Handled by, department
Agneta Olsson-Jonsson
Energy Technology
+46 10 516 51 86, agneta.olsson-jonsson@sp.se

Isola AS, Fabrikk Platon
Richard I. Waterhouse
Lienfossveien 5
N-3678 NOTODDEN
Norge

This is a translation from the Swedish original document. In the event of any dispute as to the content of document, the Swedish text shall take precedence.

Test of radon transmission and permeability on one material

(3 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 Technical Research Institute of Sweden) on 26 May 2008, without visible damages.

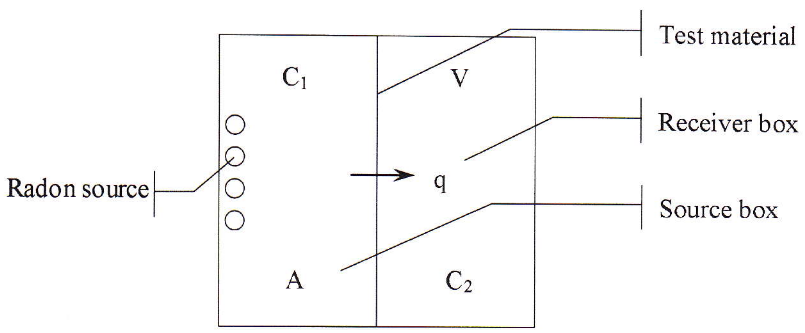
Description of the test material

The test material was named Platon RadonStop 400 PEL, thickness about 0.4 mm. The material was green on both sides (Appendix 1).

The material was tested without any joint.

Test equipment

Testing is carried out in a test chamber comprising two boxes of stainless steel. Each box measures 500 x 500 mm. The deep of the receiver box is 104 mm and the deep of the source box is 170 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

Postal address
SP
Box 857
SE-501 15 Borås
SWEDEN

Office location
Västeråsen
Brinellgatan 4
SE-504 62 Borås
SWEDEN

Phone / Fax / E-mail
+46 10 516 50 00
+46 33 13 55 02
info@sp.se

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, SP No. 202266, 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 August 27 2007.

Test room

Testing was carried out in a room with relative humidity of 46 %, and a temperature of 22.5-22.7 °C. The ambient air pressure varied between 980 and 995 hPa. 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

$$q = P \cdot (C_1 - C_2) \qquad (1)$$

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

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

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

Platon RadonStop 400 PEL

The test commenced on 9 June 2008, and was terminated on 13 June 2008. The results given in the table below are subject to the following constraints: the surface area of the test material is 0.2490 m², and the volume of the receiver box is 0.0260 m³.

Receiver box, C_2		Source box, C_1		Air pressure[1], hPa
Radon concentration, Bq/m³	Time, s	Radon concentration, Bq/m³	Time, s	
12	21 600	2 996	28 800	995
74	90 000	9 724	100 800	986
235	176 400	15 820	187 200	980
432	262 800	20 916	273 600	982
671	349 200	25 144	360 000	983

The radon transmittance of the material is calculated to

$P = 18.5 \cdot 10^{-9}$ m/s

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

$k = 7.4 \cdot 10^{-12}$ m²/s

Measurement uncertainty

The expanded uncertainty of the measurement is estimated to ±21 %, including coverage factor k = 2. The uncertainty of temperature is ±2 °C and of relative humidity ±5 % in the test room.

Comments

The test results are only valid for the tested specimen.

SP Technical Research Institute of Sweden
Energy Technology - Building Physics and Indoor Environment

Ingemar Nilsson
Technical Manager

Agneta Olsson-Jonsson
Technical Officer

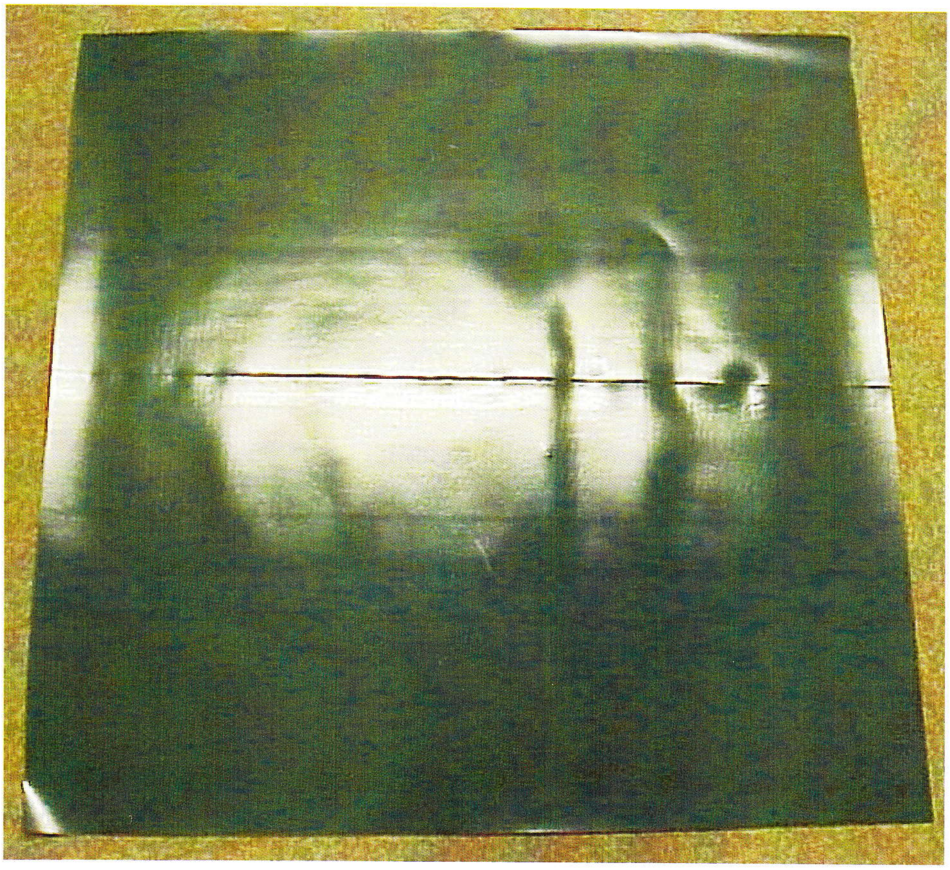
Appendices

Photograph of test sample
Photograph of test equipment
An example of calculation of radon concentration in a crawl space with ground radon barrier

