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TEST REPORT No: 124036/2015

upon the test : **Radon diffusion coefficient of the bitumen coating ÖKOPLAST® 2K 20B carried out in accordance with the method K124/02/95 (method C of ISO/DIS 11665-10)**

Client:

Heinrich Hahne GmbH & Co. KG
Heinrich-Hahne-Weg 11
457 11 Datteln
Germany

Date of issue: 14.8.2015

Approved by:

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Prof. Ing. Richard Wasserbauer, DrSc.
head of laboratory OL 124

The measurement of the radon diffusion coefficient of the polymer modified bitumen coating Ökoplast® 2K 20B was performed in accordance with the requirements for determination of the radon diffusion coefficient stated in the ISO/DIS 11665-10 standard. The test was carried out during the period from 24.7.2015 to 14.8.2015.

Test samples

Test samples were cut from the material handed by the client (V. Valvoda) on 10.6.2015. The samples were registered with marks 23/15/J (1 to 4) by M. Jiránek. The test samples were 160 mm in diameter and their thickness was from 2,17 mm to 2,69 mm.

Test method

Radon diffusion coefficient was measured according to the accredited method K124/02/95 (method C of ISO/DIS 11665-10). The tested sample is placed between two containers. Radon diffuses from the lower container, which is connected to the radon source, through the sample to the upper container. When the steady state concentration profile within the sample is reached, the growth of radon concentration in the upper container is measured. From the known time dependent curve of the radon concentration increase in the upper container the radon diffusion coefficient can be calculated. The test method was approved by the State Office for Nuclear Safety on 6.8.1998.

Laboratory conditions

Ökoplast® 2K 20B – material
Steady state radon concentration in the lower container: 7,9 ± 1,1 MBq/m^3
Radon supply rate into the upper container: 0,6 ± 0,1 Bq/m^3s

Measuring device: radon monitor RDA 200 (N12), micrometer (N11)
Laboratory temperature: 23°C ± 2°C
Relative humidity of air in the laboratory: 35% ± 4%
Pressure difference between the lower and the upper containers: 0 Pa

Test results

The results of performed tests are compiled in the following table:

TESTED MATERIAL	RADON DIFFUSION COEFFICIENT D (m^2/s)	
	mean value	**uncertainty**
Ökoplast® 2K 20B	$1,0.10^{-11}$	$\pm 0,1.10^{-11}$

The stated uncertainty of the measurement is the uncertainty with the coefficient k = 2, which for the normal distribution corresponds to the probability of coverage approx. 95 %.

Recommendation

Applicability of the tested material to a radon-proof membrane can be in a particular case considered in accordance with national building codes or standards, for example CSN 73 0601.

The test was performed by: Doc. Ing. Martin Jiránek, CSc.
The report was prepared by: Doc. Ing. Martin Jiránek, CSc.

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test manager

end of the report

How to use the value of the radon diffusion coefficient for the design of a radon barrier

1. Czech Technical Standard CSN 73 0601

Under the conditions that the insulation is placed over the entire area of structures in direct contact with the soil, all joints between sheets are airtight and any penetration of utility entries through the insulation is properly sealed, we can consider the convective transport of radon to be negligible. Therefore it is possible to assume that the radon supply rate into the house with continuous tanking is created only by the diffusion through the insulation. Based on this simplification the highest permissible radon exhalation rate into the house, E_{lim}, can be expressed by equation (1):

$$E_{\lim} = \frac{C_{dif}.V.n}{A_f + A_w} \qquad (\mathrm{Bq/m^2h}) \qquad (1)$$

where V is the interior air volume (m^3), n is the air exchange rate (h^{-1}), A_f is the floor area in direct contact with the soil (m^2), A_w is the area of the basement walls in direct contact with the soil (m^2) and C_{dif} is a fraction of the reference level for indoor radon concentration C_{ref} caused by diffusion. The value of C_{dif} can be estimated, for example according to the Czech standard ČSN 730601 as 10%. This means that the importance of the diffusion is reduced to 10 % of C_{ref} and the remaining 90 % of C_{ref} is reserved for the accidentally occurring convection.

In this context, the thickness of the radon-proof insulation can be derived with respect to real geological and building characteristics from the condition that the radon exhalation rate E from the real insulation in a real house calculated according to equation (2) must be less or equal to the highest permissible radon exhalation rate E_{lim} calculated for that house, i.e. $E \leq E_{lim}$.

$$E = \alpha_1 . l . \lambda . C_S \frac{1}{\sinh(d/l)} \qquad (\mathrm{Bq/m^2h}) \qquad (2)$$

where C_s is the radon concentration in the soil gas (Bq/m^3) measured on the building site, λ is the radon decay constant (0,00756 h^{-1}), d is the thickness of the radon-proof insulation (m), l is the radon diffusion length in the insulation $l = (D/\lambda)^{1/2}$ (m), D is the radon diffusion coefficient in the insulation (m^2/h) and α_l is the safety factor (we can assume that $\alpha_l = 1$).

On the assumption that the insulation is homogeneous, its minimal thickness can be calculated from equation (3) obtained after the replacement of E in the equation (2) by E_{lim} from equation (1).

$$d \geq l.\mathrm{arcsinh} \frac{\alpha_1 . l . \lambda . C_s .(A_f + A_w)}{C_{dif} . n . V} \qquad (\mathrm{m}) \qquad (3)$$

2. Prof Keller requirement (Germany)

A material is considered radon-tight, if its thickness is at least three times greater than is the diffusion length of radon in the material.

Radon diffusion length is calculated according to the equation (4).

$$l = (D/\lambda)^{1/2} \qquad (\mathrm{m}) \qquad (4)$$

Minimum thickness of the insulation is calculated from the equation (5).

$$d \geq 3l \qquad \text{(m)} \qquad (5)$$

Results for Ökoplast® 2K 20B

Radon diffusion coefficient of **Ökoplast® 2K 20B** is $1{,}0.10^{-11}$ m^2/s.

Radon diffusion length of **Ökoplast® 2K 20B** is 2,2 mm.

Minimum thickness of the **Ökoplast® 2K 20B** coating that is according to prof Keller radon-tight is 6,6 mm.