emtec TSA Tactile Sensation Analyzer

A test device that objectively measures the softness and other haptic parameters of nonwoven material.

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Agenda

Introduction

The touch or hand feel (HF) of a nonwoven product – e.g. wipes, diapers and so on – is more and more of great importance for consumers who use the product. Traditionally, the touch/HF is tested by subjective human hand panels, which have several disadvantages, which will be discussed later. There is a need for an objective way to test the important parameters, which determine the overall HF. This enables a successful R&D work as well as an efficient Process and Product Optimization and Quality Assurance. There have been several approaches to test the touch / the feeling objectively – with limited success. The TSA – Tactile Sensation Analyzer is a completely new approach and method in the nonwoven industry. The device measures the three basic parameters, which mainly determine the human hand feeling. By mathematical models, a hand feel value can be calculated, which correlates almost perfect with the human feeling.

The human feeling

How do humans feel

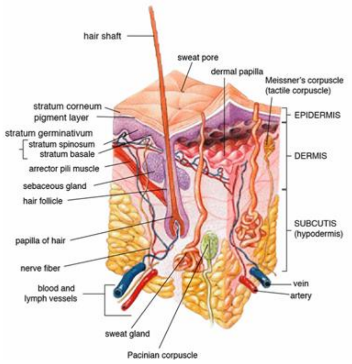
Four different cells, which are located in the skin of the finger tips (but also at all parts of the human body), are responsible for the human feeling.

These four cells are the:

- Lamellar / Pacinian corpuscles*
- Tactile / Meissner corpuscles*
- Tactile / Merkel cells*
- Ruffini bodies

* The papillary lines on the finger tips – in combination with the sample surface – generate different vibrations, which come from the different characteristics of the material: real softness, smoothness / roughness, stiffness. The four different sensors, detect the different vibration frequencies.

In the following, these four cells are explained in depth:

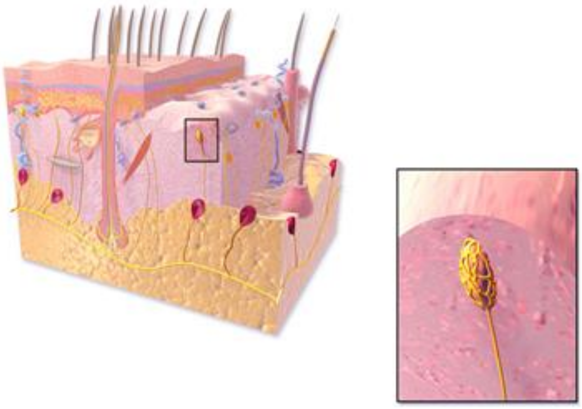


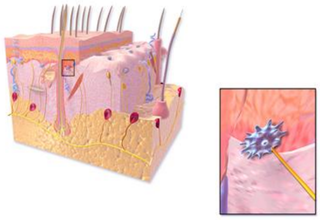
Lamellar or Pacinian corpuscles

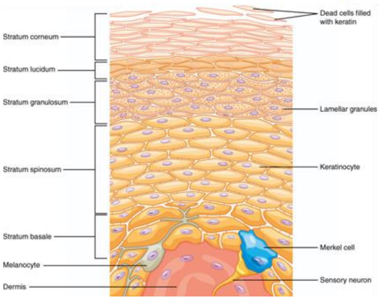
The Lamellar corpuscles are located in the lower skin and belong to the fast adapting receptors. They have their highest sensitivity at around 300Hz. The lamellar corpuscles measure the softness or better micro-surface variations of the material.

Tactile or Meissner corpuscles

The tactile corpuscles are receptors of the glabrous skin and are concentrated in the finger tips. These cells react to pressure changes between 10 and 50Hz. The Meissner bodies are responsible for the feeling of roughness/macro-surface variations. Blind people for example depend on the Meissner bodies to be able to read the Braille-Alphabet.

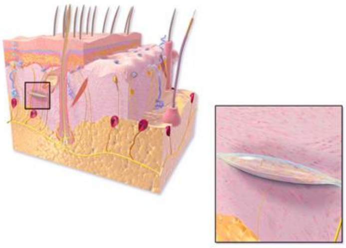


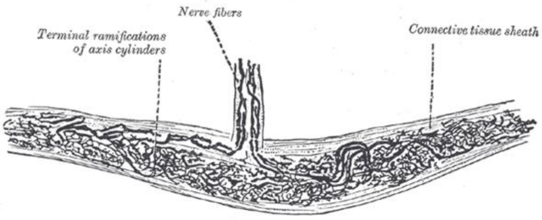




Tactile or Merkel cells

These are special sensory cells, which are located in the deeper parts of the epidermis and act as pressure receptors. They belong to the mechanoreceptors of the tactile sense. They are sensitive to a frequency of 0.3 – 3Hz. These cells are responsible to feel the stiffness of a material.





