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Water vapour permeability though

fibre and foil laminate and foil coating

with application of RADWAG moisture analyzers series MAX 50

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CONTENT

1. Introduction

Permeability of products like plasters is an important issue, as it provides safety on one hand, and gives comfort of use on the other. Thus, tests on this parameter require thorough attention. One should stress here, that tests on water vapour permeability through unwoven cloth does not have one standard, and so there is no reference to the test.

In order to establish permeability parameters, a series of comparison tests on various kinds of plasters have been performed with application of RADWAG moisture analyzer series MAX 50 and Sampler 2000. The test aimed at designing an alternative methodology with much shorter drying time. Presently used drying method requires sampling for 24 hours.

2. Description of reference method for water vapour permeability

A method which is defined as referential, requires weighing vessels, analytical balance, and climatic room with adjustable temperature and humidity. The test is perfored according to below specified schema:

- Pour distilled water to weighing vessels (approximately 20ml), stick selected samples onto tops of weighing vessels, and stabilization of samples for 15 minutes.
- Determination of weighing vessel mass in stable laboratory conditions:
    - Temperature 20ºC ÷ 25ºC ± 0,5 ºC
    - Humidity 30% ÷ 50 ± 2%
- Place samples in climatic room in test conditions, i.e. temperature 40ºC and humidity 20%, sampling time in the specified conditions 24 hours.
- Take the samples out of climatic room, stabilize samples in laboratory conditions for 15 minutes and weigh them.

The main drawback of the above specified method is its very long duration, and need to control the climatic room with maintaining specific parameters for period of 24 hours. Rests obtained with this test method are listed in the latter part of this publication.

2.1. Results of water vapour permeability with application of reference method

Rests obtained with reference method are listed in below chart.

Name	Water vapour permeability	Average value	Minimal value	Tolerance
	$g/m^2/24h$	$g/m^2/24h$	$g/m^2/24h$	15% average
Fibre laminate R21601	2730,6	2441,9	1000	366,3
	2305,7			
	2289,3			
Micropore coating NG	3500,4	3710,3 /not compatible/	4200	556,5
	3716,4			
	4033,1			
	3591,1			
Foil laminate Minifol	1599,7	1541,7	1000	231,2
	1672.4			
	1353,1			

3. Description of method for testing water vapour permeability with application of RADWAG moisture analyzers

Testing water vapour permeability with application of moisture analyzers is determining the decrement of water mass that has evapourated from weighing vessel covered with tested plaster. Water vapour permeates through tested plaster as result of increased temperature and pressure inside the sampler.

A measuring device used in this method is a moisture analyzer, which consists of:

- Precision balance with 1mg readability,
- Drying chamber equipped with set of halogen lamps,
- Temperature sensor and converting circuits with digital display.

A moisture analyzer is to determine a mass in a measuring process. Automatic circuit with feedback from temperature sensor and halogen lamps maintains temperature at set value, and electronic circuits are responsible for processing data and displaying them on moisture analyzer display. Data are processed automatically, without operator's interference and in set time interval. Data are sent to a computer with PomiarWin software or to a printer.

If a computer with PomiarWin is applied, than collected data are used for creation of a graph from drying procedure. The graph indicates the speed at which water vapour permeates through tested sample.

Water vapour permeability is expressed by a formula $[\frac{mg}{cm^2 * h}]$ which stands for quantity of water vapour that permeates through a substance (plaster).

3.1. Test conditions

Ambient conditions control requires monitoring of temperature and humidity. Room temperature should be set between 20°C and 25°C and relative humidity should not exceed thresholds between 30% and 50% . Temperature changes during test cycle should not exceed ± 2°C, and humidity ± 5 %. It is assumed, that temperature of drying chamber in which a sampler is located during the test is stable.

