BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

Dr. Joachim Kemski
von der IHK Bonn/Rhein-Sieg öffentlich bestellter und vereidigter
Sachverständiger für Radon

Prüfbericht 2015061501d
Abdichtungsbahn „DualProof“
15.6.2015

Translation
of
Report 2015061501d

Provision of the Radon Diffusion Co-Efficient
and Radon Diffusion Length
for the sealing membrane “DualProof”

Proposer:	BPA GmbH Behringstrasse 10 D-71083 Herrenberg
Assignment Date:	11.05.2015
Test Period:	03.06.2015 to 10.06.2015

This report is 8 pages including cover page.

HRB Nr. 244565 Amtsgericht Stuttgart | Gerichtsstand Böblingen | USt.ID-Nr. DE 812566450 | Steuer-Nr. 5602040026
Geschäftsführer: Dipl.-Ing., Dipl.-Wirtsch.-Ing. Adrian Pflieger | Isabella Huthmacher-Pflieger (Dipl.-Betriebswirtin/FH)
Volksbank Hbg-Nagold-Rtbg eG BLZ 603 913 10 | KTO 709 701 004 | IBAN: DE92 6039 1310 0709 7010 04 | BIC: GENODES1VBH
Kreissparkasse Tübingen BLZ 641 500 20 | KTO 2 452 106 | IBAN: DE81 6415 0020 0002 4521 06 | BIC: SOLADES1TUB

BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

1. Assignment

The company BPA GmbH, Herrenberg, hereby authorise Radon Test Office of Dr. Kemski from 11.05.2016 to perform a test of the radon inhibition capabilities of the DualProof sealing membrane.

DualProof is a PVC membrane with a Polypropylene fleece on one side. The total thickness of the membrane, including the fleece, amounts to 2.1mm (The PP Fleece weighs 200g/m²). The thickness of the PVC Layer is 1.2mm.

The request included the provision of the Radon diffusion co-efficient and the Radon diffusion length of the materials.

2. Method

There are many different methods in use worldwide for the reporting of the Radon diffusion co-efficient substantially based on measurement of the Radon flow. The specimen is placed between two chambers to determine the rate of Radon flow between the chambers. The first chamber contains a radon source which provides a steady production of radon gas. The second chamber is measured for changes in the concentration of Radon Gas caused by the possible Radon flow from the first chamber through the specimen sample of material into the second chamber.

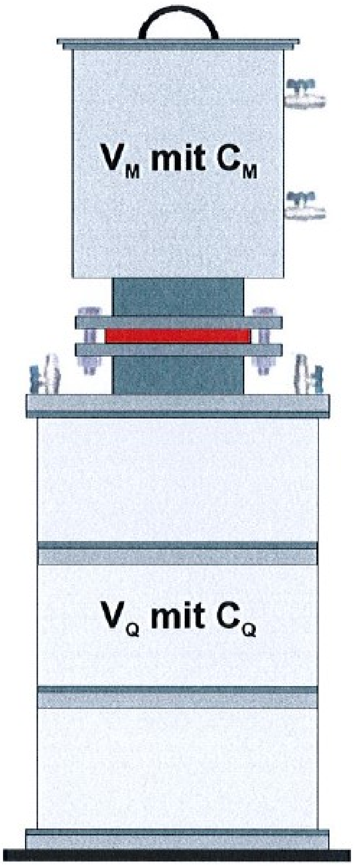
In Germany, there is no unified process exist for the testing of Radon gas tightness of a sealing (waterproofing material) however DIN ISO 11665-10 sets out a test method for determining the radio activity in the air of Radon 222. Part 10 sets of the provision for determining the diffusion co-efficient in waterproofing/ sealing membranes by means of measuring the active concentration in the air. This will be the basis for the test undertaken.

The method being used closely follows the DIN- design. The diagrams, which follow, illustrate the measurement method used.

HRB Nr. 244565 Amtsgericht Stuttgart | Gerichtsstand Böblingen | USt.ID-Nr. DE 812566450 | Steuer-Nr. 5602040026
Geschäftsführer: Dipl.-Ing., Dipl.-Wirtsch.-Ing. Adrian Pflieger | Isabella Huthmacher-Pflieger (Dipl.-Betriebswirtin/FH)
Volksbank Hbg-Nagold-Rtbg eG BLZ 603 913 10 | KTO 709 701 004 | IBAN: DE92 6039 1310 0709 7010 04 | BIC: GENODES1VBH
Kreissparkasse Tübingen BLZ 641 500 20 | KTO 2 452 106 | IBAN: DE81 6415 0020 0002 4521 06 | BIC: SOLADES1TUB

BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

The following are the parameter applied:



Vq = Volume of the Source Chamber = 0,2m³

Vm = Volume of the Measuring Chamber = 0,05m³

Cq = Active Radon concentration equilibrium in the Source Chamber (Bq m^{-3}, is being measured)

Cm = Active Radon concentration in the measuring chamber (Bq m^{-3}, the increase in Radon concentration is being measured)

The measurement method is being applied under ‘steady state’ conditions as outlined in 2. Fick’schen’s Law using the following equation:

Formula:

$$\frac{\partial c(x,t)}{\partial t} = D\frac{\partial^2 c(x,t)}{\partial x^2} - \lambda c(x,t) = 0$$

With

D = the Radon diffusion co-efficient ($m^2\ s^{-1}$),

c(x, t) = c(x) **=** Radon concentration in the specimen sample (Bq m^{-3})

λ = Decay constant of Radon 222 (0,0000021 s^{-1})

HRB Nr. 244565 Amtsgericht Stuttgart | Gerichtsstand Böblingen | USt.ID-Nr. DE 812566450 | Steuer-Nr. 5602040026
Geschäftsführer: Dipl.-Ing., Dipl.-Wirtsch.-Ing. Adrian Pflieger | Isabella Huthmacher-Pflieger (Dipl.-Betriebswirtin/FH)
Volksbank Hbg-Nagold-Rtbg eG BLZ 603 913 10 | KTO 709 701 004 | IBAN: DE92 6039 1310 0709 7010 04 | BIC: GENODES1VBH
Kreissparkasse Tübingen BLZ 641 500 20 | KTO 2 452 106 | IBAN: DE81 6415 0020 0002 4521 06 | BIC: SOLADES1TUB
tuev-sued.de

BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

With the boundary conditions constant the Active Radon Concentration in the Reservoir and in the measuring, Chamber balances the Radon flow and disintegration in both chambers. The following formula enables the solving of the of the mass of Radon diffused:

Formula

$$\cosh\left(\frac{d}{L}\right) = \frac{C_Q}{C_M}\left[1 - \frac{1 - \left(\frac{C_M}{C_Q}\right)^2}{\frac{V_Q}{V_M}\left(\frac{f}{\lambda V_Q C_Q} - 1\right) + 1}\right]$$

With

d = Thickness of the Probe (m): here 0,0021m

L = Diffusion length (m) with $L = \sqrt{\frac{D}{\lambda}}$.

f = Radon production rate from source (Bq s^{-1})

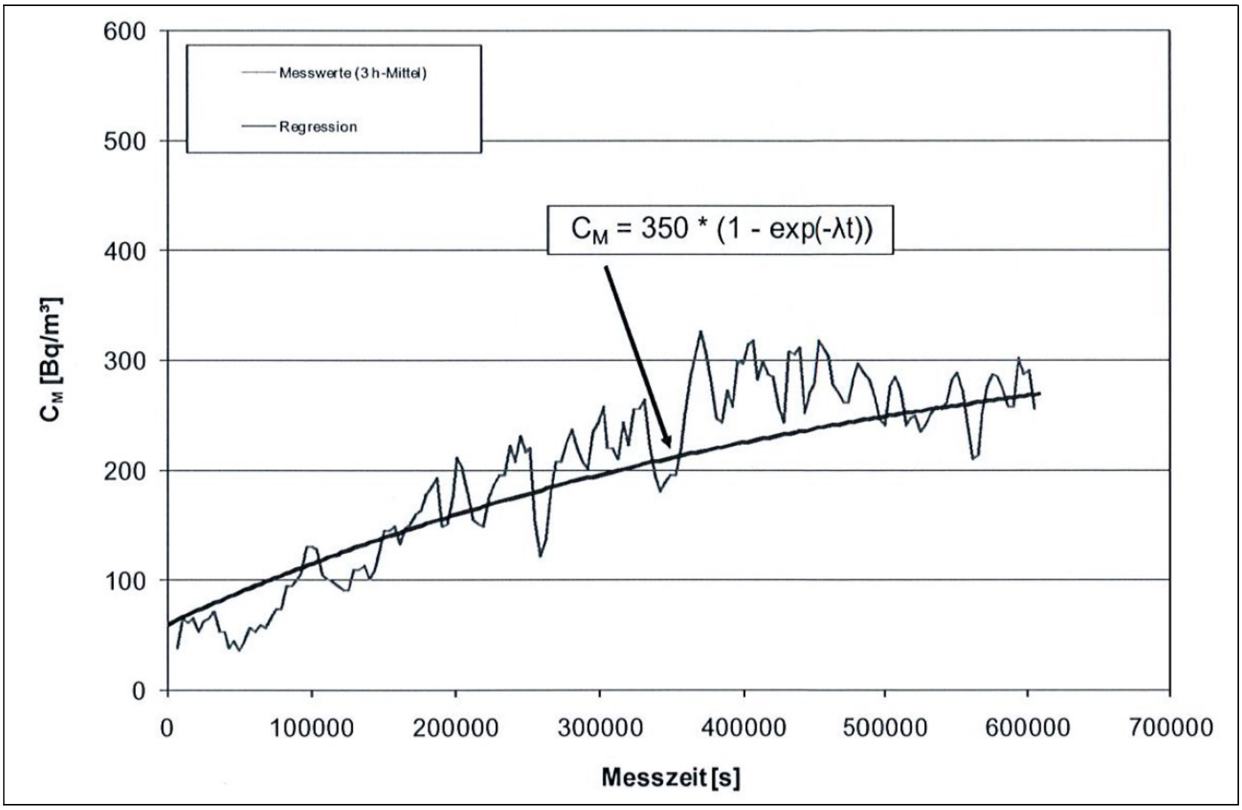
The active Radon concentration in the measuring chamber is calculated by the non-linear regression of the concentration from the resolved measurement curve.

