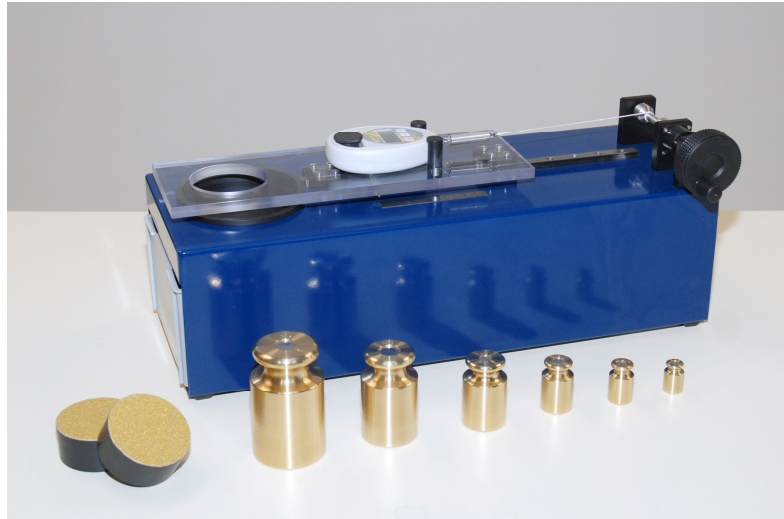




# 08.66 Surface shear test apparatus

## Operating instructions



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### All it takes for environmental research

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## About these operating instructions



If the text follows a pointer (as shown on the left), this means that an important instruction follows.



**If the text follows a warning (as shown on the left), this means that an important warning follows relating to danger to the user or damage to the apparatus.**

**The user is always responsible for his or her own personal protection.**

*Text*

**Text in italics means that the actual text is shown on the device or display screen.**

## General safety precautions



**Please read and understand these entire instructions before proceeding.**

- This apparatus is for soil research applications.
- Ensure your personal hygiene and environmental precautions if working with contaminated samples.
- Do not expose the equipment to rain, or use in wet locations; it is rated for indoor lab locations only.
- For service or repair only use original replacement parts supplied by Eijkelkamp.

## 1. Product Description

### 1.1 Introduction

In many land use systems worldwide soil deformation is a major problem arising from increasing land use intensity. Altered soil functions, in particular reduced hydraulic conductivities and impeded aeration, influence the top soil layers. This has an important effect on erosion vulnerability in particular.

Assessing very thin soil layers like soil crusts requires very sensitive and highly accurate equipment which should also allow very small vertical stress application during measurement. Many different shear test devices are available for measuring the shear strength, including direct shear equipment, shear vanes or cone penetrometers, but the construction of the frame shear test requires a thickness of the sample of at least 3 cm for example, which excludes such test devices for soil crust strength determination.

Soil stability is a factor of decisive interest in reducing the risk of erosion. Soil stability is determined by shear resistance or the angle of internal friction, depending on or varying from soil-water pressure and humus-content. Soil shear resistance will increase with increasing organic carbon content. Air-dry soil-state samples will result in the smallest resistance to shearing in comparison with the range of water content applied. The effect of bulk density on soil shear strength depends on water content and is distinct for a higher range of vertical loads.

### 1.2 Applications

- Erosion;
- Geotechnical engineering;
- Geo-Hydrologic research;
- Basic material research.

### 1.3 User groups

- Laboratories;
- Universities;
- Research institutes;
- Educational institutes, etc.;

### 1.4 Features

- Easy manual operation;
- Accurate measurement principle, digital read-out;
- Sample size d103x100 h30 mm;
- Excellent price-quality ratio;

- Developed in cooperation with Christian-Albrechts University, Kiel.

### 1.5 Method

Surface shear:

Soil samples into sample rings are sheared by force at a defined soil-water pressure and normal stress.

Soil-water pressure e.g.: -30; -60; -150; -300; -500 hPa

Normal stress e.g.: 2; 5; 8; 10; 20 hPa

### 1.6 Global method (steps) of measurement

Very small vertical stresses (between 1 and 30 hPa) are applied to a fixed round soil sample (diameter 100 mm / height 30 mm) via a cylindrical shear container, covered with special high-quality abrasive at the bottom to create a rough shear-plane. The horizontal force is applied with a manual precision-winding mechanism. The spring construction transfers distance to force and damps for force increments.



