English *Page*

2 Declaration of conformity

CE

The Feltest Standard Caliper Gauge and the Feltest Caliper Profiler are instruments that conform to the following directive:

- 89/336/EEC of 03.05.1989, EMC directive

The following Generic Standards have been used to show compliance with this EMC Directive:

a) Emission : NEN-EN 50081-1 January 1994
b) Immunity : NEN-EN 50082-2 June 1995

Signed on May 1st 2004,

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3 Safety instructions

3.1 Intended use

The Feltest Standard Caliper Gauge and the Feltest Caliper Profiler are intended *only* to measure the caliper of forming fabrics and press felts on running paper machines.
The instrument is not intended, nor suitable to be used on *any other object*.

3.2 Safety precautions

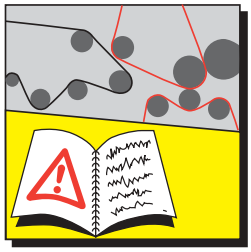

diagram 1

- Before using the instrument, read this manual carefully, it contains important safety information. If you not fully understand this manual, please contact Feltest Equipment bv for more information.
  Store this manual with the instrument, so the user can easily find it.

- Use the instrument only as intended and according to this manual. Do not measure running dryer screens or similar products. The seam of these products could strike the instrument out of ones hands, which might cause severe injuries and/or costly damages.

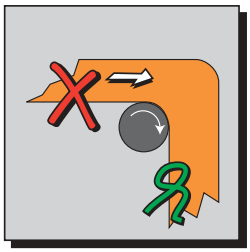

diagram 2

- Be aware of the danger of rotating machine parts (diagram 2). Do not make measurements close to in-going nips. You or the instrument could be grabbed into the machine, which might cause severe life threatening injuries and/or costly damages.

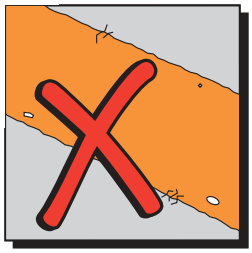

diagram 3

- Do not measure forming fabrics or press felts with holes or damaged edges (diagram 3). Before starting measurements, check with the staff of the paper machine if holes or damaged edges are known. At the machine, first check for defects or signs indicating defects, before starting the measurements. If you doubt, do not measure.

- Before starting a measurement, make sure you find a stabile position with two feet on a solid base (diagram 4).

diagram 4

- Always hold the instrument with two hands during the measurement procedure (diagram 4), to avoid it being stroked out of ones hands.

- Do not push the edge of the instrument against the edge of the fabric or felt (diagram 5). Irregular edges could strike the instrument out of ones hands.

- Do not bend over into the machine. If you must lean against a safety fence, first check its stability. Do not ignore or remove safety constructions. Always follow the safety instructions that apply for the location where measurements are done.

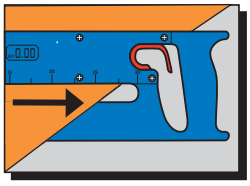

diagram 5

Please note:

Doing measurements (of any kind) on running paper machines is dangerous and requires alertness, concentration and common sense. Feltest Equipment bv's instru-ments are designed and constructed to be as save as possible for their intended use. Nevertheless it is the user's responsibility to actually use the instrument in a safe way. Feltest Equipment bv can not be held responsible or liable in any way for suffered injuries or damages that occurred while using this Feltest caliper gauges.

4 About the instrument

4.1 Standard Caliper Gauge vs. Caliper Profiler

The Feltest Caliper Gauge comes in two versions: the Standard caliper Gauge (diagram 6) and Caliper Profiler (diagram 7).

diagram 6: Feltest Standard Caliper Gauge

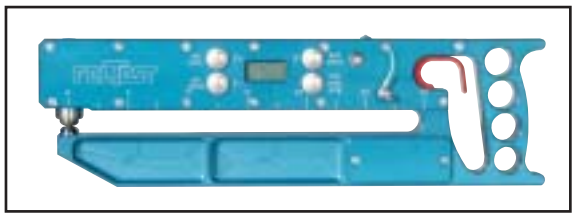

diagram 7: Feltest Caliper Profiler

Compared to the Standard Caliper Gauge, the Caliper Profiler has three additional pushbuttons and a connector for communication with a personal computer.

The instrument contains a number of high precision parts and therefore must be treated with care. Avoid strong mechanical shocks. The instrument has been protected against dust and spray water. However, avoid totally submerging the instrument in water.

