Technical Discussion of the Emtec Tissue Softness Analyzer (TSA

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Abstract: This presentation will address the technical aspects of the Emtec TSA. How does the brain interpret softness? What is handfeel? With an understanding of how these values are traditionally derived, we can recognize the technical basics of the test, and show how it relates to handfeel. Does this test replace the handfeel panel of old, or is it a supplement?

The discussion will address the technical side of the instrument....the physical test itself, and how the derived parameters (acoustic signals, deformation, etc) are then used to arrive at a reliable handfeel value. This will also include discussion of the algorithms and possible applications (process control, QC tool, etc).

Introduction: The TSA is an instrument that provides and objective measurement of tissue softness, or handfeel. Translation of sound and deformation, with minimal user influence, allows for the repeatable and reproducible evaluation of standards, across a variety of grades, applications and markets.

The TSA is a mechanical device, designed to simulate the human sensory perception in the evaluation of softness, or handfeel (HF). It utilizes a positional measurement head, equipped with a rotor and blades, a measurement cell, microphones and a balance, all coordinated by a robust software program on an attached PC. The end result is an objective test that provides repeatable and reproducible handfeel values which correlate well with subjective human evaluation.

Human handfeel is determined by three basic parameters:

- Softness (micro-surface variations) – mainly determined by fiber stiffness, micro-compressibility and chemicals/additives
- Smoothness/roughness (macro-surface variations) – mainly determined by creping, embossing and bulk
- Stiffness – mainly determined by fiber behavior/structure, production technology and chemicals

Human fingers and hands house a number of sensors that respond to different frequency and pressure inputs. As our hands move across a sample, these sensors in our fingers detect the subtle vibrations, mainly due to the softness of the fibers and the surface/bulk structure of the sheet. As we crumple the sample in our hands, they help us develop a sensation of stiffness. These signals are transported to the brain, where an overall impression of touch is generated.

Hand panels, developed over the years by companies to provide a rating or ranking of various tissue samples, are based on human perception. As such, there is an inherent subjectivity to the procedure. Results can be affected by the difference in sensitivity between testers, testing procedure, personal and market preferences, culture, climate conditions or mood. Therefore, a more objective test is recommended…one that is not affected or can be controlled by the aforementioned factors. Additionally, humans cannot reliably separate the three basic parameters that determine the overall handfeel of a sample. An objective test that can do so provides more opportunities for troubleshooting, quality control, etc. The TSA is an instrument which answers these needs.

The following is a breakdown of the instrument and its basic parts, as shown in figure 1.

1. Measuring head – Vertical travel is controlled by a high-precision stepper motor.
2. Rotor & blades – Housed in the measuring head, the blades are specially selected for their frequency response.
3. Measuring cell – A fixing ring locks the sample atop an open cell. At the bottom of the cell is a microphone to measure the sound.
4. Vibration sensor – Contains a load cell and balance to ensure the proper force into the sample and a stable environment before measurement.

5. External microphone – Detects surrounding noise, which will be canceled from the signal for processing.

The measurement is a two-step process. The first step is sound analysis. The head is lowered until the rotor is pressed onto the sample at a pressure of 100 mN. Once it is determined the pressure is stable, the rotor will turn, causing the blades to rub the sample. The generated sound is recorded and processed by the software to generate the TS7 and TS750 peaks.

The TS7 peak, measured at approximately 6500 Hz, represents the softness of the sample. As the blades pass over the sample, they 'stick' and 'slip' across the fibers, generating a vibration in the blades. The amplitude of this vibration (measured in dB) depends on the stiffness of the fibers and the overall surface softness. The stiffer the fibers, the higher the amplitude of the TS7 peak. As the TS7 value increases (all other factors remaining the same), the HF value will decrease.

The TS750 peak occurs between 200 – 2000 Hz, and represents the roughness of the sample. Embossing, creping, etc. will all have a direct effect on this value. The texture of the sheet is a series of peaks and valleys. As the blades pass over, the sheet is forced down and released, creating a vibration. The greater the texture, the greater the vibration, resulting in a higher amplitude of the TS750 peak. As with the TS7, an increase in TS750 will result in a lower HF.

The second step of the measurement is a deformation measurement. The measuring head presses the rotor into the sample to a force of 600 mN. The amount of travel of the head into the sheet is measured and this value represents the stiffness of the sheet, D. The stiffer the sheet, the less the head will travel, resulting in a lower value for D. The rotor is raised and pressed in again for a second deformation. This provides the additional parameters of elasticity, plasticity and hysteresis (E, P and H). These are not used in determining handfeel, but work is being done for application of these values for use in textile applications.