**The 'Surface Shear Test' is a comparison test so it is important to use the same initial conditions to enable a reliable comparison between different measurements.**

The shear container with established vertical load, placed on top of the sample, needs to be exposed to a horizontal force until it starts to move visually. The shear stress under applied vertical load is calculated by the weight divided by the area of the shear container. Three replicates for one vertical load are needed for each type of soil core (to determine the shear stress). Measurements can be performed on soils with different predetermined water tension values. The same sample cannot be used for measurement twice, because of irreversible damage in the surface structure, caused by shearing.

- The soil container with soil sample is placed into the instrument.
- A shear container ( $\varnothing = 68$  mm) with high-quality abrasive (free from dirt; in good condition) material is placed on top of the soil sample.
- The soil sample is exposed to a vertical pressure/load (different weights are available) by placement of the weights into the shear container.
- To execute the surface shear test, a horizontal load is applied manually to the shear container with a vertical load by slowly turning (for about max. 1 turn/sec.) the hand wheel of the precision-winding mechanism.
- The surface shear load (= slowly applied max. load to create a movement of the shear container with vertical load) is measured by a digital balance. This balance logs the max. applied force until movement for 5 seconds.

## 2. Technical specifications

Soil sample	:	Ø = 100 mm; h = 30 mm		
Soil sample rings	:	Ø = 103 x 100 mm; h = 30 mm		
Shear container	:	diameter = 68 mm		
Roughness abrasive	:	P-40 (special proven quality!)		
Weight container	:	for about 40 g	->	1.08 hPa*
Weight 1	:	50 g	->	1.35 hPa
Weight 2	:	100 g	->	2.70 hPa
Weight 3	:	200 g	->	5.40 hPa
Weight 4	:	500 g	->	13.51 hPa
Weight 5	:	1000 g	->	27.01 hPa
Weight 6	:	2000 g	->	54.02 hPa
Shear speed	:	manually		
Shear force	:	Range digital scale : 0 – 5000 g		
		Resolution : 5 g		
		Peak value and hold function		
Dimensions	:	L x W x H = 50.5 x 21 (24) x 21 cm		
Weight	:	approx. 10 kg (total weight including additional parts e.g. different weights)		

Eijkelkamp states explicitly that these instructions are only indicative.  
 These instructions and specifications may be changed without notice and no rights whatever may be claimed.

\*)  $p = (m \cdot g) / A = F / A = [N/m^2] = [Pa]$        $1[hPa] = 100[Pa]$   
 $m = \text{mass [kg]}$   
 $A = \text{bottom area weight container [m}^2]$   
 $g = \text{gravity [m/s}^2] \text{ (average value: } 9.81[m/s^2])$