4.2 Names of parts

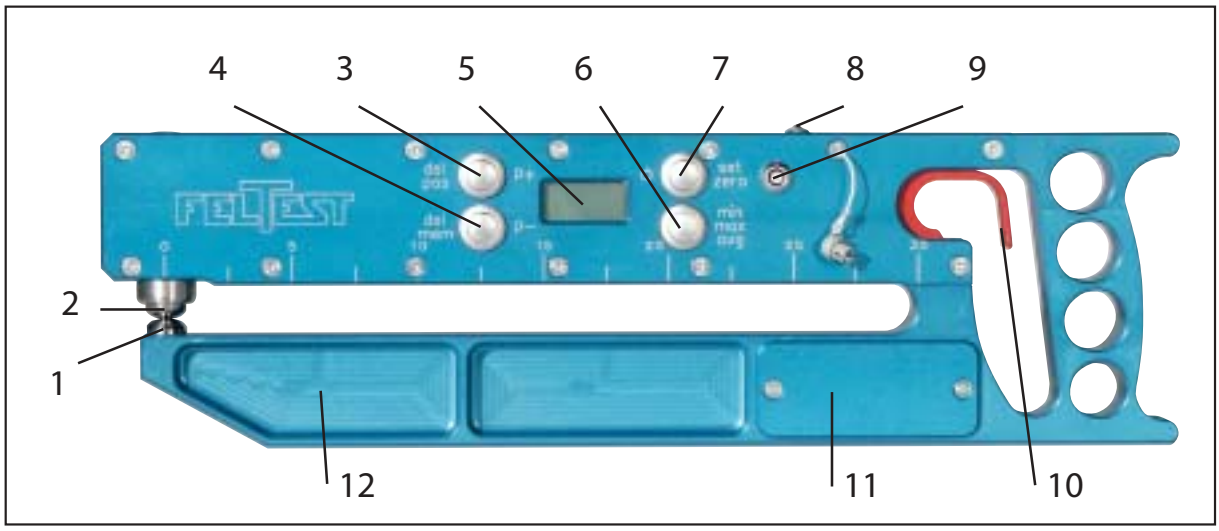

diagram 8: names of parts

1 Bottom feeler
2. Upper feeler
3. (only Profiler) Pushbutton to go to a higher memory position (p+) or to delete the current memory position (del pos)
4. (only Profiler) Pushbutton to go to a lower memory position (p-) or to clear all memory positions (del mem)
5. Alphanumerical display
6. (only Profiler) Pushbutton for the statistical functions (min, max, avg).
7. Pushbutton to turn the instrument on or off (press shortly) or to set zero (press longer)
8. Red indication LED
9. (only Profiler) Connector for serial communication with a personal computer.
10. Trigger
11. Battery container
12. Handgrip

4.3 Working principle

The working principle is as follows: a variable resistor (potentiometer) is mechanically connected with the upper feeler. The electric resistance measured when the mouth is closed is the reference or 0.00 mm. Opening the mouth gives a change in the electric resistance, which is transformed into millimetres or mills (1/1000 of an inch).

The sampling rate of the Caliper Profiler can be set between 5 and 25 Hz (i.e. the resistance is measured 5-25 times per second). The Standard Caliper Gauge has a fixed sampling rate of 10 Hz. The values shown on the instrument's display are slightly dampened to avoid a rapidly changing and therefore unreadable display.

The instrument has a high accuracy of ± 0.01 mm. This means there can be a slight zero-shift when the instrument undergoes temperature chances. For example: a fast running, relatively dry 4th press felt can generate a lot of friction and therefore heat during the measurement. The instrument needs some time to adjust to this new temperature (i.e. the metal parts need to expand) before the most accurate results can be acquired.

The trigger has a double function: when pulled, the mouth opens and the caliper gauge can be moved into the running fabric or felt. When the trigger is pushed, an electronic switch is activated. In the Standard Caliper Gauge it switches the HOLD function on and off. In the Caliper Profiler this switch is used to start or stop the recording of data into the memory.

From the linear scale one can read the distance (in centimetres) that the instrument is moved into the fabric or felt.

5 The measurement

The following instructions apply in most cases for both the Standard Caliper Gauge and the Caliper Profiler. Differences between the two versions are clearly indicated.

5.1 Finding a good position

The best position for doing measurements is different for every paper machine. Most important is to find a safe and stable position (see chapter 3). If there are several safe positions to measure, select one on the following criteria.

