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PERMETEST

A new fast response measuring instrument (Skin Model) for the non-destructive determination of water-vapour and thermal resistance or permeability of textile fabrics, nonwovens, foils and paper sheets

Main technical parameters (subject to small changes without notice, due to continuing development of the instrument):

Range of water vapour resistance Ret: **from 1 to 200 m^2Pa/W**
Range of relative water-vapour permeability: **from 1,5 to 100%**
Range of thermal permeability: **from 1 to 50 W/m^2/K**
Range of thermal resistance Rct: **from 0.02 to 1 m^2K/W**
Range of fabric thickness: **from 0,1 to 7 mm (or more at lower precision)**
Adjustable main velocity of the parallel air stream: **approx. 1,0 and 2,0 m/s**
Supply voltage: **120 or 220 V / 50 - 60 Hz, input 50 W**
Instrument dimensions: **540 x 230 x 130 mm, net weight 7 kg**

Main features of the instrument:

- **very short time constant,** given by the application of a special heat flow sensor, whose thermal inertia is similar to that of human skin, therefore the full response while measuring the water vapour permeability (resistance) of synthetic fabrics is achieved **within 2- 3 minutes**, for dry thermal resistance the measurement is completed even within 1 minute (for the simulated human skin temperature 35^{O}C),
- **small size** of the measured sample - less than 12x12 cm, **measured area 80 mm dia,**
- **ease of operation** and evaluation of the results, which allows to be operated not only in laboratory, but also in the factory conditions,
- **high sensitivity**, given by a new concept of measurement, which enables to distinguish even very small changes of water amount absorbed in the fabric during unsteady state of diffusion and to record e.g. the heat of absorption and the effects of the fabrics composition and structure, resulting in very good measurement repeatibility, with CV often under 3%.
- **the possibility to operate both under isothermal and non-isothermal conditions**,
- **results are presented in digital form** both on the instrument display and on the screen of any modern computer.

The instrument provides all kinds of measurements very similar to the ISO Standard 11092, and the results are evaluated by the identical procedure as required in the ISO 11092. The differences in relation to this standard depend in smaller sample, application the 20-22^{O}C isothermal laboratory temperature instead of 35^{O}C (at the water-vapour resistance measurements) and by the application of the laboratory (environmental) water-vapour concentration (humidity) of the parallel air flow 45 - 60%, instead of the air humidity level of 40%. The heat flow levels used for calculation of water vapour resistance or permeability are displayed on digital indicator + external PC PC and (if required) recorded by means of any sensitive line recorder (nor the PC nor the recorder are included in the standard delivery). The correlation coefficient of measurements related to the ISO Standard SKIN MODEL exceeds 0.9.

Guarranty: Free repairs within 12 months after the instrument delivery.

MANUAL OF USE OF THE INSTRUMENT VERSION 2009 WITH DIGITAL INDICATION OF HEAT FLOW AND DIRECT CONNECTION TO PC

A. The PERMETEST instrument consists of the following parts:

- Wind channel attached to a suction part of 2 axial fans located in the electronic box.The channel is covered by highly reflective metalic removable window.
- Measuring head in suspension, whose surface is made of porous metallic water distributing layer. The porous surface is covered by removable semi-permeable layer with the medium durability.
- Dosing syringe 10 ml to be inserted into a special orifice, supplying measuring liquid to the measuring head, when the water vapour resistance or permeability of fabrics are measured.
- Box of electronic which contains the transformer, power supply part, intelligent digital temperature controller OMRON, amplifier, A/D converter and 2 additional fuses. The box of electronic can be opened by removing 4 screws on the bottom of the box.

