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FACULTY OF CIVIL ENGINEERING – TEST LABORATORY
Test laboratory No. 1048 accredited by ČIA according to
ČSN EN ISO/IEC 17025:2018
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TEST REPORT No: 124042/2021

upon the test : **Determination of the radon diffusion coefficient
of VOLTEX GB-500 membrane carried out in accordance
with the ISO/TS 11665-13**

Client's name and address:

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CETCO Sp. z o.o. S.K.A.
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Date of issue: 26.7.2021

Approved by:




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prof. Ing. Martin Jiránek, CSc.
head of OL 124 laboratory

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Subject of the test: VOLTEX GB-500 – GB-500 multilayer polymeric membrane integrally bonded to VOLTEX geomembrane

Testing procedure: Determination of the radon diffusion coefficient

Test regulation: ISO/TS 11665-13, method A

Test execution date: 16.7.2021 – 23.7.2021

Test execution place: laboratory OL124 – D2044d

Test samples

Test samples were cut from the material handed by the client representative Łukasz Mikoda on 16.7.2021. The samples were registered with marks 29/21/J (1 to 3) by M. Jiránek. The dimensions of the samples were 135 x 325 mm (effective area 293.10^{-4} m²) and their thickness was 0,50 mm. As required by ISO/TS 11665-13, the permeable surface layers (VOLTEX geomembrane) shall be removed from the sample before testing. For this reason, the same samples as for the GB-500 membrane without geomembrane were used to determine the diffusion coefficient of VOLTEX GP-500.

Test method

Radon diffusion coefficient was determined according to the method A of ISO/TS 11665-13. The tested samples were placed between the source and the receiver containers. Radon diffuses through the samples from the source container, which is connected to the radon source RF 100, to the receiver containers. Concentrations on both sides of the tested samples are measured continuously by radon detectors TSR-4 of the TERA system (receiver containers) and current mode ionization chambers (source container). Radon diffusion coefficient was derived from the process of fitting the numerical solution to the curves of radon concentration measured in the receiver containers. Numerical solution is based on the one-dimensional time-dependent diffusion equation describing radon transport through the tested material.

Laboratory conditions

VOLTEX GB-500 – material

Steady state radon concentration in the source container: $4,6 \pm 0,1$ MBq/m³

Maximum radon concentration in the receiver containers: $0,4 \pm 0,1$ kBq/m³

Laboratory temperature: $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$

Relative humidity of air in the laboratory: $49\% \pm 3\%$

Pressure difference between the lower and the upper containers: $1 \text{ Pa} \pm 1 \text{ Pa}$

Test device

Radon detectors TSR-4 of the TERA system (N17)
Measuring system with ionization chambers operating in current mode (N14)
Radon concentration measuring system RM-2 (N15)
Micrometer (N11)

Test results

The resulting values of the radon diffusion coefficient, the radon diffusion length and the radon resistance including expanded measurement uncertainty, are listed in the following table. The results refer to the samples as they were taken over.

TESTED MATERIAL		VOLTEX GB-500
RN DIFFUSION COEFFICIENT D (m ² /s)	mean value	$7,1 \cdot 10^{-14}$
	$\pm U$	$\pm 0,8 \cdot 10^{-14}$
RN DIFFUSION LENGTH l (m)	mean value	$1,8 \cdot 10^{-4}$
	$\pm U$	$\pm 0,2 \cdot 10^{-4}$
RN RESISTANCE R_{Rn} (Ms/m)	mean value	19 557
	$\pm U$	$\pm 2 327$

The expanded uncertainties of measurement $\pm U$ mentioned are the product of standard measurement uncertainties and the expansion coefficient $k = 2$, which provides a confidence interval of approx. 95 %. The radon diffusion length was calculated according to the equation $l = \sqrt{D/\lambda}$ and the radon resistance as follows: $R_{Rn} = \frac{\sinh(d/l)}{\lambda \cdot l}$, where $\lambda = 2,1 \cdot 10^{-6} \text{ s}^{-1}$ and $d = 0,50 \text{ mm} = 0,50 \cdot 10^{-3} \text{ m}$.

The test was performed by: prof. Ing. Martin Jiránek, CSc., Ing. Veronika Kačmaříková, Ph.D.

The report was prepared by: prof. Ing. Martin Jiránek, CSc.