Once the physical measurement is completed, mathematical algorithms will use the values derived from the test (TS7, TS750 and D), along with user-input data of caliper, grammage and number of plies, to generate a handfeel number for the sample. In its simplest form:

$$HF = (TS7, TS750, D, \text{caliper}, \text{grammage}, \text{number of plies})$$

The values are weighted differently in the various algorithms, dependent upon the type of product, region or desired correlation. While several standard algorithms are available, custom algorithms can also be created.

Correlation to existing hand panels is achieved through a process of measuring samples with known values, across as wide a range as possible. Once completed, a function in the software is used to compare the hand panel values to those generated by the TSA. A factor is applied and a scale is created. Any future tests utilizing that custom scale will generate values that correspond with the hand panel. It is important to note that the best correlations will involve testing of a high number of samples (25-50), over as many ranges as possible. The more samples read, the better the statistical average of the group. With the right samples and the right algorithm, correlation of nearly 100% is easily achievable.

The goal of the TSA is not to replace the hand panel, but to supplement it and better utilize the data provided. The final decision on whether or not we like a tissue product is still a human decision, subjective to individual tastes. Hand panels do take time, however, and can be costly. Unless a panel is maintained on-site (not a common situation), samples have to be collected and sent away for evaluation. Results may be returned in a day, a week or a month.

The TSA allows for nearly instant feedback. Each sample tested generally takes less than a minute. The test is virtually operator independent, controlled primarily by the software and mechanics of the instrument, and the results are stable and reproducible. A group of samples from the same batch will yield repeatable results, test after test , the primary variability being that of the product itself.

Applications are numerous. Not only does the TSA provide a handfeel value, it also provides the individual parameters which are used to calculate that value. This opens a great number of opportunities.

- R&D / product optimization – Small pilot runs or lab testing can be done with various furnishes, chemicals, etc. prior to full-scale implementation in production. Changes in softeners or furnish can be more closely monitored by tracking the TS7 value. Different embossing or creping patterns will affect TS750.
- Process optimization – Use TS750 to more closely track the life of the Yankee blade.
- Incoming control – Test supplier products prior to placement on the machine. By creating a database of values and cross-checking that against converting results, issues on the machine can be minimized.
- Quality control – Test outgoing product to ensure it meets the standards that are expected, either by a customer or the end user.
- Troubleshooting / complaint management – With the instrument near at hand, complaints can easily and quickly addressed internally. With the individual parameters provided, it should be much easier to pinpoint issues with softness and determine a root cause.

Conclusion: Tissue is a competitive market, and softness is an important attribute for the end user. The TSA allows a technological translation of handfeel…something that has traditionally required a 'human touch'. The ability to break that handfeel down into critical components -TS7(softness), TS750 (roughness) and D (stiffness) - provides greater opportunity to fine tune the manufacturing process, improve efficiency and troubleshoot problems in real time. In addition, a test that is based on physical measurement, and not human subjectivity, lends itself to more consistent results.

Technical Aspects of the Emtec Tissue Softness Analyzer (TSA)

Presented by:

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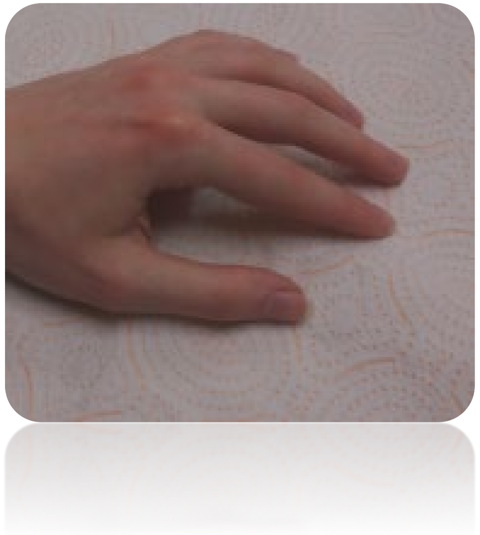


What is Handfeel?