3.2. Instruments and substances used for the test

A workstation for testing water vapour permeability should be equipped with below specified instruments and substances:

- A moisture analyzer with 1 mg readability
- Sampler 2000
- Thermohigrometer /for control and record of ambient conditions /
- A pipette /for transport of distilled water /
- Distilled water
- Control thermometer PT 101 / control of distilled water temperature and control of temperature inside drying chamber of a moisture analyzer /optional equipment /
- PC computer with software PomiarWin /optional equipment /
- KAFKA thermal printer /optional equipment /

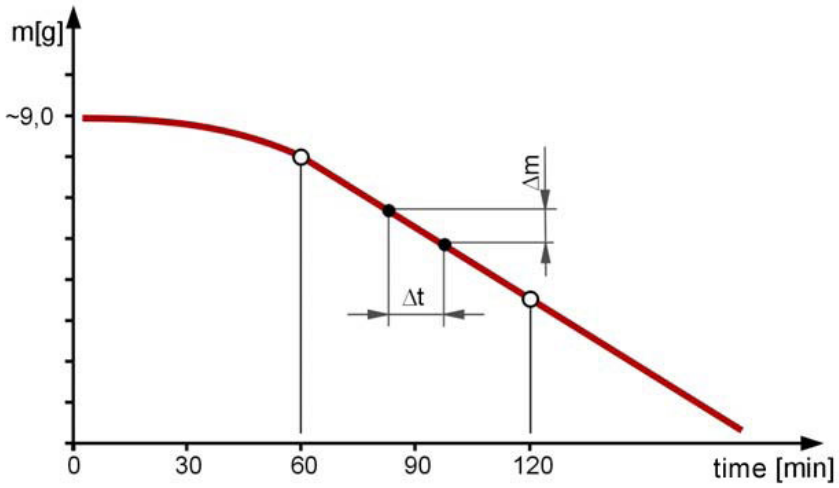
3.3. Matching process: Test procedure

Test of water vapour permeability should be performed in stable ambient conditions ambient conditions are assumed stable if temperature and humidity are within limits and thresholds specified in point 3.1.

A moisture analyzer should be plugged to mains at least 30 minutes before measuring process initiation. Distilled water that is used for measuring process should have temperature close to ambient one. 24 hour storage period of distilled water in weighing room is sufficient for its thermal stabilization.

Sample collection and storage:

Cut a disc 56 ± 1 mm in diameter from a plaster. As cut, place the plasters in a weighing room in which the permeability test is performed. It is recommended, that sample temperature is close to ambient one.

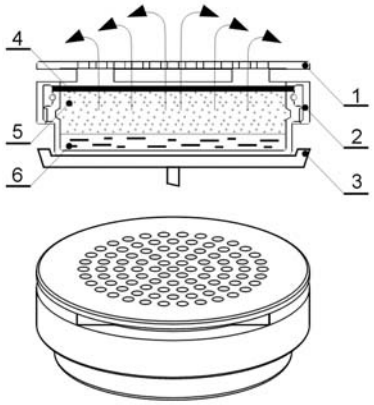


A graph from test procedure

A course of procedure:

1. Start a moisture analyzer according to procedures described in user manual of the instrument
2. Start a computer with PomiarWin software (if this kind of data storage is selected) or switch on a printer
3. Program drying parameters to:
   - temperature 45^{o}C
   - analysis time 2h /time defined switch off criterion /
4. stick a plaster sample to press ring (please put on protective gloves not to damage the sample).
5. Place a sampler with sample inside drying chamber of a moisture analyzer, and as it stabilizes, press ZERO/TARE button
6. Using a pipette dose approximately 9 g – [M0] of distilled water to sampler interior. If a moisture analyzer does not cooperate with any peripheral devices, not down mass of dosed water /manual notes /.
7. Place sample on the sampler, over water surface. Plaster side with glue should face water surface. Close the sampler with cover by screwing it tightly to sampler body.
8. Place sampler in drying chamber of a moisture analyzer.

9. Drying procedure will start automatically. During drying procedure, display of a moisture analyzer will indicate current amount of distilled water and additional data like test time, temperature in drying chamber, etc.
10. After 60 minutes of test procedure, read display indication of water mass [M1] that is in the sampler and write it down/ save it.
11. As the analysis is completed, the display of moisture analyzer will show final mass og water that left in the sampler [M2]. Read it and note it down / save it.



