SP REPORT

Necoflex Ltd
Kilcoole Industrial Est.
Kilcoole, Greystones
Co. Wicklow
Ireland

Handläggare, enhet / *Handled by, department*
Ingemar Nilsson, Building Physics, cj
+46 33 16 51 72, ingemar.nilsson@sp.se

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Test assignment

(2 appendices)

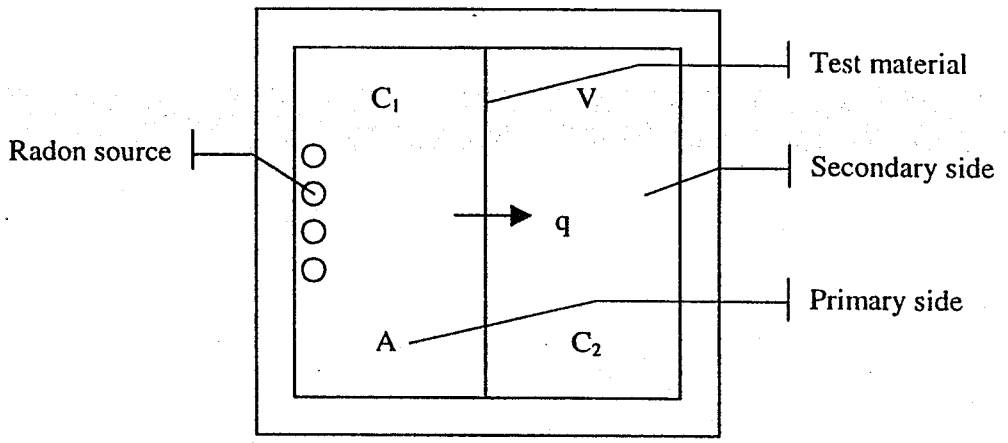
The assignment is to determine the radon transmittance and radon permeability through the membrane product Monarflex RMB. The material was sent to us by the test sponsor, Mr Peter Mercier of Necoflex Ltd, Ireland. The sample arrived at SP (SP Swedish National Testing and Research Institute) on March 10, 1999.

Description of the test material

According to the written description provided by the test sponsor, the material is 0.4 mm (minimum thickness according to the test sponsor) low density polyethylene, of red colour, and has a reinforcing mesh grid of 12 x 9 mm. The sample we received corresponds with the written description. See Appendix 1 for a photograph of the material.

Test equipment

Testing is carried out in a test chamber comprising two boxes of aluminium. Each box measures 400 x 400 x 80 mm. The test sample is placed between the boxes. Then the sides are tightened very carefully, so that the connection between the boxes is airtight. A diagram of the test apparatus is presented in Figure 1 below. See also appendix 2 for a photograph.



The designations C_1, V etc. are described under Theory.

Figure 1. Test equipment

Radon source

The radon source is a block of aerated concrete which contains a small amount of radium. The radioactive decay of radium will produce radon gas (Rn-222) which is emitted to the atmosphere in the primary chamber. Rn-222 is also radioactive and its first decay product (RnD) is Polonium-218. Radon decay products (RnD) are not gases but particles, and cannot pass the test specimen by diffusion.

Instrumentation

The radon concentration on each side of the test specimen is determined by instruments of type RM3 produced by Alnor. The measuring principle used in these instruments is to determine the concentration of Polonium-218 and convert it into radon concentration assuming an invariable relationship between the Rn and Po concentrations.

The instruments were calibrated at the Swedish Radiation Protection Institute in March 1999.

Pre-test conditioning of material

The materials were stored in 23±2 °C and 50±5 % RH for 22 days before the test.

Test room

Testing was carried out in a room with approximately 50 % relative humidity, and a temperature of 20-21 °C. The ambient air pressure varied between 982 and 995 kPa during the test. These conditions were continuously monitored throughout the full duration of the test (7 days).

The background radon activity in the room was <50 Bq/m^3 before and <50 Bq/m^3 after the test.

Theory

The emission of radon from the radon source will lead to a build-up of the radon concentration on the primary side and a difference in radon concentration between the primary and the secondary side. This difference will cause a flow of radon by diffusion through the test specimen. Only the radon gas (Rn) and not the radon decay products (RnD) will pass the test specimen.

The radon transmittance is determined by measuring the radon concentration on both sides of the test specimen, as the radon is flowing through the test material. In evaluating the radon transmission, it is assumed that the radon concentration difference over the full area of the test specimen is constant and that the effects of radon gas decomposition are negligible.

The density of radon flow through the test specimen is written

$$q = P \cdot (C_1 - C_2)$$

where q = density of radon flow (Bq/m^2 · s)
P = radon transmittance (m/s)
C_1, C_2 = radon concentration on both sides of the test specimen (Bq/m^3)

The differential equation for the radon concentration build-up in the receiver box (C_2) is

$$\frac{dC_2}{dt} = \frac{P \cdot (C_1 - C_2) \cdot A}{V}$$

where t = time (s)
A = test specimen area (m^2)
V = receiver box volume (m^3)

and since $C_2 = 0$ at $t = 0$

$$C_2 = t \cdot \frac{A}{V} \cdot P \cdot (C_1 - C_2)$$

or

$$P = \frac{C_2}{C_1 - C_2} \cdot \frac{V}{A \cdot t}$$

Sometimes the radon resistance (Z s/m) rather than the radon transmittance is used

$$Z = \frac{1}{P} = \frac{C_1 - C_2}{C_2} \cdot \frac{A \cdot t}{V}$$

For test specimens made of homogenous materials a radon permeability can be determined

$$k = \frac{d}{Z} = P \cdot d = \frac{C_2}{C_1 - C_2} \cdot \frac{V}{A \cdot t} \cdot d$$

where k = radon permeability (m^2/s)
d = test specimen thickness (m)

Test results

The test commenced on March 10, 1999 and was terminated on April 2, 1999. The results given in the table below are subject to the following constraints: the surface of the test material is 0.16 m^2, and the volume of the receiver box is 0.0128 m^3.

Radon content		Time, s	Radon transmittance, P (m/s)	Radon permeability, k (m^2/s)	Air pressure, kPa
Primary side, Bq/m^3	Secondary side, Bq/m^3				
14 740	310	99 300	$17 \cdot 10^{-9}$	$7 \cdot 10^{-12}$	995
18 310	500	155 100	$14 \cdot 10^{-9}$	$6 \cdot 10^{-12}$	995
21 150	590	187 500	$12 \cdot 10^{-9}$	$5 \cdot 10^{-12}$	994
23 740	700	242 700	$10 \cdot 10^{-9}$	$4 \cdot 10^{-12}$	993

Dependent on the uncertainty of the measurements the radon transmittance of the material can be estimated at $12\text{-}18 \cdot 10^{-9}$ m/s and the radon permeability at $5\text{-}8 \cdot 10^{-12}$ m^2/s.

Measurement uncertainty

The uncertainty in measured radon content is estimated to ±5 %. Additional uncertainties might arise, such as the quality of the material, instruments etc. This uncertainty is estimated to ±5 %, i.e. the total uncertainty of the measurement is estimated to ±10 %.

Comments

The test results are only valid for the tested specimen.

SP Swedish National Testing and Research Institute
Building Diagnostics

Per Ingvar Sandberg
Technical Manager

Ingemar Nilsson
Technical Officer

Appendices
1 Photograph of test material – Monarflex RMB
2 Photograph of test equipment

Photograph of test material – Monarflex RMB