REPORT

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Test assignment

(2 appendices)

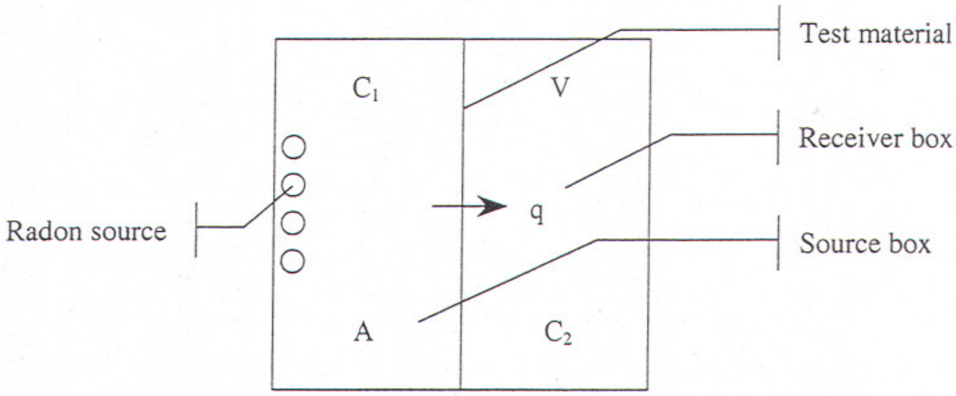
The assignment is to determine the radon transmittance and radon permeability through the material. The material was sent to us by the test sponsor. The sample arrived at SP (SP Swedish National Testing and Research Institute) on September 20, 2000.

Description of the test material

The test material was DELTA-Maurwerkssperre with joint sealed with sealing compound "Rhodia 5C". The thickness of the test material was 400 µm.

Test equipment

Testing is carried out in a test chamber comprising two boxes of stainless steel. Each box measures 410 x 385 x 95 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.



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 source box. 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 Atmos 33 produced by Gammadata in Sweden. 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 instrument was calibrated at the Swedish Radiation Protection Institute on June 16, 2000.

Pre-test conditioning of material

The material was stored in 23±2 °C and 50±3 % RH for 5 days before the test.

Test room

Testing was carried out in a room with approximately 51±3 % relative humidity, and a temperature of 22.0-22.5 °C. The ambient air pressure varied between 988 and 1005 hPa during the tests. These conditions were continuously monitored throughout the full duration of the test (5 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 in the source box and a difference in radon concentration between the source and receiver box. 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 in both the source and receiver box is increasing linearly with time during a time interval t_1 to t_2. Radon gas decomposition is considered only in the receiver box.

The density of radon flow through the test specimen is written

$$q = P \cdot (C_1 - C_2) \tag{1}$$

where q = density of radon flow ($Bq/m^2 \cdot s$)
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

$$\frac{dC_2}{dt} = P \cdot (C_1 - C_2) \cdot \frac{A}{V} - \lambda \cdot C_2 \tag{2}$$

where t = time (s)
A = test specimen area (m^2)
V = receiver box volume (m^3)
λ = $2{,}1 \cdot 10^{-6}$ decay constant (s^{-1})

With $C_1 = a + b \cdot C_2$ equation (2) becomes

$$\frac{dC_2}{(a + b \cdot C_2 - C_2) \cdot \frac{P \cdot A}{V} - \lambda \cdot C_2} = dt \tag{3}$$

or

$$\frac{dC_2}{a + C_2 \cdot \left(b - 1 - \frac{\lambda \cdot V}{P \cdot A} \right)} = \frac{P \cdot A}{V} \cdot dt \tag{4}$$

Integration between t_1 and t_2 and C_2^1 and C_2^2 gives

$$\frac{1}{b - 1 - \frac{\lambda \cdot V}{P \cdot A}} \cdot \ln \left[\frac{a + \left(b - 1 - \frac{\lambda \cdot V}{P \cdot A} \right) \cdot C_2^1}{a + \left(b - 1 - \frac{\lambda \cdot V}{P \cdot A} \right) \cdot C_2^2} \right] = \frac{P \cdot A}{V} \cdot (t_1 - t_2) \tag{5}$$

From equation (5) P is calculated.

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

$$Z = \frac{1}{P} \tag{6}$$

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

$$k = \frac{d}{Z} = P \cdot d \tag{7}$$

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

The first readings of C_1 and C_2 are taken at the earliest 4 h after the test commenced and further readings are taken once or twice every day.

Calculation and presentation of transmittance/permeability is done as soon as both the C_1- and C_2-curves are linear with time. The results are presented for the whole period with linear curves, normally a period of 2-6 days.

