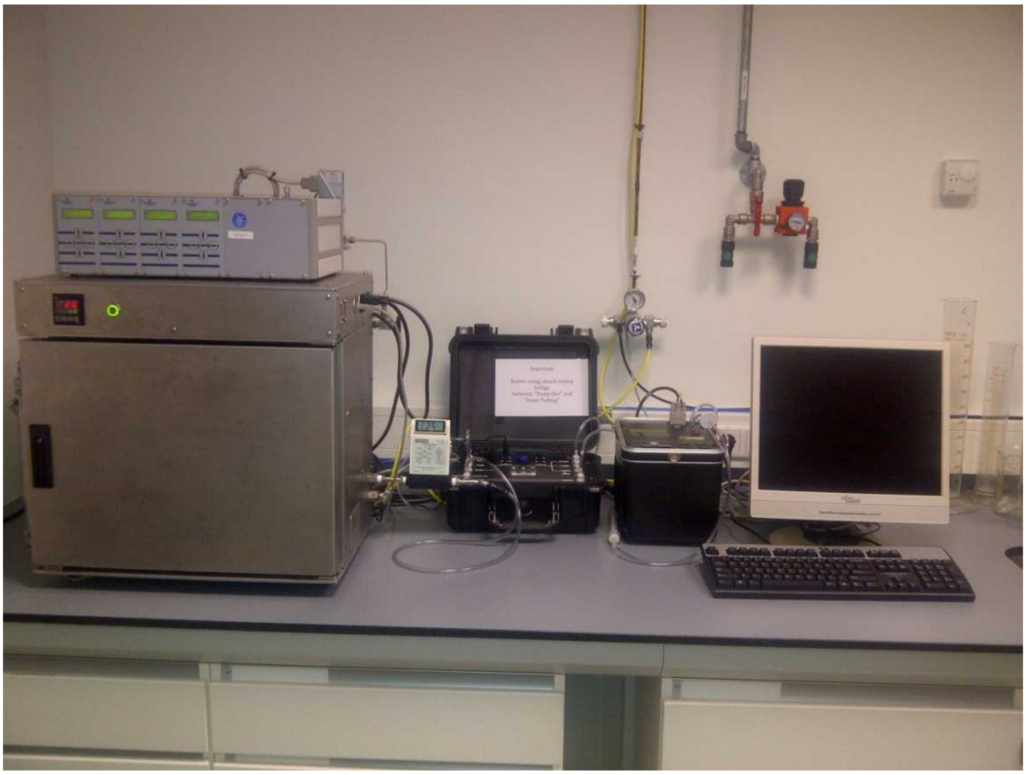

Figure 1 Photo of the thoron test facility.

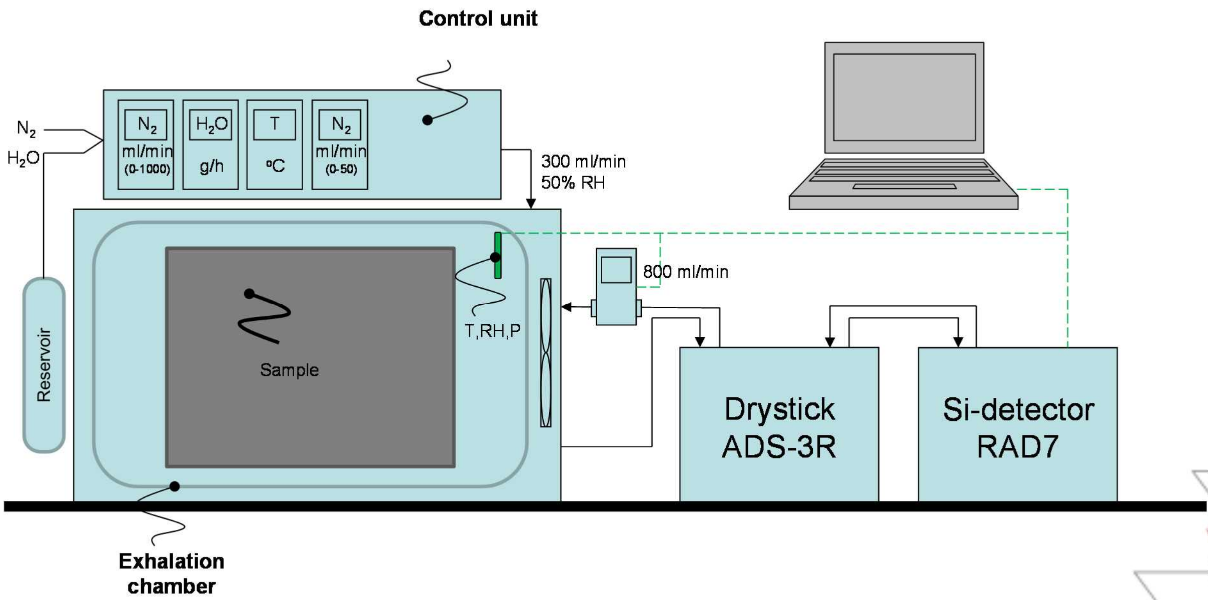

Figure 2 Schematic view of the thoron test facility.

Sample pre-treatment

The test samples for the ^{222}Rn exhalation rate measurements are conditioned at a temperature of 20ºC and a relative humidity of 50 %.

Results

The results from the thoron exhalation measurement are presented in Table 1. The standard deviation (SD) is based on the uncertainty due to counting statistics and the uncertainty in the calibration factor of the detector. Due to the short half-life of thoron of 56 s only the thoron formed in the outer layer of the material is exhaled. Therefore, thoron exhalation is a surface phenomenon; hence, the exhalation is expressed in terms of exhalation rate per unit area.

Table 1 Sample specifications and thoron exhalation rate expressed in $mBq \cdot s^{-1}$ and $mBq \cdot m^{-2} \cdot s^{-1}$.

Sample code	Surface (m^2)	Exhalation rate ($mBq \cdot s^{-1}$) x	($mBq \cdot s^{-1}$) SD	($mBq \cdot m^{-2} \cdot s^{-1}$) x	($mBq \cdot m^{-2} \cdot s^{-1}$) SD	(%) SD
5850	0.35	31	4	90	12	13

Effective dose from thoron

The annual effective dose from inhalation of the short-lived ^{220}Rn progeny is based on the so-called equilibrium equivalent ^{220}Rn concentration (C_{eq}^{220}). The equilibrium equivalent concentration in $Bq \cdot m^3$ is computed using the following rule of thumb as proposed by Zhuo and Tokonami[3]:

$$C_{eq}^{220} = 3.35 E_{Tn} A_{Tn} / V \, , \qquad (6)$$

where E_{Tn} is the thoron exhalation rate ($Bq \cdot m^{-2} \cdot s^{-1}$), A_{Tn} is the surface area of the building material (m^2) and V is the room volume (m^3). Based on a typical room volume of 24.3 m^3 and a surface area for the concrete of 47.4 m^2 the concentration C_{eq}^{220} becomes 0.58 $Bq \cdot m^3$. To convert the equilibrium equivalent concentration into an effective dose rate, a conversion factor of 40 $nSv \cdot h^{-1}$ per $Bq \cdot m^{-3}$ is applied[4]. The time spent indoors is taken as 7000 h per year (80% of the total time). Based on this calculation the annual effective thoron dose for building material no. 5850 is 0.16 mSv. In this approach possible effects from paint and wall paper on the thoron exhalation are not considered.

References

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[4] UNSCEAR (2000).
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