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Compression test apparatus (0867) and Shear strength test apparatus (0868)

User manual

1 About these operating instructions

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

⚠ **If the text follows a mark (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 its own personal protection.**

Text **Italic indicated text indicates that the text concerned appears in writing on the display or must be typed.**

1.1 General safety precautions

☞ **Read and understand these entire instructions before proceeding.**

- This apparatus is for soil research applications and has to be operated by qualified operators only.
- A qualified operator is well trained, mental and physical fit to operate complex multiple instruments.
- Take care for personal hygiene and environmental precautions in case operating contaminated samples.
- The apparatus operates with severe test forces, be sure to follow the safety instructions at all times to prevent injuries.
- Do not operate with damaged cord, wires, hoses or any other parts.
- Do not operate at any voltage or frequency other than 120- 240 VAC, 50- 60 Hz.
- Disconnect apparatus from electrical and airpressure supply before installation, or servicing.
- Do not expose apparatus to rain, or use in wet locations it is rated for indoor lab locations only.
- Servicing should be performed by QUALIFIED PERSONNEL ONLY!
- Do not operate with removed enclosure panels or disabled safety precautions.
- Only original replacement parts supplied by Royal Eijkelkamp are allowed to service.

⚠ **Please be aware of the instrument safety precautions to prevent human danger or instrument damage, do not change, manipulate or operate the instrument in any possible harmful way.**

⚠ **In case of problems press the EMERGENCY/STOP button.**

The button will be locked and a save situation is secured. To recover turn the button clockwise to unclock and press the yellow button to continue.

☞ **Royal Eijkelkamp explicit informs you that product training is highly recommended and this operating instructions are only for indicational purpose.**

☞ **The instructions and specifications can be changed without notice and no rights whatever can be claimed.**

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2 Product descriptions

0867 Soil compression test apparatus for measuring soil compression and (simultaneous) soil moisture tension with tensiometer on undisturbed sample. Sample Ø 100 mm. Complete instrument.

- Sample diameter 100 mm
- Sample height 30 mm
- Complete instrument inclusive software to configure, calibrate and read-out the instrument
- Simultaneously operation of up to 8 instruments

The ‘Compression test apparatus measures the compression of an undisturbed round soil sample. During the measurement(s) the soil water matrix, compression stress and settlement are measured.

This equipment measures the soil consolidation in accordance to NEN 5118, EN17892-5 and ASTM D698 - 07e1 considering the following restrictions:

- The maximum specimen load is 600 kPa for a 100 mm sample ring
- Tests are conducted in non water immersed condition
- Please consult instrument specification for detailed information in case of accreditation

Global method (steps) of measurement:

- Placement of the soil-sample (ring) into the device
- The soil sample is exposed to a vertical pressure/load. The pressure step(s) depend(s) on the structure of the sample.
- The installation is accommodated with a linear measuring apparatus; tensiometer; load cell; etc.
  - The displacement sensor measures the compaction/compression of the soil sample.
  - The ground-water pressure (soil moisture tension) in the soil sample is measured by a tensiometer.
  - The load cell registers the pressure/load and gives feedback to the DAQ (Data Acquisition Device) device and regulator to control the load accurately.
- During the exposed load, the sample is compressed and all sensors are measured at predefined Log-intervals.
- The test indicates the difference in compression of samples with different soil-densities (saturated/unsaturated soil-samples and disturbed/undisturbed soil-samples).
- The measurement results are stored and presented both numerical and graphical by the software

0868 Shear strength test apparatus for measuring soil shear strength under compression, with (simultaneous) measuring of soil moisture tension with tensiometer on undisturbed sample. Sample Ø 100 mm. Complete instrument.

- Sample diameter 100 mm
- Sample height 30 mm
- Complete instrument inclusive software to configure, calibrate and read-out the instrument
- Simultaneously operation of up to 8 instruments

The ‘Shear test apparatus measures the shear stress of an undisturbed round soil sample. During the measurement(s) the soil water matrix, compression stress and settlement are measured.

This equipment measures the soil shear stress in accordance to EN17892-10 and ASTM D3080-98 considering the following restrictions:

- The maximum specimen load is 600kPa for a 100mm sample ring
- Tests are conducted in non-water immersed condition
- Please consult instrument specification for detailed information in case of accreditation

Global method (steps) of measurement:

- Placement of the soil sample (ring) into the device (soil sample holder).
- The soil sample is exposed to a vertical pressure/load. The pressure step(s) depend(s) on the structure of the sample.
- The installation is accommodated with a linear measuring apparatus; tensiometer; load cell; etc.
  - The displacement sensor measures the compaction/compression of the soil sample.
  - The ground-water pressure (soil moisture tension) in the soil sample is measured by a tensiometer.