$$\frac{0.04 \cdot 9.81}{(\pi/4 \cdot 0.068^2)} = 108.05 [Pa] = 1.08 [hPa]$$

### 3. Schematic construction

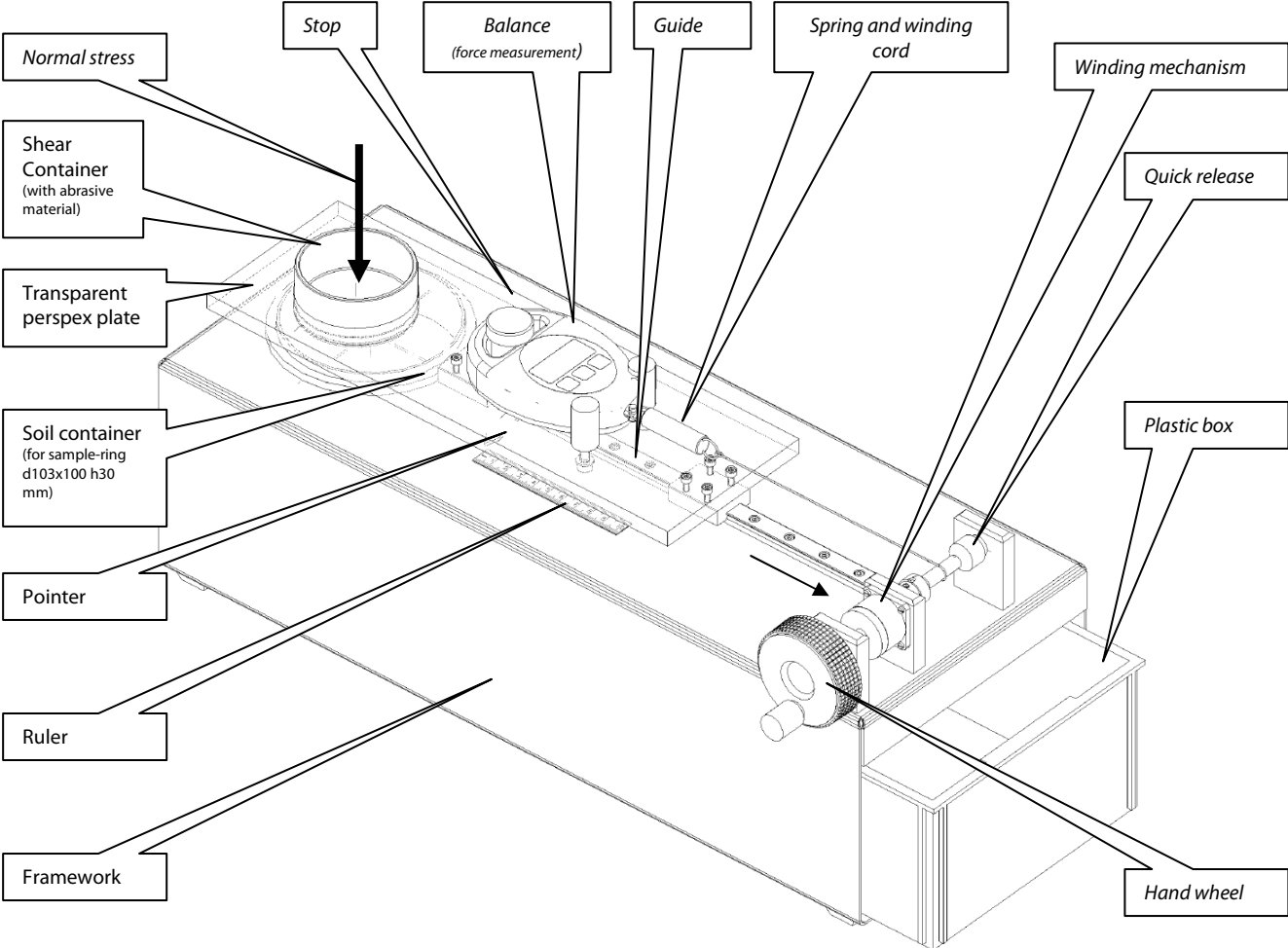


Fig. 1: Schematic view of surface shear test apparatus.

## 4. Preparation (unpacking, etc.)

Remove all packaging materials, check for completeness and damage and report irregularities directly to your supplier.

Table 1: Parts list

<b>Description:</b>	<b>Quantity:</b>	<b>Art.no.:</b>
Surface Shear Test Apparatus	1	086601
Shear container with abrasive material	2	086605
Spare abrasive material	2	086607
Weights		
50 g	1	086620
100 g	1	086621
200 g	1	086622
500 g	1	086623
1000 g	1	086624
2000 g	1	086625
Grey plastic box	1	H269380



**Only use original Eijkelkamp spare parts!**

## 5. Installation

### 5.1 Placement of the apparatus

Place the apparatus in a clean and dry environment, not exposed to direct sunlight, at room temperature for best operational performance and measurement results. The apparatus should be easily accessible. The instrument should be placed on a flat level surface.

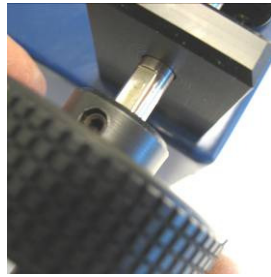
### 5.2 Mounting the control hand wheel

Required:

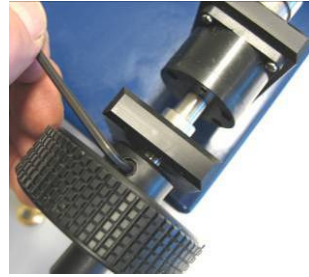
- hand wheel;
- Allen key (2.5 mm).



Step 1



Step 2



Step 3

Fig. 2: Steps for mounting the control hand wheel.

Step 1:

Placement of the hand wheel.

Step 2:



**Be sure the hexagonal head screw is above the flattened side of the shaft.**

Step 3:



**Slightly tighten the hexagonal head screw by using the Allen key (2.5 mm).**

## 6. Soil samples

The soil sample should be undisturbed, and as the measurement quality depends on the soil sample quality, care should be taken during sampling. A practical way of sampling is by using the hammering method (see fig.3 for equipment); the most precise but costliest method is using hydraulic sampling equipment, which is not discussed further here.