Ruffini bodies

Belong to the slow adapting mechanoreceptors. They are located in the very deep layers of the skin and register mechanical deformation in the joints (angle change and continuous pressure states). Similar to the Merkel cells, the Ruffini bodies are responsible to feel stiffness and compressibility.

The traditional hand test

As the pictures below show, there are different ways to test a piece of fabric: it is possible to touch the material from just one side, from two sides at the same time or it can be crumpled. Independent from the test method, different vibrations and forces are generated against the deformation. These depend on the softness, roughness and stiffness of the material. Sensors, which are located in the skin and joints of the fingers, are responsible to feel the three basic parameters, softness, roughness and stiffness.

Hand moves over the sample surface

Sample is crumpled by the hand

Generation of different vibrations, shear forces and resistance against the deformation, which depend on:

- micro-surface variations (feeling of softness)
- macro-surface variations (feeling of roughness)
- stiffness

These different signals (the vibrations in the different frequency areas) are detected by the four sensors in the human skin and transported to the brain via the nerves. In the brain, these signals are combined to an overall impression of touch, comfort, hand feel.

The human feeling is determined by the following three parameters:

» softness / micro-surface variations

» roughness / macro-surface variations

» stiffness / in-plane stiffness.

Due to the fact that a hand panel is done by a group of humans, who are influenced by subjective factors, hand panels have several disadvantages. First of all, the sensitivity of different testers varies, in some cases a lot. Besides this, humans cannot satisfyingly distinguish between the three parameters, softness, roughness and stiffness and are only able to provide information about the overall haptic impression, the hand feel or touch. And, the results depend on the testing procedure, the daily mood, the culture and personal as well as market specific preferences.

Technical principle of the TSA

In a world, where the comfort of a nonwoven product becomes more and more important, it cannot be satisfying to accept that tests of haptic quality parameters are done by hand. The disadvantages mentioned above show that human tests are not as reliable and accurate as necessary. An objective test device should be preferred, but although all different kinds of parameters are tested objectively by measuring devices, there wasn't a device available for the test of haptic parameters. In the past, different approaches have been made, but either the solution is not applicable in the industry or the correlation between the test results and the human expectation isn't good enough. This situation has changed since 2015. Since that, the emtec TSA Tissue Softness Analyzer is introduced to the nonwoven industry. As the name indicates, the device is coming from the tissue paper industry. It is used in the R&D, process and product optimization, in the converting and also by retailers, institutes and universities. Although it is no ISO/CEN/DIN standard, it has become industrial standard over the years. In the nonwoven industry, the device is known as emtec TSA Tactile Sensation Analyzer.

1 Measuring Head

2 Rotor with ceramic paddles

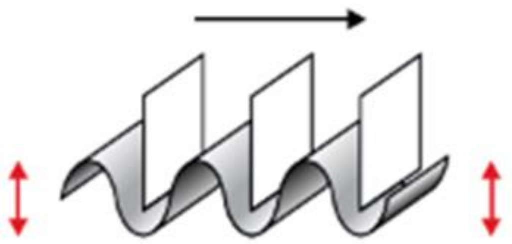
3 Measuring cell with micro-phone on the bottom