Forming fabrics:
- Measure only on the return-run, were the fabric runs without paper.
- Preferably before a driven roll, as at that position the fabric stability will be the highest.
  Stay away from the in-going nip!

Press felts:
- Measure only on positions where there is no paper on the felt (pick-up and tissue felts!).
- Preferably close after the press nip, before any showers or felt conditioning (see also chapter 7, Interpretation of the results).
- The caliper must be measured within the sheet's run.

For press felts the measurement is only of value when the felt has been running for at least one hour under a steady press load.

5.2 Measuring procedure

1. Switch the instrument on by pushing the on/off button (nr. 7) at the front.

2. Pull the trigger a few times to move the upper feeler. Check if the display reads "0.00 mm" with closed and clean feelers. If necessary, set zero by pushing the set zero button (nr. 7) longer than 2 seconds. When the display reads "set zero" the button can be released.
   Note: due to temperature differences the zero may shift temporarily. Therefore always check the zero setting before each measurement.

3. Open the mouth of the instrument by pulling the trigger (nr. 10) and move the instrument into the running fabric or felt. Do not let the end of the instruments mouth (at the 30 cm sign) touch the edge of the fabric or felt (diagram 5)!
   Keep the instrument *perpendicular* to the fabric or felt as shown in diagram 9 and release the trigger quietly.

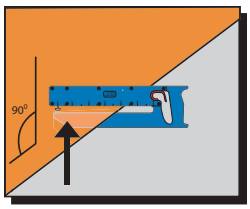

diagram 9

4. Slightly *push* the instrument upward (diagram 9) to make sure that the upper feeler has free movement. After approximately 2 seconds a stable result is achieved.

5. Standard Caliper Gauge: *pushing* the trigger once will activate the HOLD function. The current test result is frozen on the display, the red indicator on top (nr. 8) will light up.
   Caliper Profiler: *pushing* the trigger will start the recording the test results into the next available memory position. The red indicator on top (nr. 8) will start flashing.

6. Caliper Profiler: to make a caliper profile or to measure the thinnest or thickest spot, move the instrument slowly towards the edge of the fabric or felt (diagram 10). The data recording will stop automatically when the feelers go over the edge of the fabric or felt. When the recording stops, the red indicator on top will dim.
   For press felts it is not always necessary or useful to make a caliper profile. In that case keep the instrument steady and after a few seconds switch off the data recording manually by pushing the trigger once more. The red indicator will dim.

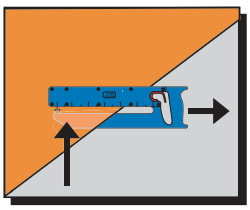
diagram 10

7. Open the mouth by pulling the trigger and remove the instrument from the felt or fabric.

8. Standard Caliper Gauge: read the value from the display and push the trigger once again to release the HOLD function (the red indicator will dim).

9. Check the zero setting. If, due to temperature differences during measuring, zero is more then ± 0.03 mm off the procedure must be repeated until a reproducible result is achieved.

10. Caliper Profiler: to see the lowest and highest test result and the average value, press button nr. 6 several times. Pressing the button one more time will show the current value again.

11. Pressing the on/off button (nr. 7) shortly will turn off the instrument. If during 30 minutes no button is pressed, the instrument switches off automatically.
All the stored data remain in memory.

5.3 Feltest Caliper Profiler memory navigation

The Feltest Caliper Profiler has an onboard memory module. It can contain several thousands of values divided over a maximum of 99 memory positions. Obviously a high sampling rate and long lasting measurements will fill the available memory faster than short measurements on a low sampling rate.

Every time a recording is started, automatically a new memory position is created. If the memory was cleared, the first measurement is stored under **p 01**, the next under **p 02** etc. By shortly pushing **p+** (button nr. 3) or **p-** (button nr. 4) it is possible to navigate through the memory positions.

When the **del pos** button (nr. 3) is pushed longer than 2 seconds the current memory position will be deleted. As long as the display reads **p xx delete**? (xx represents the current memory position) it is still possible to cancel this action by releasing the button. After the 2 seconds the display will show p xx deleted and the data of this memory position are no longer available. This position is then identified by **– xx** in stead of **p xx**. Please note that deleting a position does *not* create additional memory space for new positions.

Pushing the **del mem** button (nr. 4) longer than 2 seconds will fully clear the memory. All stored memory positions are deleted and all memory space comes available for new measurements.