Fig. 3: Tools for field sampling.

### 6.1 Field sampling (fig.4)

- Clear and prepare the soil surface to ensure representative samples can be taken.
- Place 5 sample rings on the soil surface.
- Place the sample tool over the sample ring.
- Drive the ring fully into the soil by hammering the sample tool.
- Excavate the sample by spade or trowel.
- Remove the surplus soil to approx. 2-5 mm of the sample ring both sides.
- Cover the ring with transport caps preventing drying out and compressing the soil sample.
- Register the ring number and sample details.



Fig. 4: Steps for field sampling.



## 6.2 Lab sample preparation

- Carefully remove the surplus soil on both sides of the sample ring by stepped vertical cuttings breaking horizontal parts of soil away. This will keep the pore structure in its original condition.
- Optionally weigh the sample for volumetric soil moisture content of the field capacity.
- Bring the soil moisture matrix to a predetermined value (Eijkelkamp can supply the right equipment for this; fig.5).
- Weigh the sample for volumetric soil moisture content.



*Fig. 5: Equipment for sampling / preparation (08.27).*

## 7. Operation of the surface shear test apparatus

Use by properly trained personnel (soil scientists) is preferred, especially for interpreting the measurement results. Use of the surface shear test apparatus is intended for soil samples only! Other use than that for which it is intended may damage the equipment.

### 7.1 Requirements

- Shear test instrument, placed on a level surface;
- Soil container to place the soil sample;
- Shear container with abrasive material;
- Prepared soil samples (sample rings:  $\text{Ø}103 \times 100 \text{ mm}$  h30 mm);
- Different weights.

### 7.2 Checking zero load

Before starting the measurement, measure the zero load of the system. This is necessary to calculate your measured values into net values.

1. Place the transparent Perspex plate at its furthest left position, using the quick-release mechanism (fig. 6).



Fig. 6: Quick adjustment of the winding mechanism for placement into furthest left position.

2. Wind the first part of the cord around the reel using the quick adjustment mechanism. Wind the cord until just before it pulls the spring.



**When turning the quick adjustment winding mechanism, turn anticlockwise to wind the cord (fig.7). So the cord will wind by turning the hand wheel clockwise.**



**Be sure the spring is always hanging in the horizontal position, free from the perspex plate (fig. 7). Be sure the hexagonal head screw is above the flattened side of the shaft.**



Fig. 7: Quick winding the first part of the cord; be sure the spring is in the horizontal position.

3. Switch on the digital scale and tare it (fig. 8).



Fig. 8: Tare the scale / start winding smoothly clockwise / read the maximum value after minor movement.

4. Start turning the hand wheel smoothly clockwise to wind the cord of the winding mechanism carefully (one turn per second; count 21; 22; 23; 24; 21; 22 and so on). These movements results in a tensile force on the shear container with weight (fig. 8).



**While turning the winding mechanism, observe the ruler beside the guidance system. As soon as movement is noticed, read out the maximum load from the digital scale.**

5. Repeat this measurement several times (e.g. three times) over the first three-centimetre stroke (use the ruler and pointer beside the scale). Calculate the average value; this is the value to calculate the net values.

## 7.2 Measurement sample preparation and placement

1. Only start the measurement when the apparatus is clean (cleaning: see Chapter 8).
2. Note the sample information (see appendix 1 for an example form).
3. Place the transparent Perspex plate into the maximum right position (fig.9).



Fig. 9: Perspex plate into maximum right position



Fig. 10: Removing soil container from apparatus.

4. Remove the soil container from the apparatus (fig.10).
5. Put the sample-ring with sample into the soil container (you can put a very loose sample into the plastic box, in a vertical position); see fig. 11.



Fig. 11: Placement of sample-ring into soil container.



Fig. 12: Placement of assembly into blue frame.

6. Put the soil container into the opening of the blue frame (fig.12).

- Unwind the cord of the winding mechanism completely, using the quick-release mechanism (fig.13).