Three primary factors are:

Softness

- Fiber stiffness
- Micro compressability
- Chemical additives

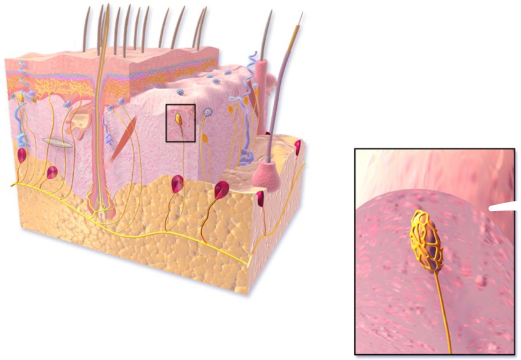
Roughness

- Creping
- Embossing
- Bulk

Stiffness

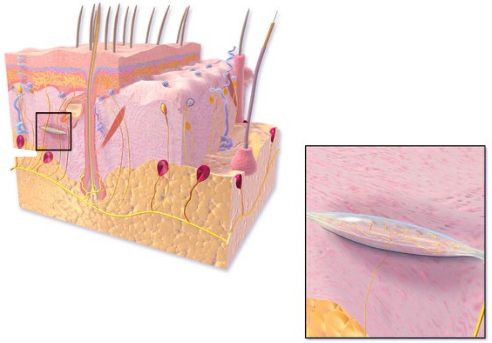
- Fiber structure
- Production technology
- Chemical additives





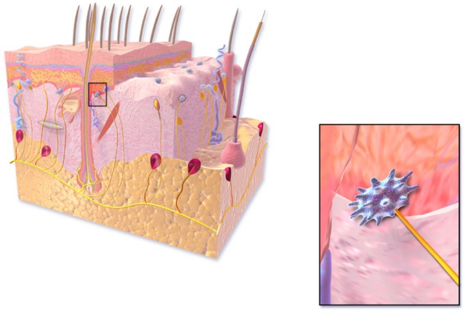
Tactile Corpuscle
(Meissner's Corpuscle)

https://en.wikipedia.org/wiki/Tactile_corpusc

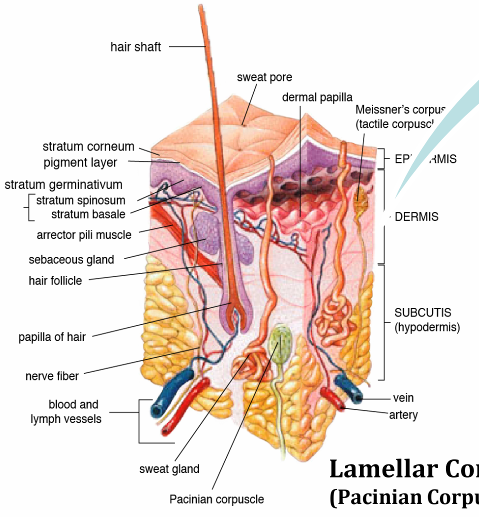


Ruffini Corpuscle

https://en.wikipedia.org/wiki/Bulbous_corpuscle



Merkel Cell
(Tactile Disc)
https://en.wikipedia.org/wiki/Merkel_cell



Lamellar Corpuscle
(Pacinian Corpuscle)