5.4 Feltest Caliper Profiler PC communication

The Feltest Caliper Profiler can be connected to a personal computer (PC) with the supplied serial cable (RS232). The software **Feltest Service** "FS" makes it possible to load the measured data from the instrument or to chance the settings of the instrument. A manual and a help file are enclosed in the software.

Available settings:

setting	*description*	
measuring unit	either in millimetres [mm] or in 1/1000" [mil]	mm – mil
sampling rate	number of measurements per second stored in memory	5 – 25 Hz
auto-off level	when during recording the auto-off level is reached (in [mm] or [mil]) the recording is stopped automatically	0.10 – 1.50 mm 3.9 – 59.1 mil

To load the measured data from the instrument to the PC, one could use the **Feltest Service** software, but also any other terminal program, like for example Hyperterminal that is supplied with Microsoft Windows.
Communication settings for terminal programs: 19.200 baud, 8 bits, 1 stop bit, No Parity.
Sending the command **$R1** to the instrument will result in a list of all the stored data, including a linefeed-character after each value. Use **$R0** for a list without the linefeed-character.

6 *Interpretation of the results on forming fabrics*

The Feltest Caliper Gauge can be used to measure the caliper of running forming fabrics. Due to the relatively high spring-load and special shaped feelers it will generate accurate values, not influenced by contamination or 'water skiing'. The results are independent of the person who does the measurements. The digital display makes the read out simple and clear.

The interpretation of the measurement is quite easy. Most suppliers of forming fabrics maintain a minimum caliper for their products, which is stated in their product information. The measured result can be compared directly with this minimum caliper value.

Usually the thinnest spot determines when a forming fabric must be replaced and in many cases this spot can be found within 30 cm from the wire edge. This local wear can be caused by the edges of foils, poorly positioned stops on suction boxes, etc. etc.. In these cases the Feltest Caliper Profiler is an excellent tool to locate and accurately measure this thinnest spot.

The *theoretical* rest potential of a fabric can be calculated with the following formula:

$$\text{Rest potential}[\%] = \frac{\text{caliper}_{(run)} - \text{caliper}_{(min)}}{\text{caliper}_{(min)}} \times 100\%$$

Please be aware that this calculation is only of limited value because it is not possible to determine on which side the fabric has lost material. Usually forming fabrics have more material at the roll side to withstand abrasion. The warp, which gives the fabric it's strength, is usually located on the paper side. Therefore, a caliper decrease of 0.2 mm is much more serious if the material is lost on the paper side then if it would be lost from the roll side! Only a visual inspection during a stop may clear this up.

7 Interpretation of the results on press felts

The caliper of the felt alone is difficult to interpret and should be judged in conjunction with the felt weight. A combination of these two units is felt compaction.

When a piece of the felt goes through the nip, the felt is first compressed and afterwards it will expand. During the lifetime of the felt this expansion will decrease and the felt will become compacted.

One could imagine a felt with all the felt material concentrated on the bottom and all the storage volume (containing water) on the top, as sketched underneath in diagram 11:
with h = felt caliper in mm, as measured with the Feltest Caliper Gauge

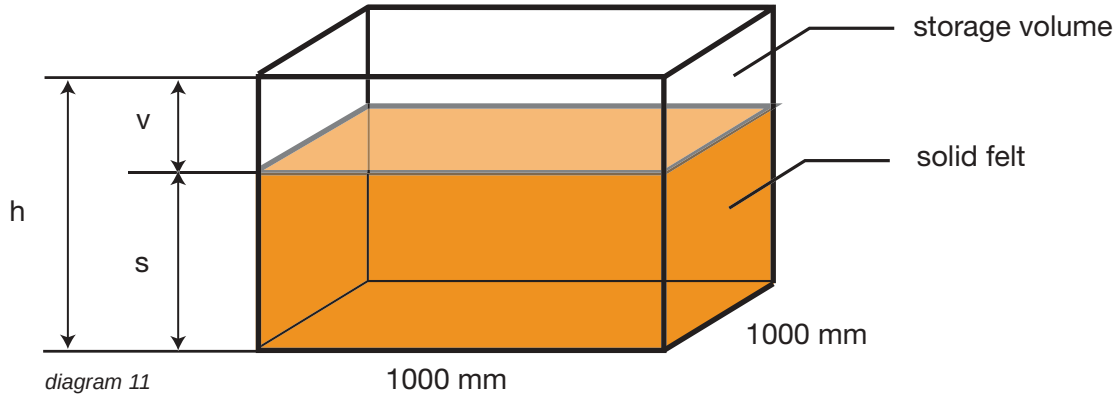

diagram 11

s = solid component of the felt (in mm), depending on the felt weight
v = void component of the felt in mm
F = actual felt weight in g/m²
ρ = density or Specific Gravity of the applied material. For press felts this usually is 1.14 g/cm²