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

Appendix 1

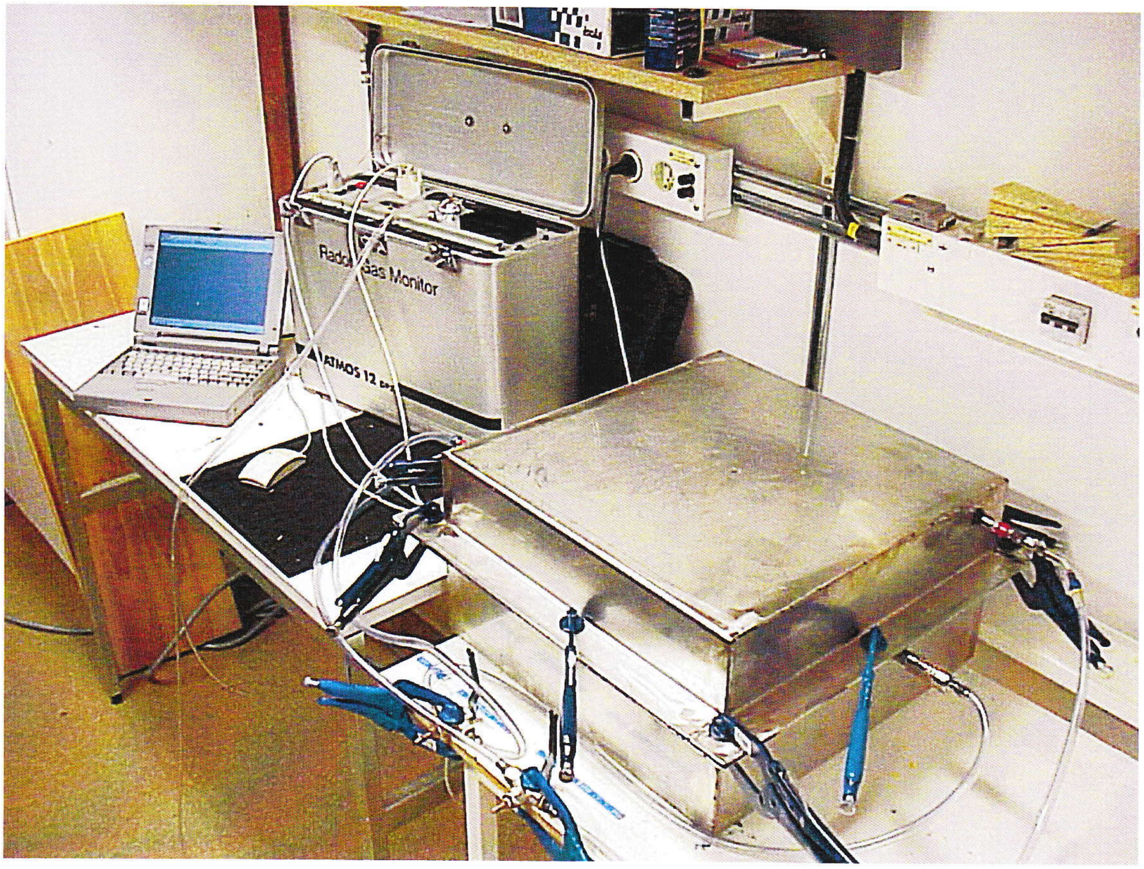
Photograph of test sample



Platon RadonStop 400 PEL

Appendix 2

Photograph of test equipment



Appendix 3

An example of calculation of radon concentration in a crawl space with ground radon barrier

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

Given

Crawl space area A = 100 m² (to the ground)
Crawl space height = 0.5 m
Crawl space volume V = 50 m³
Radon concentration in the ground C_g = 50 000 Bq/m³
Ventilation air change rate in the crawl space n = 0.5 air changes/h

Calculation

The radon flow, q, from the ground to the crawl space is given by

$$q = P \cdot (C_g - C_i) \qquad \text{Bq/m}^2\text{s}$$

where P = the radon transmittance (m/s)
C_i = the radon concentration in the crawl space (Bq/m³)

For the material Platon RadonStop 400 PEL, P is calculated to $18.5 \cdot 10^{-9}$ m/s (see test report).

Assuming that C_i is small compared to C_g this gives a radon flow rate q = 0.000925 Bq/m²s.

The radon concentration in the crawl space, C_i, can be expressed as the outdoor concentration, C_e, plus the quantity of radon emitted to the crawl space from the ground.

The radon concentration, C_i, in the crawl space can be calculated

$$C_i = C_e + \frac{q \cdot A \cdot 3600}{n \cdot V}$$

This gives a radon concentration in the crawl space of about 13 Bq/m³ plus the outdoor radon concentration (C_e), which is assumed to be 0 Bq/m³.

The same calculation as above, except for an air change rate of 0.1 air changes/h, gives a radon concentration in the crawl space of about 65 Bq/m³.

Note

This type of calculation can be used for barriers applicable to protect against ground radon. It assumes that joints, inlets and connections are radon tight. The value of P in the calculation above, is valid for the material without any joints.