https://en.wikipedia.org/wiki/Lamellar_corpuscle

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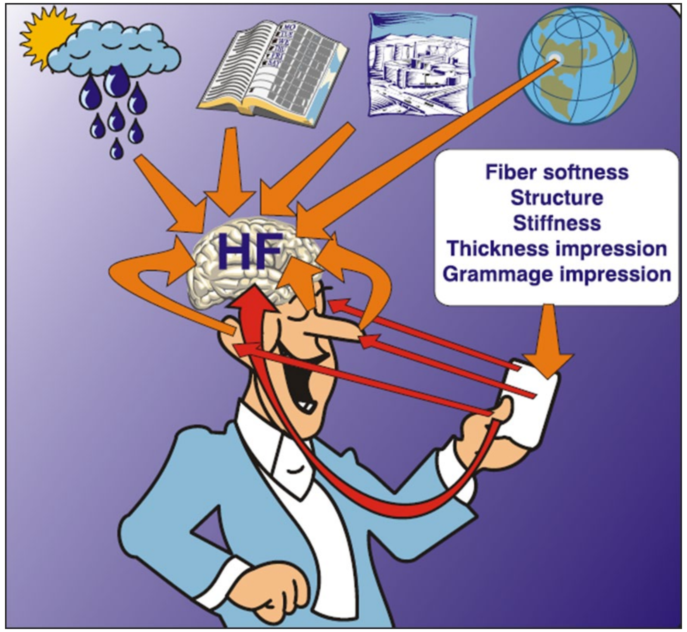
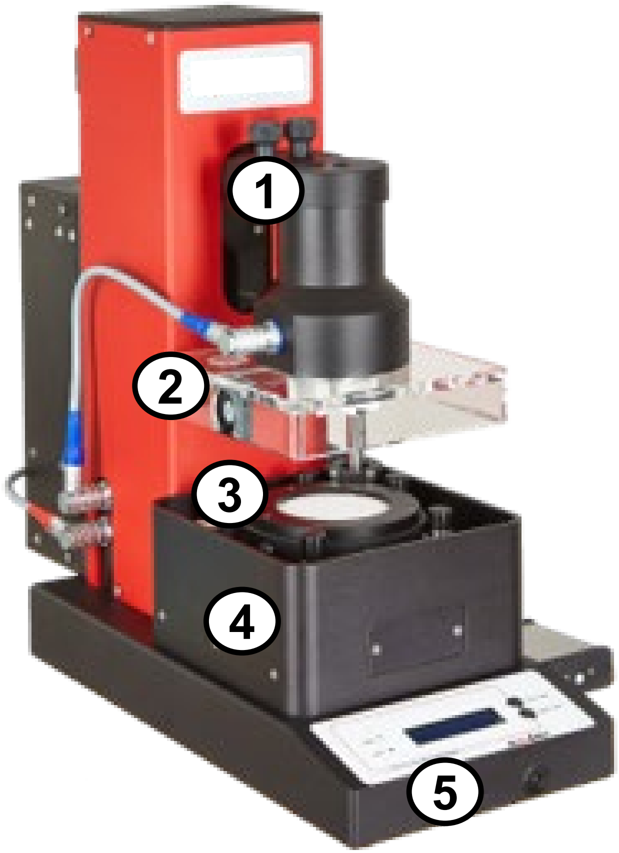
Disadvantages of Hand Panels

Results depend on:

- **Tester sensitivity**
- **Testing procedure**
- **Personal and market-specific preferences**
- **Culture**
- **Mood**



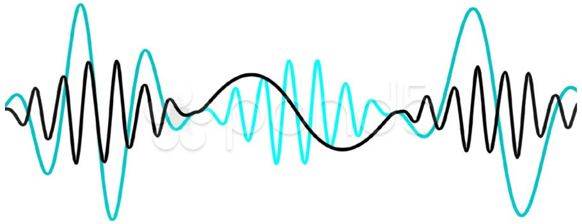
A more objective method for softness testing is needed…



Tissue Softness Analyzer (TSA)

- Objective measurement of handfeel

1. **Measuring Head**
2. **Rotor with blades**
3. **Measuring Cell, incl. fixing ring, load cell, internal microphone**
4. **Vibration sensor**
5. **External microphone, for cancellation of surrounding noise**