4 Load Cell

5 Noise cancellation system

6 Surface microphone

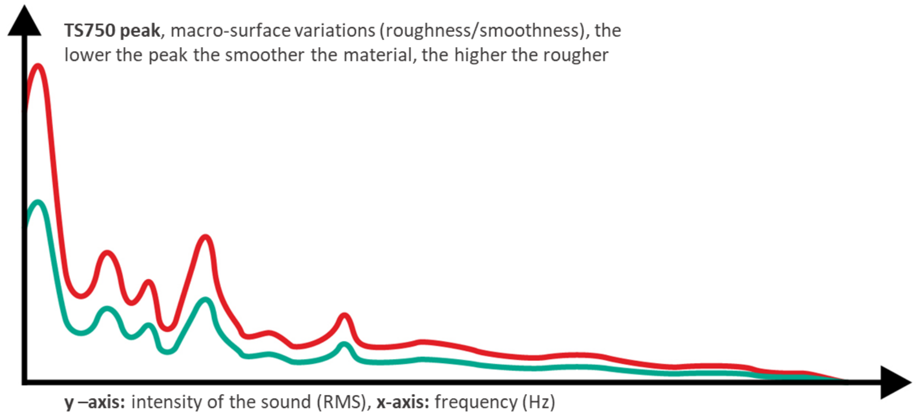
With the device, it is possible to measure the three basic parameters, which determine the human feeling, the softness, the roughness and the stiffness. Also measured are the visco-elastic, plastic and elastic properties of the material, the hysteresis, the plasticity and the elasticity. The TSA measurement is a two-step measurement. With the first step, the roughness of the material is characterized by a sound analysis. With the second step, the softness is measured, again by a sound analysis. Right after this, stiffness as well as the visco-elastic, plastic and elastic parameters are measured by a deformation measurement.



Vertical vibration of the sample

First step of the measurement (sound analysis)

Once the measurement is started, the measuring head, including rotor and paddles, moves down to the sample, which is fixed in the measuring cell like a membrane of a drum. The motion over the sample happens at a load of 100mN and the rotor rotates with a speed of 10cm/sec.



The vibration of the sample provides the information about the roughness (macro-surface variations) of the material. The rotor is fixed in vertical direction, but rotates over the sample with a load of 100mN. This leads to a vibration of the sample, which depends on its surface structure. This vibration causes a sound, which is recorded by the microphone. The y axis represents the intensity of the sound, which is caused by the vibration of the sample and recorded by the microphone. The x axis shows the frequency area at what the parameter is measured. The higher the peak, the louder is the sound, which is recorded. The louder the sound, the stronger the vibration of the sample and this means a rougher surface.

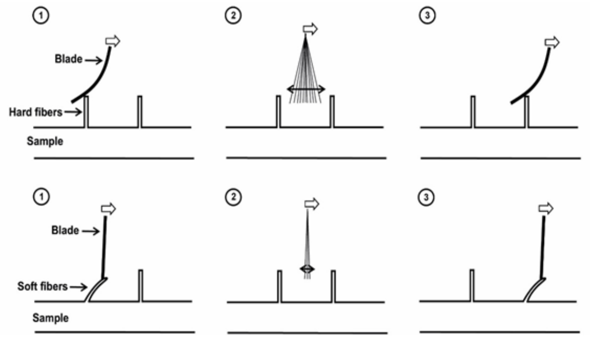
Important: during the roughness measurement, a special plastic film is placed underneath the sample. This is done to ensure that different porosities of different materials that are tested and compared do not influence the measurement.

The higher the TS750 (roughness) peak, the rougher the material. The lower the peak, the smoother.

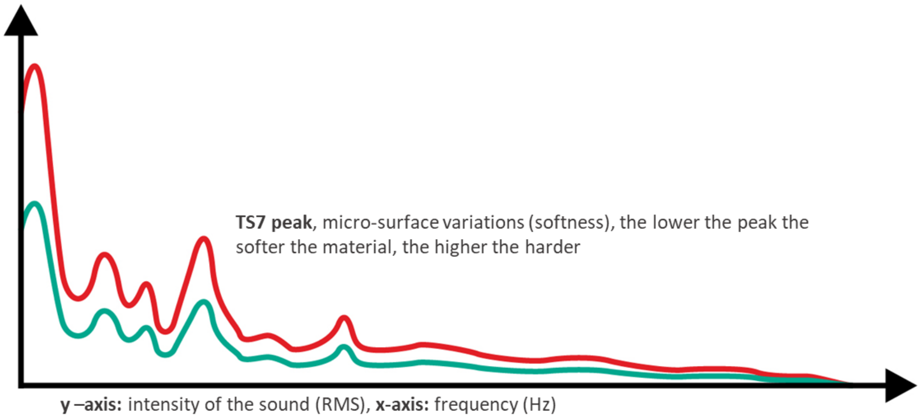
Second step of the measurement (sound analysis and deformation measurement)

Similar to the sound analysis of step one, again the measuring head moves down to the sample until a load of 100mN is applied. Once the load is reached, the rotor starts to move and the paddles move/scratch over the material. This motion doesn't only cause the vibration of the sample itself, which gives the roughness, it also causes the vibration of the paddles. Right after the softness measurement, a load between 100 and 600mN is applied to the sample, once the 600mN are reached, the measuring head moves back up and then applies a load between 100 to 600mN a second time. By this two-cycle deformation measurement, in-plane stiffness, elasticity as well as the recovery parameters hysteresis and plasticity are measured.