On the instrument front panel next operational components /elements are located:

- Air temperature and air relative humidity digital meter indicate the room air parameaters, which also aproximatly characterize the air parameters in the channel.
- Output voltage digital indicator. The display shows the level of heat flow [W/m^2] passing through the sample in mV (after multiplication). The amplification level is adjustable.
- Intelligent digital temperature gradient controller OMRON. The red scale shows the real temperature gradient between the measuring head and the room (channel) air temperature, the green scale indicates the preset temperature gradient. The preset temperature can be changed by the “up” and “down” knobs. The controller programming (e. g. the time of periodical switching “on” and “off” of the heating input) is described in the enclosed controller leaflet.
- A zero switch which in postion I makes a short circuit in the amplifier entrance, and in position 0 enables the measurement.
- A button of the electric zero adjustment. If the zero shortcircuit switch is on (I), then the zero on the indicator should be adjusted.
- A button of the aplification level (sensitivity) adjustment. Optimum level of sensitivity is given when the digital indicator of the instrument without sample shows 95-105. This level of sensitivy is used when the instrument measures (roughly) the relative water vapour permeability. Then, after insertion of a sample, after approx. 2-5 minutes the instrument shows directly the mentioned relative water vapour permeability in %. When measuring the w ater vapour resistance, the knob must be kept at any, but constant position, for which the sensitivity constants C and K (see later) are specific. These constants should be used for similar room temperature (± 2^{o}C) and humidity (±10%) as the air parameters in the calibrating regime.
- If necesssary, a linear chart recorder with sensitivity at least 2 mV/full width of paper can be used in connection with the instrument. The recorder is delivered on special demand only. The analogue output of the instrument is located in the rear panel

B. MEASURED PARAMETERS

Relative water vapour permeability of the textile sample p_{wv} can be determined from the relation

$$p_{wv}\,[\%] = 100\, u_S / u_O \qquad (1)$$

Here, u_S means the instrument reading without a sample (heat loses of the free wet surface), and u_S presents the heat loses of the wet measuring head (skin model) with a sample.

Water vapour resistance R_{et} [m^2Pa/W], when expressed in terms of the according to the ISO 11092 Standard (Textiles - Physiological effects - Measurement of the thermal and water-vapour resistance), then the following relationship is applied (and used :

$$R_{et} = (p_{wsat} - p_{wO})\,)(1/u_s - 1/u_o) = C\,(100 - \varphi)(1/u_s - 1/u_o) \qquad (3)$$

The values of water vapour partial pressures $p_{w\,sat}$ and p_{wO} in Pascals in this equation represent the water vapour saturate partial pressure valid for the temperature of the air in the measuring laboratory t_O (22-25 ^{O}C), and the partial water vapour pressure in the laboratory air. The relative humidity φ should be kept between 45-60 %. The constant **C** will be determined by the calibration procedure. Special hydrophobic polypropylene reference fabric for this purpose is delivered with the instrument.

During the the PC evaluation procedure, the the calibration constant determined from the measurement of the reference sample should be inserted in the PC by means of the keyboard. Thus, the instrument can be recalibrated under real conditions in the laboratory, as real instantaneous values of air temperature and humiditity are continuously measured and used in all the calculations. This procedure substantially increases the measurement precision. After calibration, the PC evaluation program calculates automatically the R_{et} values. All steps necessary to operate the R_{et} determination are easy, due to simple windows system.

Thermal resistance R_t of dry textile samples: the whole procedure is similar to the above described procedure, but the measuring head is kept dry, and the measuring head is maintained at the temperature $t_H = t_O + 10\ ^{O}$C (practically 32-35 ^{O}C), for at least 5 minutes. The time of measurement is very short in this case, it takes less than 1 minute for 1 sample. No heat power corrections are necessary, but thermal edge losses corrections for textile fabric with thickness over 3-5 mm are recommended.

Calculation of thermal resistance of the textile sample R_t [m^2K/W] then follows from the equation

$$R_t = K\,(t_H - t_O)\,(1/U_1 - 1/U_O) \qquad (4)$$

where U_S and U_O represent the steady state electrical voltages shown on the digital display, for the case of measurement with the sample and without the sample. The sensitivity constant **K** will be determined by the calibration procedure. Similarly as in the

previous case, the constant K related to the voltage levels read on the digital display will differ from the constant valid for the voltage levels indicated by the recorder. The PC evaluation procedure for $\mathbf{R_{et}}$ and $\mathbf{R_t}$ values is described in the next rext.