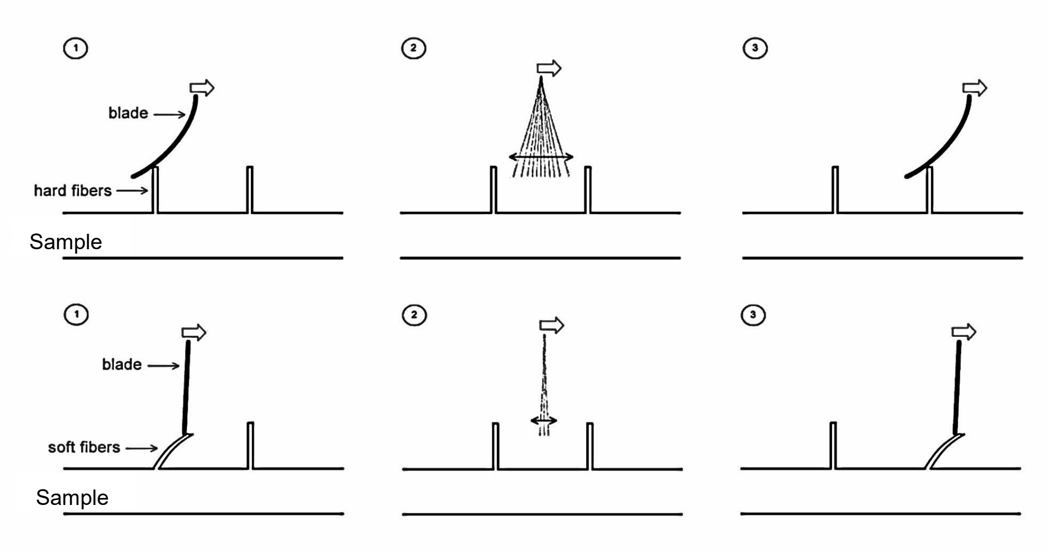


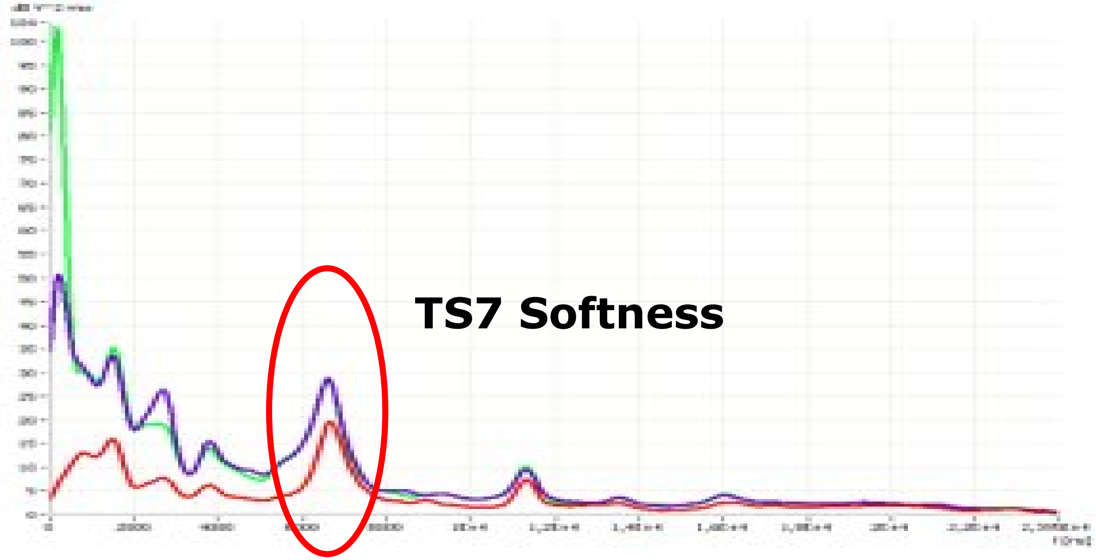
The TSA measurement is a two-step process:

- Step one is a sound analysis, by which the softness and roughness of the material are measured

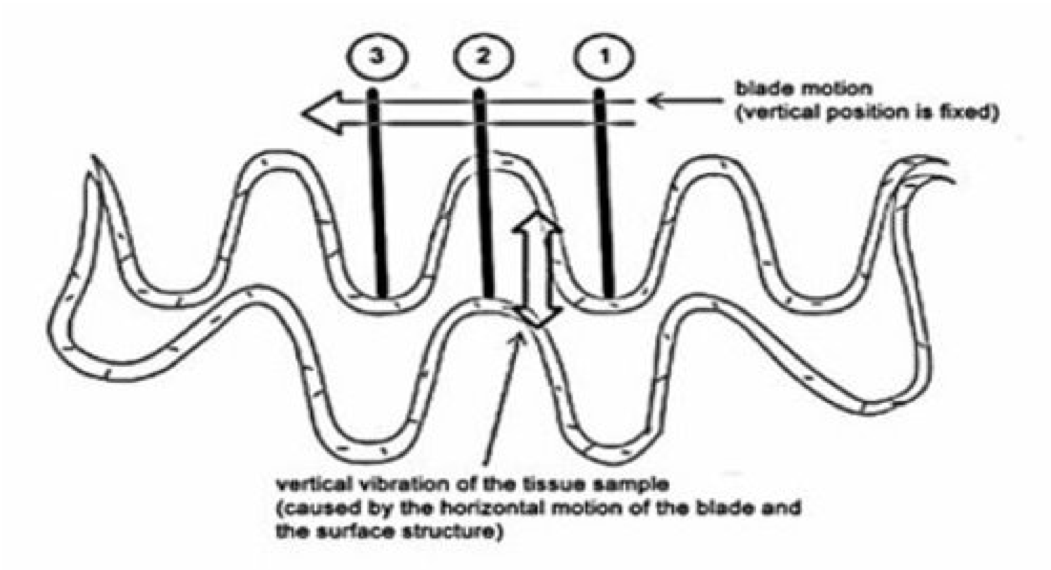
- Step two is deformation measurement, measuring the stiffness of the sample