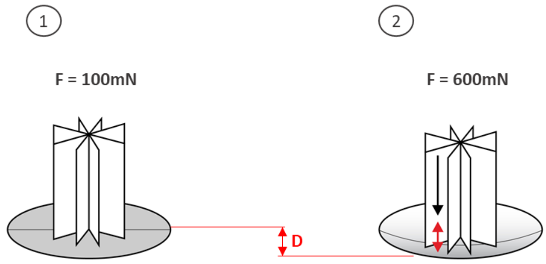
<u>Softness measurement (measurement of the micro-surface variations)</u>



The vibration of the paddles provides the information about the softness (micro-surface variations) of the material. The paddles move over the fibers, which stick out of the material. If the fibers are hard and stiff, the paddles get into strong vibrations, after passing the fiber. If the fibers are flexible, the paddles get into less strong vibration after passing the fiber (stick and slip principle). This vibration causes a sound, which is recorded by the microphone, which is mounted into the measuring head, right next to the paddles. The following sound spectrum helps to illustrate the results better. The softness peak in the sound spectrum is called TS7 peak and is usually located around 6500Hz. The higher the TS7 (softness) peak, the harder the material. The lower the peak, the softer the material.



Deformation measurement



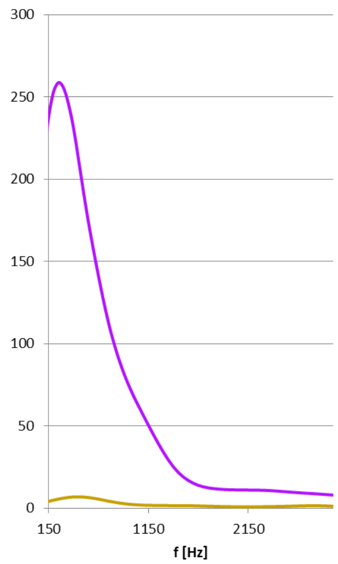
A load between 100 and 600mN is applied on the sample (as shown in the below picture). The deformation is measured in mm/N. Besides the stiffness/in-plane stiffness of the material, also the elastic, viscoelastic and plastic properties are measured, which are represented by the elasticity (E), plasticity (P) and the hysteresis (H).

Results

Roughness/macro-surface variations

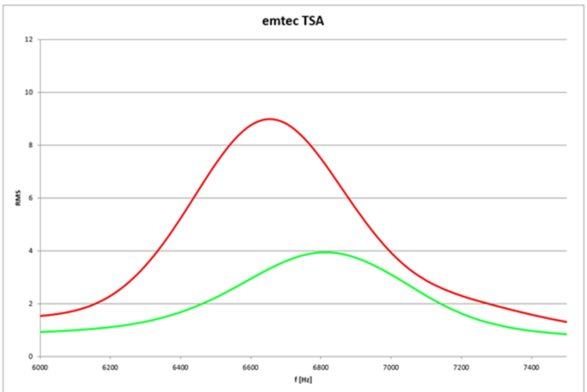
This parameter is determined by the surface topography of the fabric, and can for example be influenced during the production process or by special treatments in the converting.

The below diagram compares the roughness of two different wipes. The material, illustrated by the purple curve (wipe 1) is much rougher, compared to the material, illustrated by the brown curve (wipe 2).



Explanation: wipe one created a higher TS750 peak, which represents the roughness/smoothness of a material. A higher peak in the case means a louder sound, recorded by the microphone below the sample, a louder sound means a rougher surface.