**Ensure the cord of the winding mechanism is completely unwound to prevent damage to the instrument!**

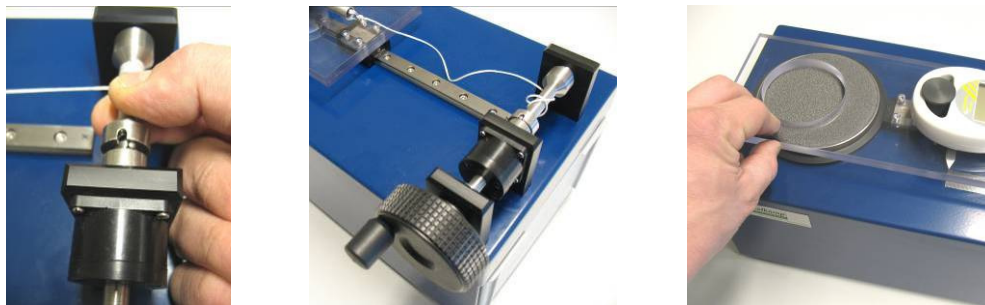


Fig. 13: Quick adjustment of winding mechanism for placement into maximum left position.

- Place the transparent Perspex plate in the left position (fig. 13).
- Put the shear container with abrasive material on top of the soil sample, into the opening of the Perspex plate (fig. 14).



**Ensure the abrasive material is in good condition and clean (see Chapter 8)! Never use worn or sludged abrasive.**

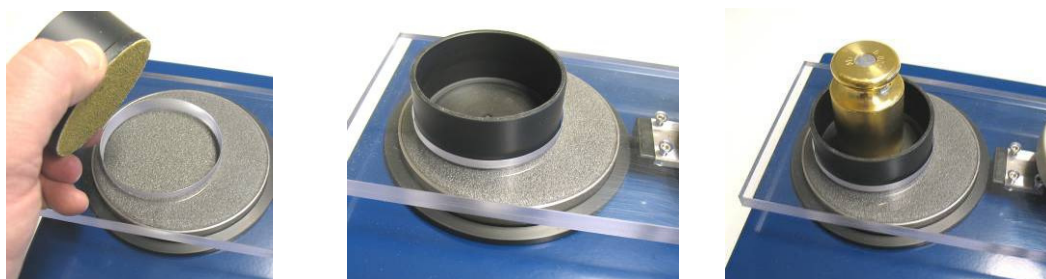


Fig. 14: Placement of the shear container with abrasive material on top of the soil sample.

- Place the weight (weight depends on the kind of sample-material) in the MIDDLE of the shear container (fig. 14).
- Note the value of the chosen weight on the form (see appendix 1 for an example form).
- Wind the cord of the winding mechanism with the quick-release mechanism by turning counter clockwise so it just slackens (no tensile force to the spring).
- Ensure the spring is in the horizontal position (fig. 15).
- Switch on the digital balance and tare it (fig. 15).



Fig. 15: Tare the scale, start winding smoothly clockwise, reading the maximum value after minor movement.

- Start turning the hand wheel smoothly clockwise to wind the cord of the winding mechanism carefully (one turn per second; count 21; 22; 23; 24; 21; 22 and so on). These movements result in a tensile force to the shear container with weight (fig. 15).



**While turning the winding mechanism, watch the ruler beside the guiding system. As soon as there is movement, read out the maximum load from the digital scale.**

**Every measuring instrument has an accuracy. It is advisable to wind back the winding mechanism counter clockwise until the cord just slackens and read out the possible residual value. If there is a residual value, adjust the maximum load value.**

16. Note the value of the shear load on your form (see appendix 1 for an example form).



**Beware of continuing the measurement with the same sample, because of material accumulating at the front of the plastic box with weight during movement.**

**Once the plastic box has slid over the surface, the sample cannot be used a second time.**

**This is because of irreversible damage to the surface structure, caused by shearing.**

17. Remove the sample in reverse order.
18. Clean the apparatus, using a brush for example. Never use compressed air to blow away dust, as this will damage the guiding system.

## 8. Cleaning/service

### 8.1 Instrument

Always use a fine soft brush (possible clean lint-free wipes; beware of scratches!), no compressed air. Blow fine dust/dirt away gently by mouth. Never blow between the guiding slider. Keep solvents or water away from steel parts.



**Regularly use a minimum of silicone or Teflon spray (wet) to lubricate the guiding rail if the guiding system runs dry or becomes noisy. Never use thick sticky lubricants like grease!**

### 8.2 Abrasive material

During the measurements, the abrasive material has to be clean and in good condition. Remove dirt by brushing and/or at least rinse with water.