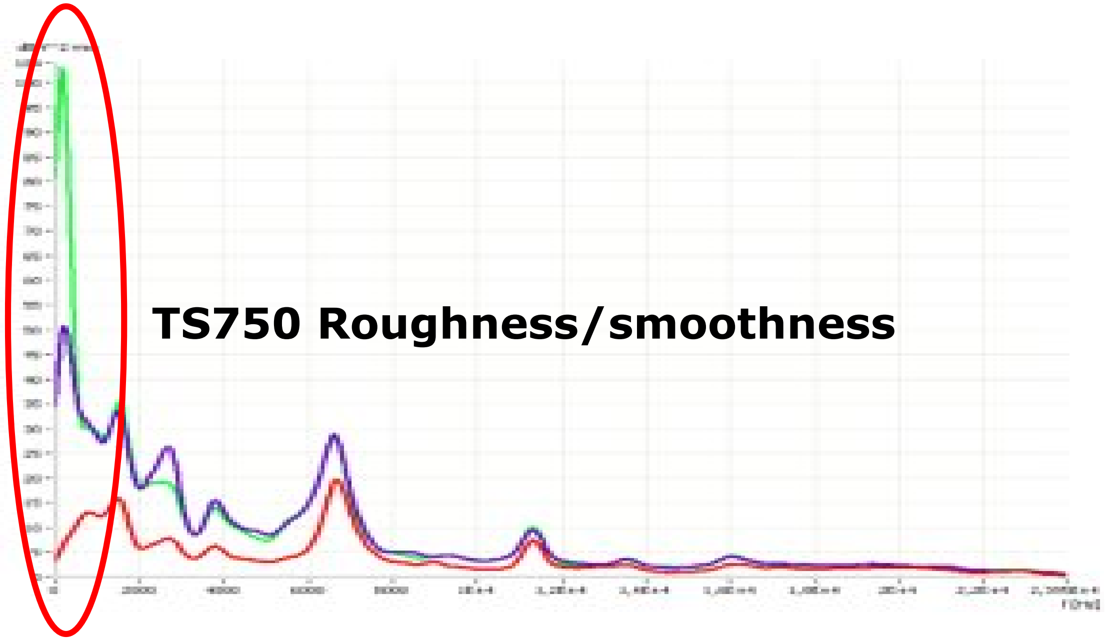
Measurement step one – assessment of softness (TS7)