Softness/Micro-surface variations

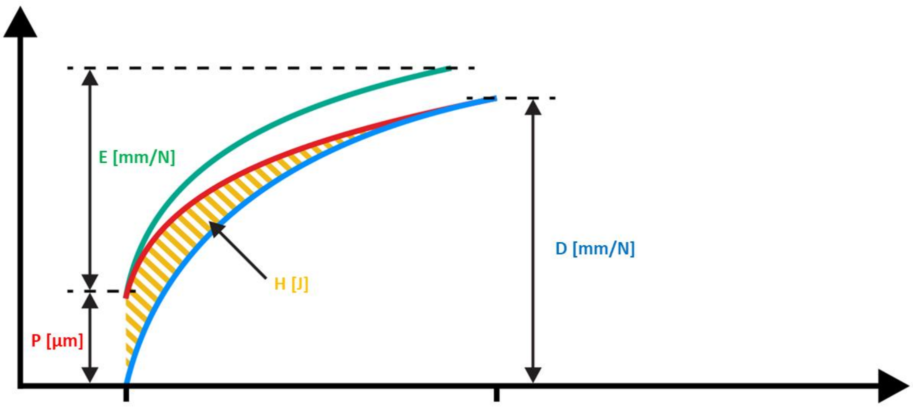


This parameter is determined by the stiffness of the fibers, which stick out of the material and other micro-surface variations. It can be influenced by the fiber, by softener additives and other treatments.

The following example shows an untreated material and a material treated with a softener additive. The red curve represents the untreated material, the green curve represents the treated material. The peak of the red curve at 6500 Hz is significantly higher than the peak of the green curve, this means that the treated sample is significantly softer than the untreated material. A lower TS7 peak means less sound, which means less vibration of the paddles, which is a sign for more flexible fibers, which means a softer material.

Stiffness/in-plane stiffness (as well as elasticity, plasticity and hysteresis)

This parameter shows, how much a fabric deforms under a defined load. The results correlate very well with the TEA Tensile Energy Absorption. The in-plane stiffness is influenced by the fibers and the production technology. It can also be influenced by special additives.



The deformation measurement is done in two cycles, which means that the material is deformed, then it recovers and after recovery it is deformed a second time. With the first deformation from 100 to 600mN, the in-plane stiffness is measured. After applying the maximum load, the measuring head moves back up. Once the measuring head has moved back up, plasticity and hysteresis are measured. Both parameters determine the recovery characteristics of a fabric and with the second cycle (deforming the sample with an increasing load, 100 to 600mN), the elasticity is measured.

Application areas

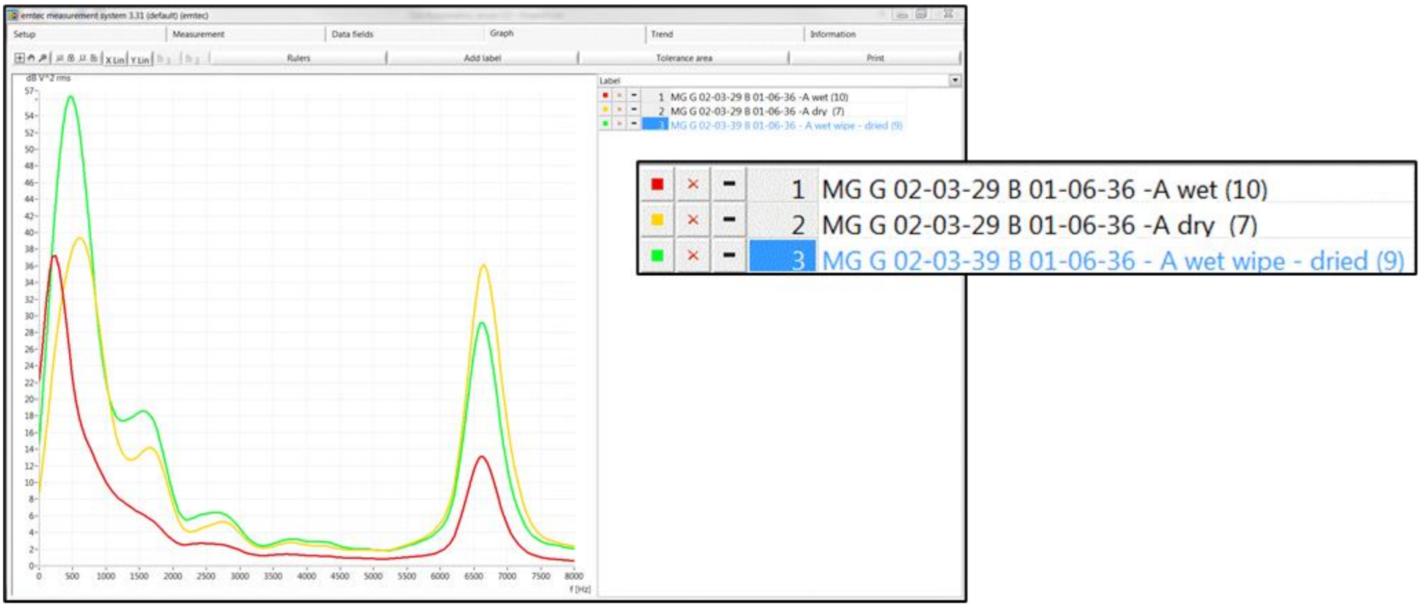
The device can be used in many steps of the production process. The availability of the three basic parameters, softness, roughness and stiffness within a few minutes after the production is a big advantage compared to the traditional hand test. But also, elasticity, plasticity and hysteresis are measured automatically during the deformation measurement (stiffness measurement).