C. HINTS TO OPERATE THE PERMETEST INSTRUMENT IN THE ANALOGUE MODE.

1. Join the PT with any modern computer (no VISTA, pls) by means of a RS 232 cable. The FRB cable for small computers (desktops) is also, included, along with a special conversion programme.
2. Swirch on both devices.
3. Install the CD program into the PC. The program must be downloaded on the C harc disciplines, and open the PERMETEST window. The use of the program will explained later.
4. On PT select the air velocities I (1 m/s) or II (2 m/s).
5. On the temperature controller OMRON adjust the required teperature gradient (0 deg. C for water vapour resistance measurement and 10 deg. C for thermal resistance measurement). The gradient shows the green scale. Use the buttons on the right hand side.
6. Install a small cup on the output of the free end of plastic tube, which will contain the water excess.
7. Fill the syring with distilled water containing 0,1 % of pure non-aggressive liquid soap used for hand washing, and insert it into the hole on the right hand side of the PT. Warning: using the tape water instead of the distilled water will plug the tiny channels in the measuring head. In this case, no warranty will be provided.Very slowly press 1 volume of water in the syringe into the instrument (measuring head). Check, whether the water excess enters into the cup. The volume of any additional syringe should enable approx. 1 hour measurement.
8. Wait 5 minutes to get the temperature deviation less then 0,2 deg. C (later it will be less then 0,1 deg.C), and the membrane on the measuring head surface returns back to the porous surface.
9. Press the „zero short“ on the top (I) to make short circuit on the entrance of the analogue amplifier.
10. Adjust slowly the **zero potentiometer** to zero on the black digital indicator. The adjustment requires patience, but it will keep adjusted for long time.
11. Press the „zero short“ on the bottom to open the entrance of the analogue amplifier.
12. Move the **amplifier potentiometer** to reach the signal level on the black digital indicator approx. 100, practically between 90 and 110.
13. Repeat the procedure according to 7,8,9 and 10 points, to improve the zero adjustment.
14. Adjust the amplification to 100 with better precision (95 to 105).
15. Pull down the measuring head (special knob on the top surface of the instrument enables easy pulling the head down) and insert the measured sample between the head and the botton of the air channel. Then pull back (upwards) the measuring head to the channel. Thus, the sample keeps fixed on the semi-permeable surface of the measuring head. Insert the measured sample between the bottom of the channel and the measuring head. Try not to scratch the surface membrane on the edges.
16. After 2-4 minutes read the relative water vapour permeability on the digital indicator. The observed turbulency is inevitable, but the PC program will avoid the variations of the readings – see the next expanation.

D. OPERATION OF THE PERMETEST WITH THE USE OF PC EVALUATION (PROVIDED THAT THE INSTRUMENT IS ALREADY WORKING IN THE ANALOGUE REGIME, WITH ZERO ADJUSTED AND SIGNAL WITHOUT SAMPLE INDICATING APPROX. 100 ON THE BLACK SCREEN).