3. Performing of the Test

The material specimens were examined from 03.06.2015 to 10.06.2015 in the measurement method as described above. The probe had strong swelling at two different points The measurement curve with the adapted equilibrium are shown in illustration 1 and 2. The calculations reflect the parameters of standard deviation. The deviation of L and D are calculated on this basis.

Experiment 1:

Measuring device in the Measuring Chamber: RadonScout, calibrated by The Federal Office for Radon Protection.
Measuring Device in the Source Chamber: Alpha Guard, calibrated by The Federal Office for Radon Protection.



Picture 1: Measured values and adjustment experiment 1

C_Q = **47.000 Bq m^{-3}** ± 10 %

C_M = **350 Bq m^{-3}** ± 15 %

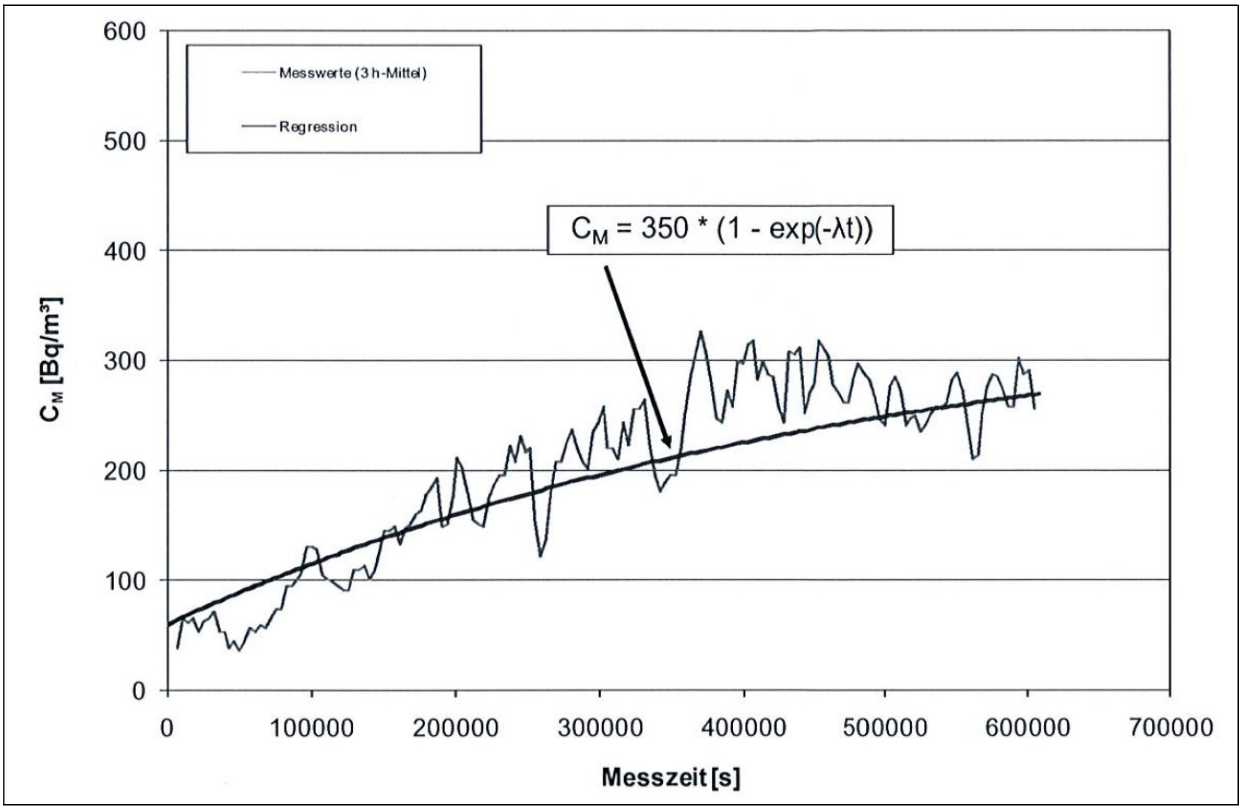
L_1 = **0,396 mm** (0,380 – 0,414 mm)