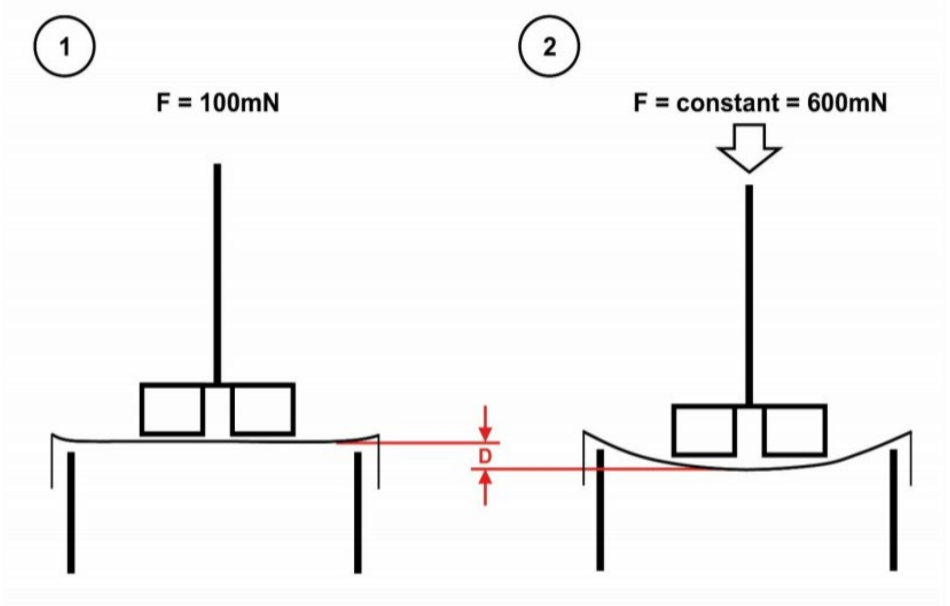


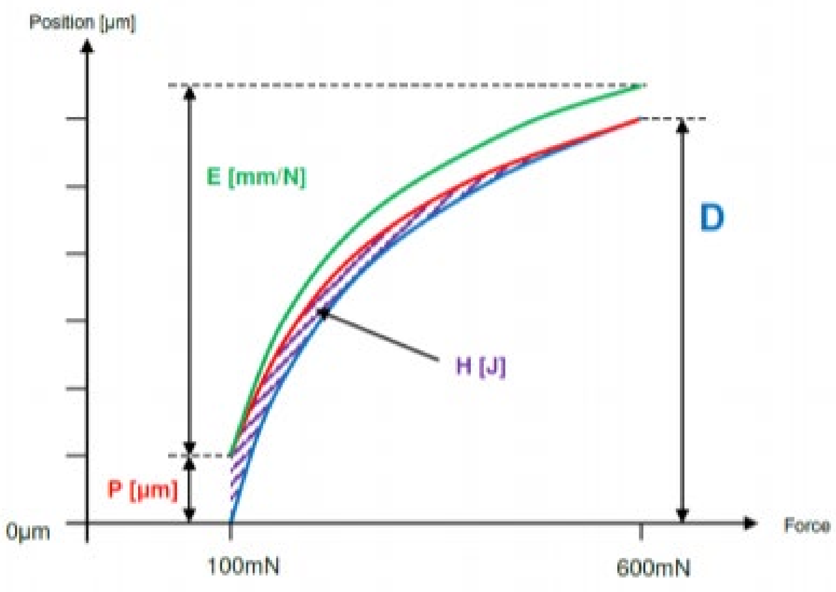
Measurement step one (continued) – assessment of roughness (TS750)





Measurement step two: assessment of stiffness (D)