The basic formula: $\text{volume} = \frac{\text{weight}}{\rho}$ gives: $s = \frac{F * 10^3\ mm^3}{1.14 * 10^6\ mm^2}$ [mm]

COMPACTION $= \frac{s}{h} * 100\% = \boxed{\frac{F}{h} * 11.4}$ **[%]**

If all the void volume of the felt would be filled with water, we refer to this as the "saturation moisture" or the "water storage capacity" of a felt. The unit is [ml/m²] or [g/m²]. The storage volume can be calculated with the following formula:

caliper [mm] * 1000 - $\frac{\text{felt weight}}{\rho \text{ or density}}$ or in other words:

STORAGE CAPACITY $= \boxed{1000 * h - \left(\frac{F}{1.14}\right)}$ **[g/m² H_2O]**

For the most common combinations of felt caliper and felt weight, the compaction percentage and storage capacity can also be found at the added tables in this manual. In order to interpret the test results (expressed as % compaction) somewhat easier, 5 graphics of various positions at high-speed machines (v_{PM} > 900 m/min) are added as a reference. Note that these graphics are an average of many different measurements on many different paper machines with many different felt types from many different suppliers.

It is recommended to develop such a curve for each specific position of your machine.

7.1 Judging the condition of a felt

It is quite possible to compare the theoretical water storage capacity of a felt with the actual water content (as produced by L&W Scanpro equipment). Interesting conclusions in regard to the felt's condition can be drawn.

Storage capacity > real water content

If the storage capacity is higher then the actual water content, the felt is not fully saturated with water.
For high-speed machines this indicates that the felt is bulky and that the de-watering over the nip is not (yet) optimal. It could mean that felt is not yet 'run in'.
For low speed machines this is quite a normal situation for a felt in a good condition.

Real water content > storage capacity

The storage capacity can also be less then the actual water content. But how can a felt contain more water then that there is theoretically space for? The answer can be found in the felt weight and/or re-wetting of the felt.

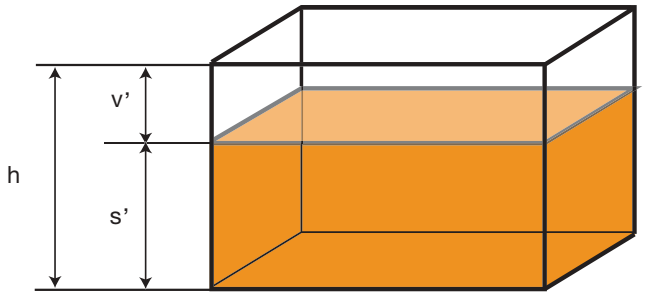

diagram 12

The caliper h is measured with the Feltest gauge and is therefore known. The water content is also measured and can be re-calculated to represent v' (see diagram 12). The only variable left is the solid felt, represented by s' in the sketch. The value of s' can only be less than it original-ly was (wear!).

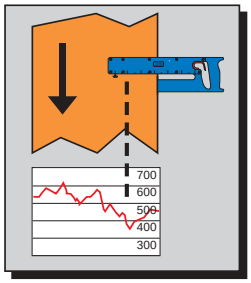

diagram 13

In theory one can calculate from s' backwards to the current felt weight. By comparing the current felt weight with the original (new) felt weight one could calculate the wear. But note: there are two important factors that have to be taken into account!
First is the measured water content: the L&W Scanpro© instrument should be calibrated correctly and one should use the water content from the same position where the caliper was measured (see diagram 13). Water from the felt conditioning system can influence the calculation in a negative way; therefore try to make a L&W Scanpro© measurement right after the nip and certainly before the felt conditioning.

The *second* factor is re-wetting. If there is much re-wetting of the felt after exiting the press nip, the L&W Scanpro© instrument measures more water than there was in the mid-nip, therefore wrongly indicating felt wear. It is important to know which kind of press roll is used; for example blind drilled rolls cause more re-wetting than grooved or suction rolls.