D_1 = **3,29 E^{-13} m^2 s^{-1}** (3,03E^{-13} – 3,59 E^{-13} m^2 s^{-1})

BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

Experiment 2:

Measuring device in the Measuring Chamber: RadonScout, calibrated by The Federal Office for Radon Protection.
Measuring Device in the Source Chamber: Alpha Guard, calibrated by The Federal Office for Radon Protection.



Picture 2: Measured values and adjustment experiment 2

C_Q = **130.000 Bq m^{-3}** ± 10 %

C_M = **580 Bq m^{-3}** ± 15 %

L_2 = **0,361 mm** (0,380 – 0,414 mm)

D_2 = **2,74 E^{-13} m^2 s^{-1}** (2,54E^{-13} – 2,96 E^{-13} m^2 s^{-1})

BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

Result: The average/mean value of the measurement, rounded off to the third decimal:

Radon Diffusion Co-Efficient	**D= 3,02 E^{-13} m^2 s^{-1}**
Radon Diffusion Length	**L= 0.379 mm**

These results prove that 'DualProof' acts as a passive radon barrier.

It is suitable for use in buildings to prevent radon migration.

Country specific regulations must be observed.

Explanation of the above rating:

In **Germany**, according to the research work of G. Kellar, University of Saarland, there is a convention that membrane materials are referred to as radon gas tight when their thickness **'d'** is greater that the threefold diffusion length **'L'** (d ≥ 3 L).

For the waterproofing membrane 'DualProof' applies: d = 2,1 mm ≥ 3 L (= 1,137 mm).

4. Remarks

The tests were carried out on the samples provided by BPA-GmbH. The samples have been used up. The measurements were carried out under standardized laboratory conditions. The material was tested according to the manufacturer's specifications (e.g. foil with adhesive, thickness of thick coating). It is not possible to determine the conditions for use in construction.

The results of the radon tightness test can only be applied to materials that are identical to the sample supplied and tested. Deviations in thickness, composition and material age will invalidate the test certificate. For a general correctness and validity no liability is taken over.

When the material is used over large areas, the proper processing of the material at impacts, penetrations and detail seals according to the corresponding technical data sheet of BPA-GmbH plays an

BPA GmbH | Behringstraße 12 | DE-71083 Herrenberg
TEL +49 (0)7032 89 399-0 | FAX +49 (0)7032 89 399-29
MAIL info@bpa-waterproofing.com | **bpa-waterproofing.com**

important role for the function as a radon diffusion barrier. The investigation of these detailed solutions was not the subject of this test.

This test report may only be passed on completely and unchanged. Extracts or abbreviations must be authorised by the issuer of the report.

The certificate is valid for five years from the test date.

Bonn, 15.06.2015

J. Kemski

Dr. Joachim Kemski

von der Industrie- und Handelskammer Bonn/Rhein-Sieg
Dr. rer. nat. Dipl.-Geol.
Joachim Kemski
Sachverständiger für
Radon
öffentlich bestellt und vereidigt

HRB Nr. 244565 Amtsgericht Stuttgart | Gerichtsstand Böblingen | USt.ID-Nr. DE 812566450 | Steuer-Nr. 5602040026
Geschäftsführer: Dipl.-Ing., Dipl.-Wirtsch.-Ing. Adrian Pflieger | Isabella Huthmacher-Pflieger (Dipl.-Betriebswirtin/FH)
Volksbank Hbg-Nagold-Rtbg eG BLZ 603 913 10 | KTO 709 701 004 | IBAN: DE92 6039 1310 0709 7010 04 | BIC: GENODES1VBH
Kreissparkasse Tübingen BLZ 641 500 20 | KTO 2 452 106 | IBAN: DE81 6415 0020 0002 4521 06 | BIC: SOLADES1TUB