Application areas of the emtec TSA Tactile Sensation Analyzer are:

- R&D
- Process and Product Optimization
- Complaint Management and Trouble Shooting
- Benchmark tests
- Marketing and Sales

Application examples

Wet wipes, base product (dry) vs. finished product (wet)



	Label	HF	TS7	TS750	D [mm/N]	Algorithm
1	MG G 02-03-29 B 01-06-36 -A wet (10)	86,0	13,107	37,317	2,96	QA I
2	MG G 02-03-29 B 01-06-36 -A dry (7)	39,7	36,195	39,368	1,51	QA I
3	MG G 02-03-39 B 01-06-36 - A wet wipe - dried (9)	53,5	29,165	56,482	1,84	QA I

Calculated **HF value:**

- Big improvement from dry base material to finished wet wipe – almost 50 HF points
- This information could also be provided by a hand panel, but the hand panel cannot say what actually increases the overall quality

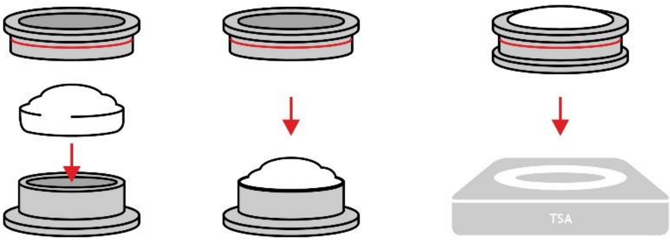
In comparison to this, the **TSA measures the basic parameters**, which determine the human feeling:

- TS7 (real softness/micro-surface variations)
- TS750 (roughness/macro-surface variations)
- D (stiffness/in-plane stiffness)

In the case of the tested material, it can clearly be seen, that the extreme increase in the overall quality comes from the real softness/micro-surface variation, roughness/macro-surface variations and stiffness/in-plane stiffness do not really change during converting.

Special applications

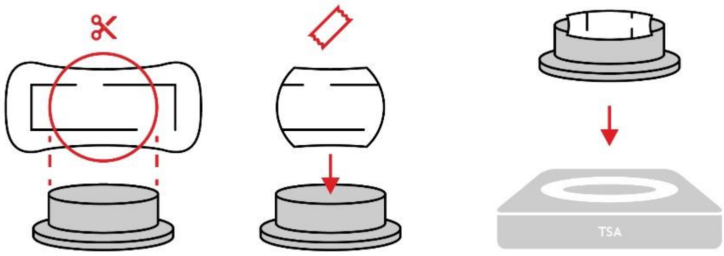
Very thick material (e.g. diapers)



Very thick material (e.g., a baby diaper) can be measured with a special adapter, the External Fixing Ring (EFR). As the pictures show, the sample is cut into the right size (diameter: 112.8mm), placed on the bottom ring and the upper ring is pulled over the sample. The advantage is that the sample can be fixed in the fixing ring outside the device, which enables a much easier handling. Once the sample is fixed in the EFR, the EFR is placed in the device.

Important: results from tests with the EFR cannot be compared to results of tests with the standard fixing.

Very narrow material (e.g. femcare products)



Very narrow material (e.g. femcare products) cannot be fixed in the standard way, but similar to very thick material, the use of a special adapter allows the measurement of such material as well. In the case of narrow material, the adapter is the so-called EFP – External Fixing Plate. The material is cut into the right size and fixed on the plate with a double-sided adhesive tape. Once this is done, the EFP is placed in the device and the material can be tested. Again, a big advantage is that the sample can be fixed outside the device, which allows an easier handling.

Important: results from tests with the EFP cannot be compared to results of tests with the standard fixing.

References

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https://de.wikipedia.org/wiki/Meissner-K%C3%B6rperchen

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Presentation Wes McConnell

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