Test results

The test commenced on September 25, 2000 and was terminated on September 29, 2000. The results given in the table below are subject to the following constraints: the surface area of the test material is 0.09 m^2, and the volume of the receiver box is 0.0150 m^3.

Source box		Receiver box		Air pressure[1], hPa
Radon concentration, Bq/m^3	Time, s	Radon concentration, Bq/m^3	Time, s	
3540	18000	30	14400	1005
13330	93600	175	86400	1005
20040	169200	475	165600	999
25300	259200	920	252000	989
30000	342000	1130	338400	988

The radon transmittance of the material is calculated to

$P = 50 \cdot 10^{-9}$ m/s

and the radon permeability (assuming thickness of test specimen 0.0004 m) to

$k = 20 \cdot 10^{-12}$ m^2/s.

[1] Recorded in connection with the reading of the radon concentration in the receiver box.

Measurement uncertainty

The uncertainty in measured radon content is estimated to ±5 %. Additional uncertainties might arise, primarily from the method of evaluation. This uncertainty is estimated to ±10 %, i.e. the total uncertainty of the measurement is estimated to ±15 %.

Comments

The test results are only valid for the tested specimen.

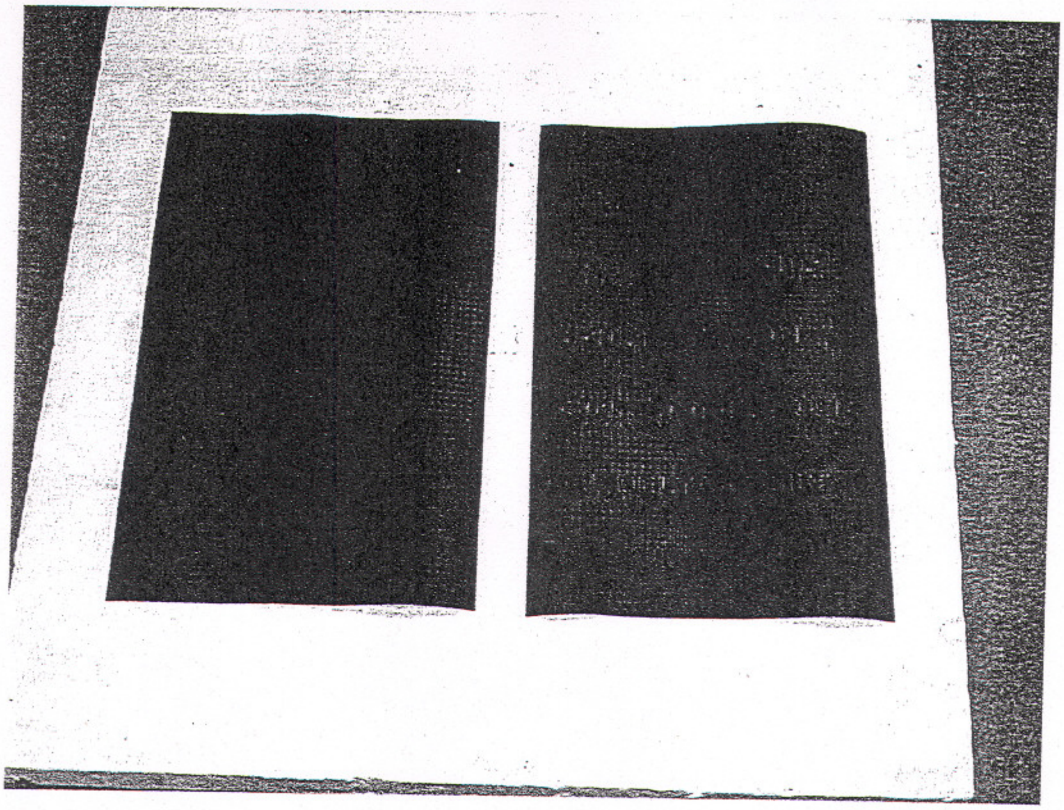
SP Swedish National Testing and Research Institute
Building Diagnostics