i. Insert the programme on CD and save it on internal hard disc C.
2. Recall the program for the hard disc C.
3. Shift the program sheet with widows in the centre of the screen.
4. Choose temeprature difference: 0°C for the water vapour permeability testing (water vapour permeability /resistance must be carried out under isothermal conditions) and 10°C for testing the thermal resistance.
5. Press the SETTINGS and choose the time of measurement (generally 4 min.)
6. Insert the value 5,0 m^2Pa/W as the water vapour resistance reference (provided you use the blue fabric as a standard).
7. Return to front side of the operation sheet.
8. Find the proper CM port and press CONNECT
9. Choose the name of the sample (material) and press NEW. Green number 1 should appear in the lower window.
10. Without a blue reference sample inside, press START for the REFERENCE phase of the measurement.
11. Green signal will show you the level od steady state measurement. When the steady state is indicated, press OK.
12. Insert carefully the blue sample into the instrument, avoiding the scratching of the white foil.
13. Press START under the SAMPLE headline.
14. Wait again, untill the steady state is achieved and then press OK.
15. Press the INSERT, and you will see the value of the water vapour resistance Ret in m^2Pa/W and also the water vapour relative permeability in %, on the right side of the operation sheet.
16. Press CALIBRATE to insert the determined value of Ret to readjust the instrument sensitivity and thus to achieve with high presision the agreement with the ISO 11092 measurement resuts.
17. Pull out the blue sample.
18. Change the name of next sample.
19. Repeat all the steps 10-17 with your new sample, al least 3 times.
20. Press VIEW and MEAN to develop the statistical evaluation.
21. See the average values and the related variation coefficients in the windows.
22. Use similar procedure for the measurement of thermal resistance Rct (with no water in the measuring head – drying the wet head takes more than 1 hour!). Use the foam foil as the reference fabric.

E. GENERAL REMARKS

1. When the instrument cannot reach the steady state level within 3 -4 minutes, (probably due to big air temperature variations in your laboratory), press the SETTINGS and change the statistical parameters of the signal evaluation.
2. As you can see, the air relative humidity indication on the front display may differ from the indication shown on the display of your computer. We have found that the front display data correlate very well with our calibrated air humidity sensor, whereas the sensor showing the humidity in the air channel of the instrument indicates higher values then the reference sensor. We have verified this difference is not caused by the sensor instalation, but the air channel sensors are slightly differently calibrated already

by their manufacturer. To achieve the agreement between both sensors, we have introduced the air humidity calibration coefficient, which is (in the newest PC programme) adjustable through the SETTINGS procedure, and its practical level ranges from 0,92 to 0,97. You can use this advice, if you like. We have to emphasize, that the mentioned different air humidity indication DOES NOT REDUCE THE MEASUREMENT PRECISION, as all such discrepancies are compensated by the instrument calibration procedure.

F. General recommendation concerning the instruments use

1. The instrument should be used preferably but not exclusively in climatized laboratory with low fluctulation of the air temperature and humidity.
2. The instrument should not be installed in the vicinity of the output orifice of the climatization unit. The best measurement precision is achieved, when the instrument works in closed box, located next to the climatized room. The climatized air then penetrates to the measuring box through small hole, and its temperature and humidity fluctulations are lower.
3. The instrument window on the air channel should not be illuminated by any thermal source of light. The fluorescent lamp is permitted.

G. Maintenance of the instrument

3. Removable semi-permeable layer**,** which covers the porous surface, exhibits limited lifetime (1-3 weeks, according to the level of use). When changing the foil, kindly choose the perfect part of the delivered spare foil, and extend it partly to both (all) sides. Remove the old foil, and make the porous surface clean by a soft brush and saponate. Put a new foil and fix it again by a rubber or plastic ring. The foil excess cut away. Remove the waves on the foil by pulling the foil edges. You can buy the spare semi-permeable PTFE foil called GORE-TEX PTFE Test Membrane from the following supplier: W. L. GORE & Assoc. GmbH, Putzbrunn, Germany, fax No.+49 89 4612 2300

4. The porous water distributing layer covering the upper part of the measuring head should be always clean. In case of necessity, clean it by soft non-metallic brush and water with excess of detergent.

Dosing syringe**,** when coming out of function, can be substituted by any other.

Fuses are installed in the rear of the instrument (2 pieces), and also 1 fuse inside the instrument. The manufacturer allows to open the instrument housing because of fuse exchange or fixing the connectors without the loss of the warranty. Other inter-iventions are not allowed.

No other maintenance is necessary. All repairs are provided by the manufacturer.

We wish you full satisfaction with our instrument.

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