## 9. Replacement

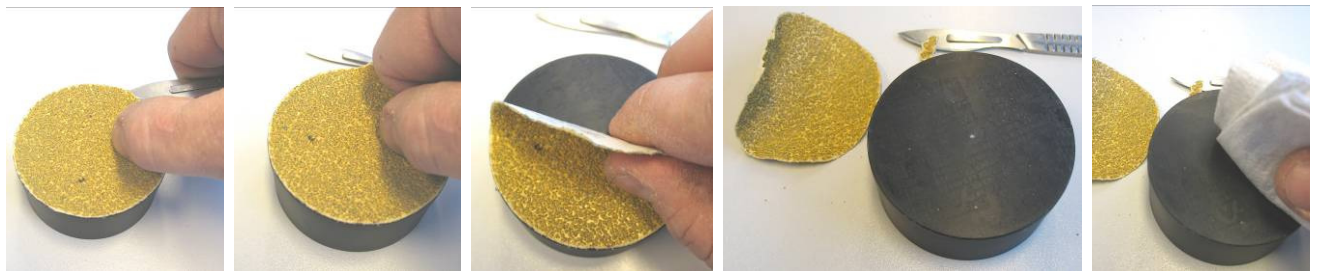
### 9.1 Abrasive material

The degree of wear of the special high-quality abrasive material of the shear container depends on the way it is used, particularly on the type (hardness) of the soil samples and the weight.

Never use worn, sludged or non-original abrasive material.

Prior to the measurement, the abrasive needs to be inspected visually and by touch. Use a new piece of abrasive for comparison.

The 'Surface Shear Test' is a comparison test so it is important to use the same initial conditions to enable a reliable comparison between the different measurements. The experienced user is responsible for checking and replacing the special high-quality abrasive in good time.



1. 2. 3.  
*Fig. 16: Steps for replacing the abrasive.*

1. Carefully detach the old abrasive using a scalpel or thin sharp knife.
2. Peel the old abrasive from the shear container.
3. Remove all adhesive and degrease (use a solvent and a lint-free wipe).
4. Mark out the round contour of the container on the rear of your abrasive.
5. Cut the abrasive carefully using a scalpel or scissors (check container weight: 40 g).
6. Align and stick the new abrasive material; ensure the abrasive is pressed on well and that the surface is flat.

### 9.2 Replacing batteries (2x AAA)



1. Unscrew 2. Remove screw 3. Remove balance 4. Remove 2x AAA batteries.  
*Fig. 17: Steps for replacing batteries.*

Remove balance in accordance with the steps in fig. 17. After replacing two AAA batteries, replace the balance in reverse order.

## 10. Measurements evaluation

The equipment available allows determination of the shear strength using a modified Mohr-Coulomb's equation:

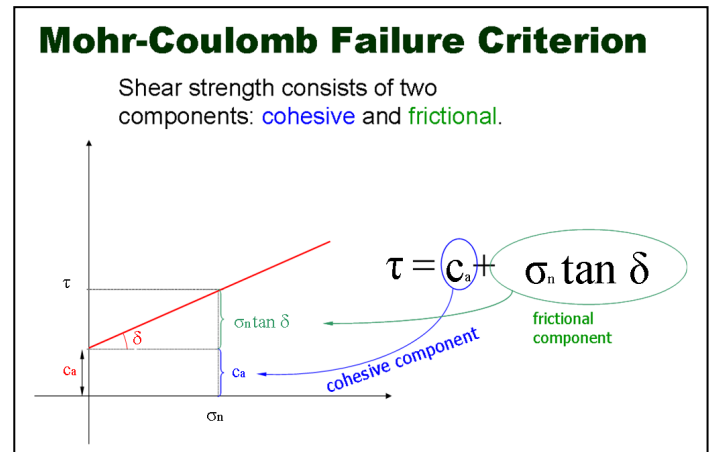
$$\tau = c_a + \sigma_n \tan \delta$$

$\tau$  = soil shear strength (hPa),

$c_a$  = adhesion between sandpaper and soil (hPa),

$\sigma_n$  = normal stress applied on the soil surface (hPa),

$\delta$  = surface angle of internal friction (°).