Low speed machines like board machines usually have considerable re-wetting of the felt,

which makes wear-calculation extremely difficult. For fast running machines one can use the following formula to estimate the current felt weight:

$F_{current}$ = (1000 * h - Scanpro©water content) * 1.14 * re-wetting factor

The re-wetting factor can vary between 1.05 (suction roll at high speeds) and 1.16 (for tissue felts). Comparing the actual wear from lab reports with this calculated wear will help you to establish representative values for the re-wetting factor.

7.2 Sources of error

It may happen that the outcome of a measurement seems to be very unlikely, hence an error must have occurred. Following sources of error must be considered:

- The most common error is that in the calculations a wrong felt weight is used, either because of wrong data being used, or because the felt has lost weight due to wear. In particular in combination with CaCO3 a loss of felt weight of 15 to 20% is not uncommon. In case of a very high calculated compaction (> 85%) one can expect that the felt has lost fibres. A low water content (L&W Scanpro©) and high airspeeds at the suction boxes could affirm this.
- The measured caliper was affected by some local wear, for instance caused by a suction box edge. Do the measurement again.
- The measurement was done outside the sheet's run. Do the measurement again.
- The 'set zero' was not checked just before the measurement was performed. The temperature difference between a 1st press position in the basement and a 3rd press position near the drying hood can be substantial. Therefore it is important to always check the 'set zero' before every measurement. Do the measurement again.

8 Maintenance

8.1 Maintenance

The instrument is almost maintenance free. After use
the instrument can be stored immediately, it does not necessarily need cleaning or drying.

Cleaning
For good and accurate measurements the two feelers (made from stainless steel) must be kept clean. The
feelers can be cleaned with a cloth or some tissue after the measurements and before storing the instrument.
The frame (aluminium) and the display window (polycarbonate) can be cleaned with a humid cloth and, if necessary, some mild detergent.

Battery change
The instrument uses a standard 9-Volt (size PP3) alkaline battery, which usually lasts over 1 year. When the battery is starting to wear our, a **low bat** warning is shown in the display for a few seconds when the instrument is switched on.
The front plate of the battery container (nr. 11) can be removed by unscrewing the two screws. Replace the battery. Before putting back the front plate, check if the rubber seal around the battery container is still on its place and in good condition. Tighten the two screws with medium force.

Lubrication
It is recommended to lubricate the shaft of the upper feeler about once every 6 months.
To lubricate the shaft, put a few drops of oil through the hole of the collar (see diagram 14). Then hold the instrument up side down and pull the trigger a couple of times.

diagram 14

8.2 Accuracy and calibration

The Feltest Standard Caliper Gauge and the Feltest Caliper Profiler both are supplied with a calibration certificate. Within the range of 0.50 mm to 5.00 mm the accuracy is ± 0.01 mm.

A little wear on the two feelers (nr. 1 and 2) does not influence the accuracy, as the zero point must be set before every measurement. More extensive wear resulting in a flat surface of the feelers, will influence the measurement negatively:

- The instrument becomes more sensitive for 'misalignment'. If the instrument is not kept exactly perpendicular to the fabric or felt the measured caliper tends to be too high.
- When measuring press felts the worn upper feeler will be pushed into the felt a little less, resulting in higher caliper values.

If the unlikely event that the accuracy gets out of specification, the instrument needs to be send to Feltest Equipment bv for a service and a new calibration.

8.3 Service

If the instrument needs a service it can be send to Feltest Equipment bv. Please add a problem description in English or German language and send it properly packed and insured to:

Feltest Equipment bv
Bijenkorf 55
NL –6961 PA Eerbeek
The Netherlands

Telephone: +31 313 652 215
Fax: +31 313 654 068
E-mail: info@feltest.nl

9 Specifications

	Feltest Caliper Profiler	Standard Caliper Gauge
Length	431 mm	431 mm
Height	130 mm	130 mm
Depth	27 mm	29 mm
Weight	1.3 kg	1.3 kg
Protection	IP 64	IP 64
Measuring range	0 – 5 mm	0 – 5 mm
Accuracy	± 0.01 mm	± 0.01 mm
Sampling rate	5 – 25 Hz (adjustable)	10 Hz
Measuring unit	[mm] or [mil]	[mm] or [mil]
Battery type	Alkaline 9-Volt, size PP3	Alkaline 9-Volt, size PP3
Guarantee period	24 months	24 months