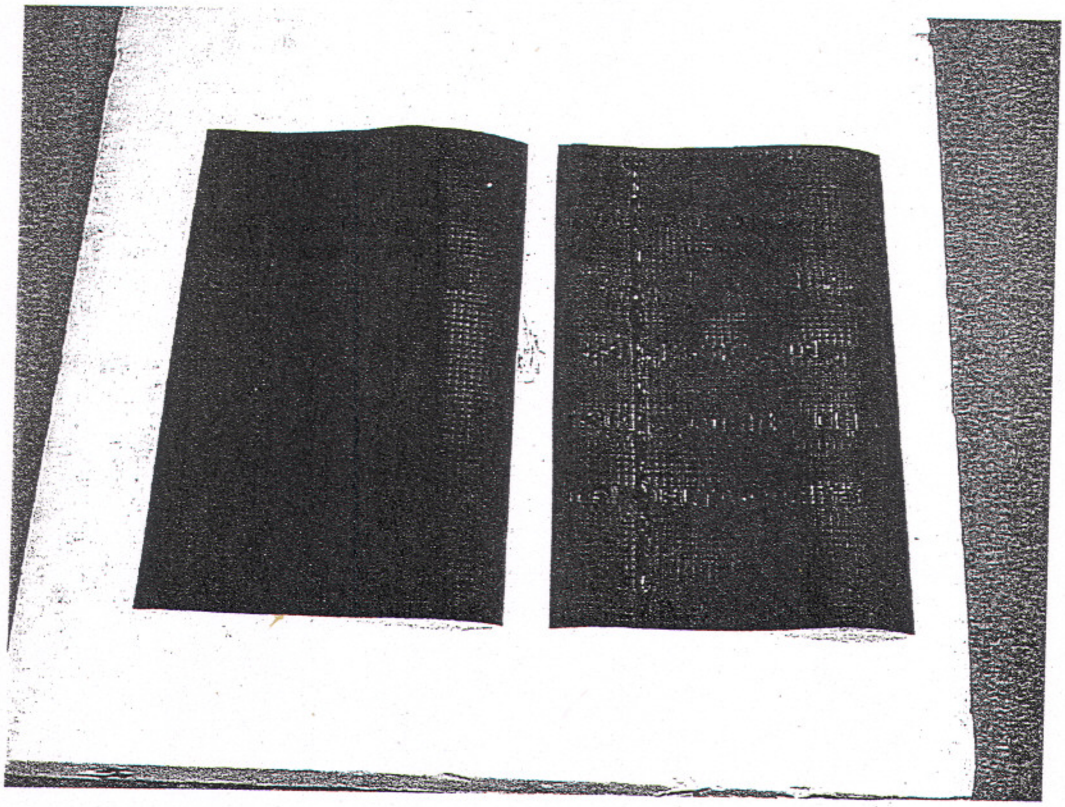
Per Ingvar Sandberg
Technical Manager

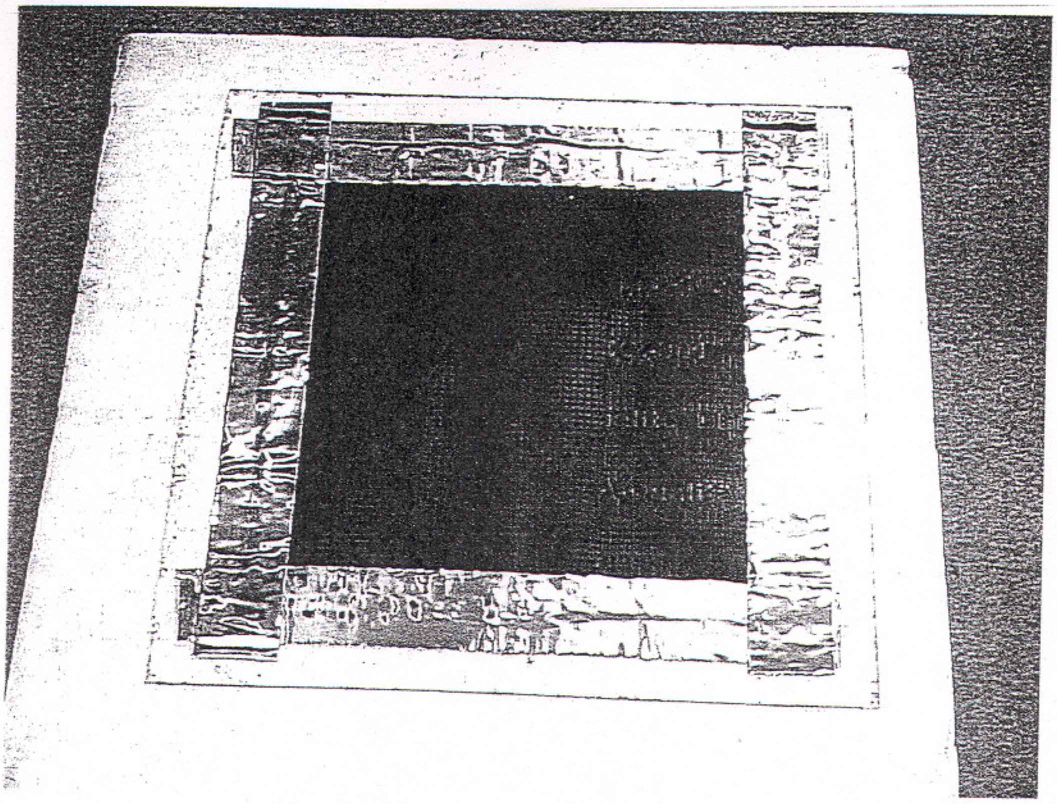
Ingemar Nilsson
Technical Officer

Appendices
1 Photograph of test material
2 Photograph of test equipment

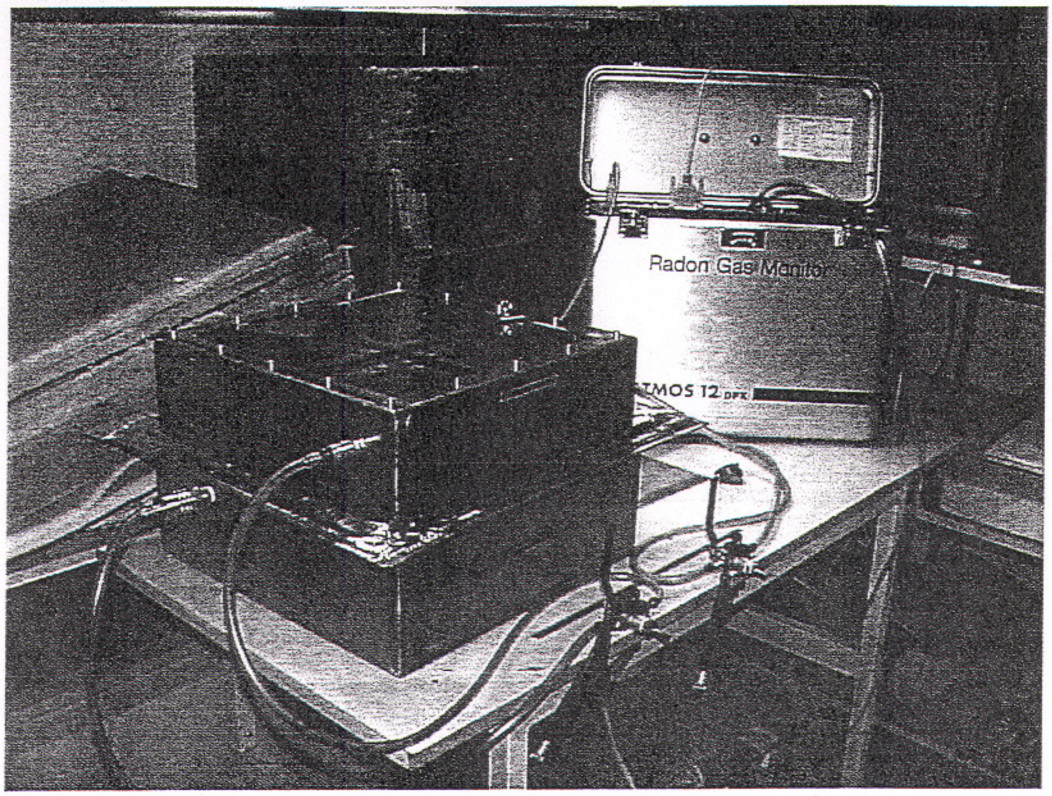
Photograph of test material







Photograph of test equipment



Byggnadsfysik

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2000-11-09

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An example of calculation of indoor radon concentration in a building with a ground radon barrier (DELTA-Maurwerkssperre with joint)

The following calculation assumes that there are ***no*** radon-emitting materials in the structure of the building.

Given:

Room volume $V = 29\ m^3$
Surface area $A = 12\ m^2$ (to the ground)
Radon concentration in the ground $C_m = 50\ 000\ Bq/m^3$
Ventilation air change rate in the room $n = 0{,}5$ air changes/h

The radon flow P from the ground to the building is given by

$P = k \bullet (C_m - C_i) / d$ Bq/m²s

where k = the radon permeability $20 \cdot 10^{-12}\ m^2/s$ (DELTA-Maurwerkssperre with joint)

where $d = 0{,}0004$ m (your materials thickness)

This gives a radon flow rate (P) of 0,0025 Bq/m²s

The indoor radon concentration, C_i, can be expressed as the outdoor concentration (C_u) plus the quantity of radon emitted to the indoor air from the ground.

The indoor radon concentration, $C_i = C_u + \dfrac{P \cdot A \cdot 3\,600}{n \cdot V}$

This gives an indoor radon concentration of 7 Bq/m³ plus the outdoor radon concentration (C_u), which is assumed to be 0 Bq/m

With best regards

Ingemar Nilsson

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