Publication about Surface Shear Resistance and interpretation of measurements:

### Surface shear resistance of soils on the micro- to mesoscale

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Eijkelkamp Agrisearch Equipment is interested in your reactions and remarks about its products and operating instructions

## Appendix 1: Form example

Surface Shear Test						
Project:						
Analyst:						
Date:						
Weight shear container (grams):						
Zero load guiding (grams):						
Sample no.:	Unique sample code:	Horizon number and suffix:	Prepared matrix potential (hPa):	Sample Load (grams):	Shear Load (grams):	Remarks:
1						
2						
3						
...						
...						
...						
...						
<b>Remarks:</b>						
Soil container:		Diameter: 100 mm / Height: 30 mm				
Shear container:		Diameter: 68mm				
		Surface Area: $\pi/4(d^2)$ ? 3631,68 mm <sup>2</sup>				
Pressure:		1Pa= 1 N/m <sup>2</sup> 100 Pa= 1 hPa 1hPa= 0,0001 N/mm <sup>2</sup>				
Force:		1 gram= 0,01 N				
The determination of the shear strength by a modified Mohr-Coulomb's equation:						
<b><math>H = c_a + H_n \tan H\phi</math></b>						
<i>H</i> soil shear strength (hPa),						
<i>c<sub>a</sub></i> - adhesion between sandpaper and soil (hPa),						
<i>H<sub>n</sub></i> - normal stress applied on the soil surface (hPa),						
<i>H</i> surface angle of internal friction (°).						



## Appendix 2: Balance operating instructions

### Technical data

	HDB 5K5
Read-out (d)	5 g
Weighing range (Max.)	5 kg

### Basic instructions

#### *Improper Use*

No permanent load must remain on the scale. This may damage the measuring system.

Impacts and overloading or exceeding the stated maximum load (max.) of the scale, without a possibly existing tare load, must be strictly avoided. The scale may be damaged by this (danger of breaking).

#### *Warranty*

Warranty claims shall be voided if:

- The conditions in the operation manual are ignored.
- The appliance is used outside the described uses.
- The appliance is modified or opened.
- There is mechanical damage or damage caused by media or liquids.
- Natural wear and tear.
- The measuring system is overloaded.

#### *Monitoring test resources*

In the interests of quality assurance, the measuring-related properties of the balance and, if applicable, the testing weight, must be checked regularly. The responsible user must define a suitable interval as well as the type and scope of this test.

### Basic safety precautions

Never exceed the maximum permitted load!

Avoid any kind of shock, torsion or oscillating (e.g. caused by inclined suspension)

### Unpacking, setup and commissioning

#### *Installation site, location of use*

The balances are designed such that reliable weighing results are achieved in common conditions of use.

You can work accurately and quickly if you select the right location for your balance.

#### **Therefore observe the following for the installation site:**

Avoid extreme heat or temperature fluctuations caused by using next to a radiator or in direct sunlight;

Protect the balance against direct draughts from open windows and doors;

Avoid jarring during weighing;

Protect the balance against high humidity, vapours and dust;

Do not expose the device to extreme dampness for long periods. Non-permitted condensation (condensation of air humidity on the appliance) may occur if a cold appliance is taken to a considerably warmer environment. In this case, acclimatise the appliance for approx. 2 hours at room temperature.

Avoid static charging of the material to be weighed, the weighing container and the windshield.

If electromagnetic fields or static charges occur, or if the power supply is unstable, major deviations on the display (incorrect weighing results) are possible. In this case, the location must be changed.

#### *Battery operation / Auto OFF function*

Remove the battery cover on the rear of the balance. Insert 2 AAA batteries. Reinsert the battery cover. If the batteries are empty, the balance display shows "LO". Press the **ON/OFF** key and replace the batteries immediately. To save battery power, the balance switches off automatically after 4 minutes without weighing. Deactivate this Auto-OFF function as follows:

With the balance switched off, press and hold the **HOLD** key.

While continuing to hold the **HOLD** key, press the **ON/OFF/TARE** key and keep it pressed.

Keep the **ON/OFF/TARE** key pressed and release the **HOLD** key.

Press the **HOLD** key again.

Keep both keys pressed until "tr" appears in the display.

Release both keys. The balance is situated in the menu.

Press the **ON/OFF/TARE** key until “**AF**” appears. Confirm the selection of the Auto Off-function using the **HOLD** key. The current “**ON**” or “**OFF**” setting appears in the display. Using the **ON/OFF/TARE** key you can select between “**ON**” or “**OFF**”. Confirm your selection with the **HOLD** key. After a short period the balance returns automatically to the weighing mode.