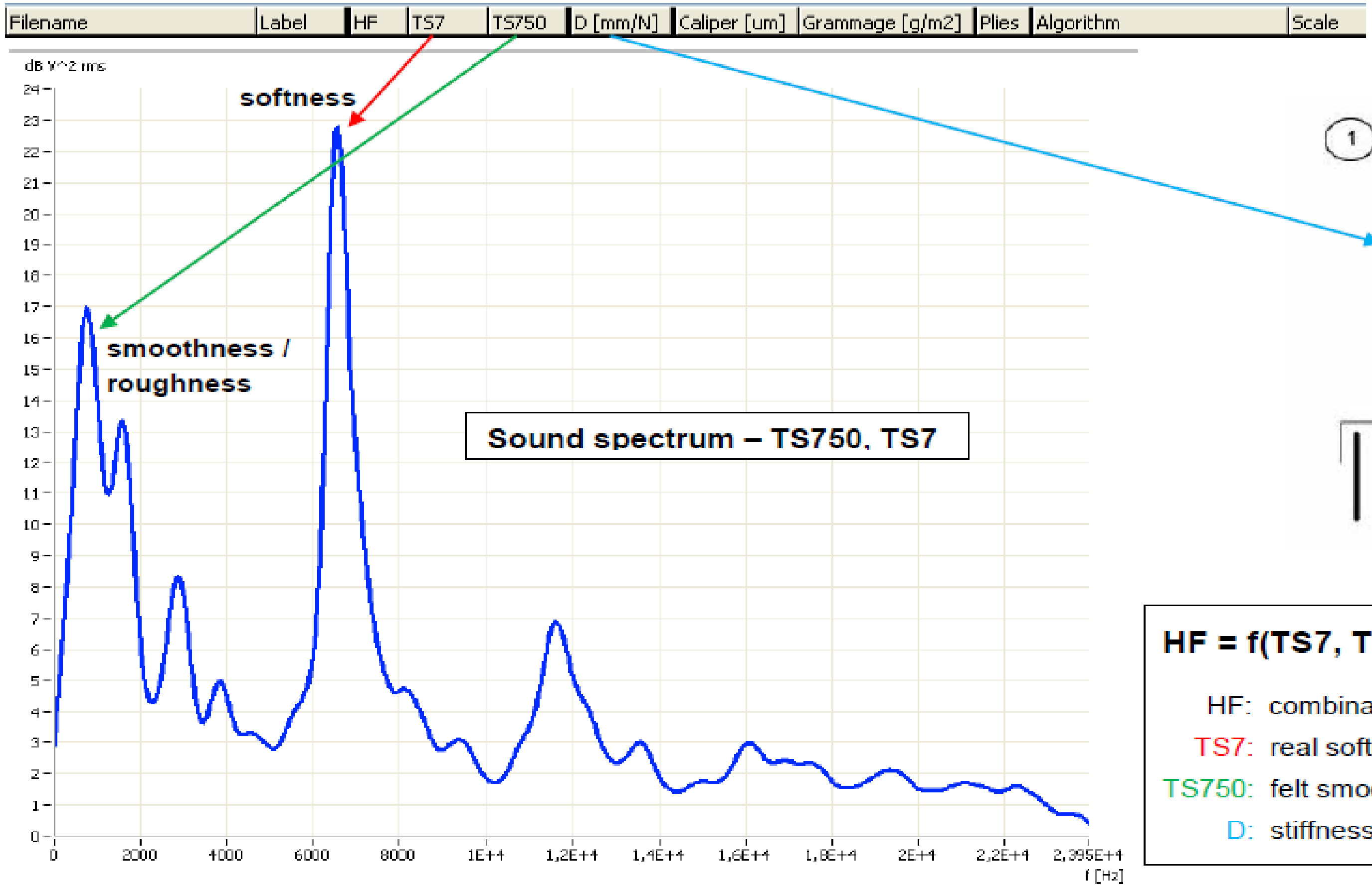


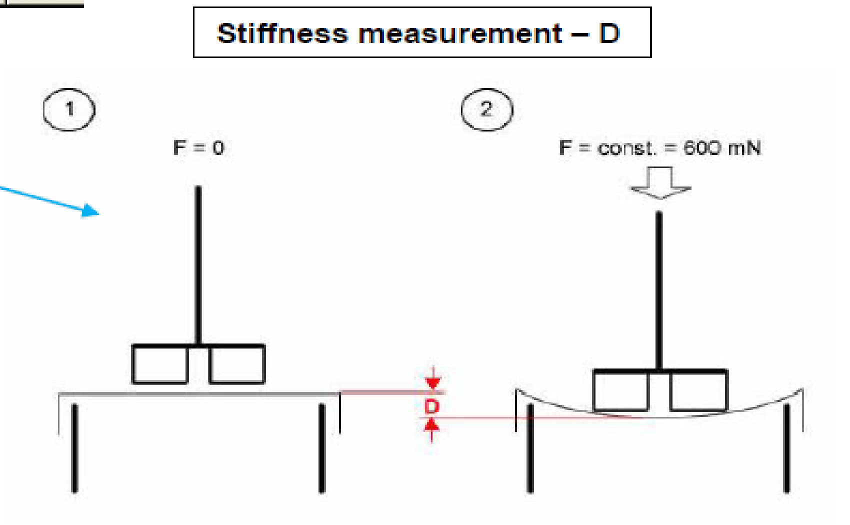


* Elasticity (E), Plasticity (P) and Hysteresis (H) are not factored in the algorithms to calculate HF.

General measuring principle of the TSA:

Based on the detection and evaluation (using a FFT) of the sound spectrum, as well as measuring the in-plane stiffness, by deformation of the sample membrane. Results are two spectrum peaks, TS7 and TS750, and one displacement number, D





HF = f(TS7, TS750, D, caliper, grammage, number of plies)

HF: combination parameter for the hand feeling

TS7: real softness (comes from the fibers, lower peak = higher softness)

TS750: felt smoothness / roughness (higher peak = higher roughness)

D: stiffness (lower number = more stiff)

Calculation of HF is a function of the measured softness (TS7), roughness (TS750) and stiffness (D), as well as the caliper, basis weight and number of plies.

HF= f(TS7, TS750, D, caliper, basis weight, # of plies)

- **Multiple algorithms available**
  - **Product (basesheet, towel, tissue, etc.)**
  - **Region (North America, Europe, etc.)**
  - **Available customization**

- **Excellent correlation**
  - **Hand panels**
  - **Internal scale**
  - **Designated instrument**

Applications

- » Research and Development
- » Process Optimization
- » Quality Control
- » Trouble Shooting and Complaint Management
- » Product Presentation (Marketing / Sales)
- » Benchmarking tests



Tissue Softness Analyzer (TSA)

Hand Panels

- Sensors in hands relay touch
  - Softness, roughness and stiffness
  - Brain interprets signals
- Subjective (100% human interaction)
  - Tester sensitivity
  - Testing procedure
  - Personal/market preferences
  - Culture
  - Mood

Tissue Softness Analyzer (TSA)

TSA

- **Objective**
  - **Minimal tester influence**
- **Measurement of sound and in-plane stiffness**
  - **TS7 (softness)**
  - **TS750 (roughness)**
  - **D (stiffness)**
- **Proven algorithms**
  - **Excellent correlation**
- **Individual parameters**
  - **Numerous applications**

Thank you

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