Sampler elevation

1 – sampler cover
2 – sampler body
3 – moisture analyzer pan
4 – tested sample, stuck to press ring
5 – water vapour
6 – distilled water

4. Results of performed test

The test on water vapour permeability was performed on three kinds of plasters, which were supplied by a manufacturer. Their characteristics is described on below chart:

Sample number	Sample name
1	Fibre laminate R21601
2	Micropore coating NG
3	Foil laminate Minifol

During the test, it has been determined, that constant value of distilled water decrement took place after 60 minutes from test initiation. Thus, for the purpose of calculation, measurement of mass was performed on:

- 60 minute of test course and in
- 120 minute of test course.

The initial stage of test procedure can not be taken into consideration, as test results are not stabilized. The test gave data on water vapour permeability of selected samples, and in accordance to below relationship:

$$P = \frac{M1 - M2}{t * P_p} [\frac{mg}{cm^2 * h}]$$

Where:

P – water vapour permeability expressed in $[\frac{mg}{cm^2 * h}]$
M1 – distilled water mass recorded in 60 minute of test course [mg]
M2 – final mass of distilled water recorded in 120 minute of test course [mg]
t – test duration in [h] – *(1h)*
P_p – evapouration surface in [cm^2] - *(19,625cm^2)*

The above criterion has been accepted as result of observed permeability stabilization factor. During test course it has been observed that water vapour permeability stabilizes after 30-40 minutes from test initiation. Drying chamber stabilizes in this period of time, and so test conditions also become stable. After upper mentioned time permeability ratio stabilizes at constant level, i.e. condition $\Delta m/\Delta t$ = const.

Following analysis of plaster samples were performed with pauses of approximately 30 minutes. Results of water vapour permeability with application of moisture analyzer are listed in below chart.

Collection of results:

Sample no.	**Sample name**	**Permeability result** $[\frac{mg}{cm^2 * h}]$	**Average value** $[\frac{mg}{cm^2 * h}]$
1.1	Fibre laminate R21601	10,60	**9,86**
1.2		9,94	
1.3		9,38	
1.4		9,38	
1.5		10,03	
2.1	Micropore coating NG	14,42	**14,20**
2.2		14,98	

2.3		13,04	
2.4		15,34	
2.5		31,20	
3.1	Foil laminate R21601	9,58	**8,41**
3.2		7,59	
3.3		9,32	
3.4		8,00	
3.5		7,54	

5. Error sources

Any dispersion in accuracy of final measuring results of water vapour permeability test with application of moisture analyzer may arise from several factors..

5.1. Moisture analyzer

Instrument errors resulting from its design, and relatively long test period (2h). An operator should also focus on errors resulting from control and maintenance of temperature in drying chamber of a moisture analyzer in test course.

5.2. Ambient conditions

Ambient conditions may influence the moisture analyzer and the tested sample. it can be assumed, that if ambient conditions are stable, than speed of distilled water evapouration is constant for test procedure of plaster permeability.

6. Comparison of test methods

The main difference between the two testing methods (traditional and with application of a moisture analyzer) is test time. In case of traditional method, the test course takes 24 hours. For a moisture analyzer it is 2 hours, but analysis is made on according to data collected in 60 minute and 120 minute of test course.

In order to determine the convergence between results of the two methods, one should unify obtained data and time. Such collection is presented on below chart.

		Test method	
		Moisture analyzer	Climatic chamber
Sample number	**Sample name**	$\bar{x} \rightarrow [\frac{mg}{cm^2 * h}]$	$\bar{x} \rightarrow [\frac{mg}{cm^2 * h}]$
1	Fibre laminate R21601	**9,86**	**10,17**
2	Micropore coating NG	**14,20**	**15,46**
3	Foil laminate R21601	**8,41**	**6,42**

Water vapour permeability values for climatic chamber have been presented in mg/cm^2/h. Such results were obtained by data transforming by a below schema:

1. A – value in mg/cm^2; A = value obtained from climatic chamber / 10
2. B – permeability /h B = A/24

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