### Adjustment

As the acceleration value due to gravity is not the same at every location on earth, each balance must be coordinated, in compliance with the underlying physical weighing principle, with the existing acceleration due to gravity at its place of location (only if the balance has not already been adjusted to this location in the factory). This adjustment process must be carried out during the initial start-up, after changing location and for variation of the surrounding temperature. To achieve accurate measuring values it is also recommended that the balance be adjusted regularly for weighing operations.

#### Adjustment

With an adjustment weight, the weighing accuracy can be checked and readjusted at any time.

Procedure to adjust:

Observe stable environmental conditions. A short warming up time of approx. 1 minute is recommended for stabilisation. Switch on the balance. Press the **Unit** key and keep it pressed (approx. 15 sec). The display will initially show “**CAL**”, then the exact size of the adjustment weight appears. Suspend the adjustment weight; a short time later “**F**” will appear, and the balance returns automatically to the weighing mode.

If there is an adjustment error or incorrect adjusting weight the display will show “**E**”; repeat the adjustment process.

### Adjusting weight: (not included)

*Weighing units switch-over*

Using the **Unit** key you can switch the display between **lb** and **kg**. The ► marks the active setting.

#### Taring

- Switch on the balance using the **ON/OFF/TARE** key and wait for the “**0**” display. Suspend the tare load and press the **ON/OFF/TARE** key.
- The balance display jumps to “**0.0**”. The weight of the tare load is stored internally. The material to be weighed can now be filled in the tare vessel and the weighing value can be read.

#### Functions

Using the **Hold** key the following functions can be activated:

Setting	Function
H1	Data-Hold function 1 Weighing value frozen for 5 sec. after pressing the <b>Hold</b> key
H2	Data-Hold function 2 The weighing value will be frozen after pressing the <b>Hold</b> key until another key is actuated
H3	Data-Hold function 3 The weighing value is automatically frozen for 5 sec.
H4	Data-Hold function 4 The weighing value is automatically frozen after reaching a stable value until a key is actuated
H5	Animal weighing function
H6	Peak value function

#### Data-Hold function

With the Data-Hold function the weighing values in the display can be retained in the display for a longer time. The user range allows choosing between 4 settings (H1 – H4).

Switch on the balance, keep the **HOLD** key pressed until the current setting “Hx” (H1 – H6) appears.

Actuate the **ON/OFF/TARE** key until the desired setting (H1-H4) appears.

Use the **HOLD** key to confirm your selection.

Suspend the material to be weighed.

The weighing value is displayed depending on your settings (H1 – H4) (see table Chap. 7.4), symbolised by the [ ] top left.

#### Peak value function

This function displays the highest load value (peak value) of a weighing.

Measuring frequency: 200 ms

**Caution:**

Never exceed the maximum permitted load of the peak value on the balance (danger of breaking!!).

Switch on the balance, keep the **HOLD** key pressed until the current setting "Hx" (H1 – H6) appears.

Press the **ON/OFF/TARE** key until "**H6**" appears.

Use the **HOLD** key to confirm your selection.

Suspend the material to be weighed .

The peak value appears for a short time, symbolised by the [ ] top left. The balance returns automatically to zero and is ready for further measurement.

**Service, maintenance, disposal***Cleaning*

Do not use aggressive cleaning agents (solvents or similar agents); use a cloth dampened with mild detergent. Ensure that no liquid penetrates into the device and wipe with a dry soft cloth.

*Service, maintenance*

The appliance may not be opened.

*Disposal*

Disposal of packaging and the appliance must be carried out by the operator in accordance with the valid national or regional law of the location where the appliance is used.

**Troubleshooting**

In the case of a fault in the program sequence, the balance should be switched off immediately. The weighing process must then be restarted from the beginning.

***Fault******Possible cause***

*Display weight does not glow.*

- *The balance is not switched on.*
- *Batteries are inserted incorrectly or empty*
- *No batteries inserted.*

*Displayed weight is permanently changing*

- *Draught/air movement*
- *Vibrations on the suspension of the balance*
- *Electromagnetic fields / static charging (choose different location/switch off interfering device if possible)*

*Weighing result obviously incorrect*

- *The display of the balance is not at zero*
- *Great fluctuations in temperature.*
- *Electromagnetic fields / static charging (choose different location/switch off interfering device if possible)*

Should other error messages occur, switch the balance off and then on again. If the error message remains inform Eijkelkamp.