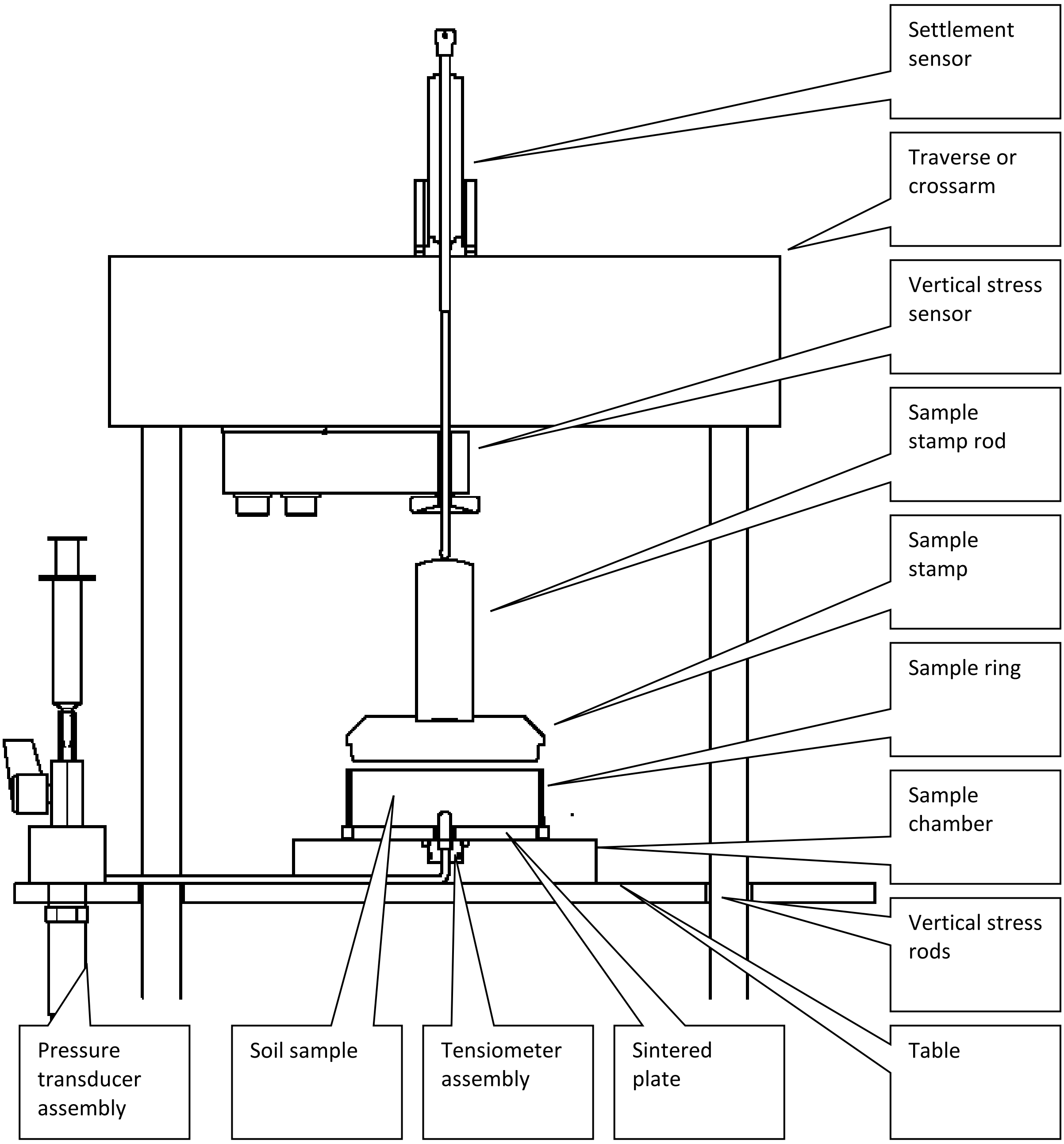
    - The load cell registers the pressure/load and gives feedback to the DAQ (Data Acquisition Device) device and regulator to control the load accurately.
    - The shear-displacement has a user defined constant speed
- During the exposed load, the sample is sheared and the shear force is measured at predefined Log-intervals.
- The test indicates the difference in shear force of samples with different soil-densities (saturated/unsaturated soil-samples and disturbed/undisturbed soil-samples).
- The measurement results are stored and presented both numerical and graphical by the software

2.1 Technical specifications

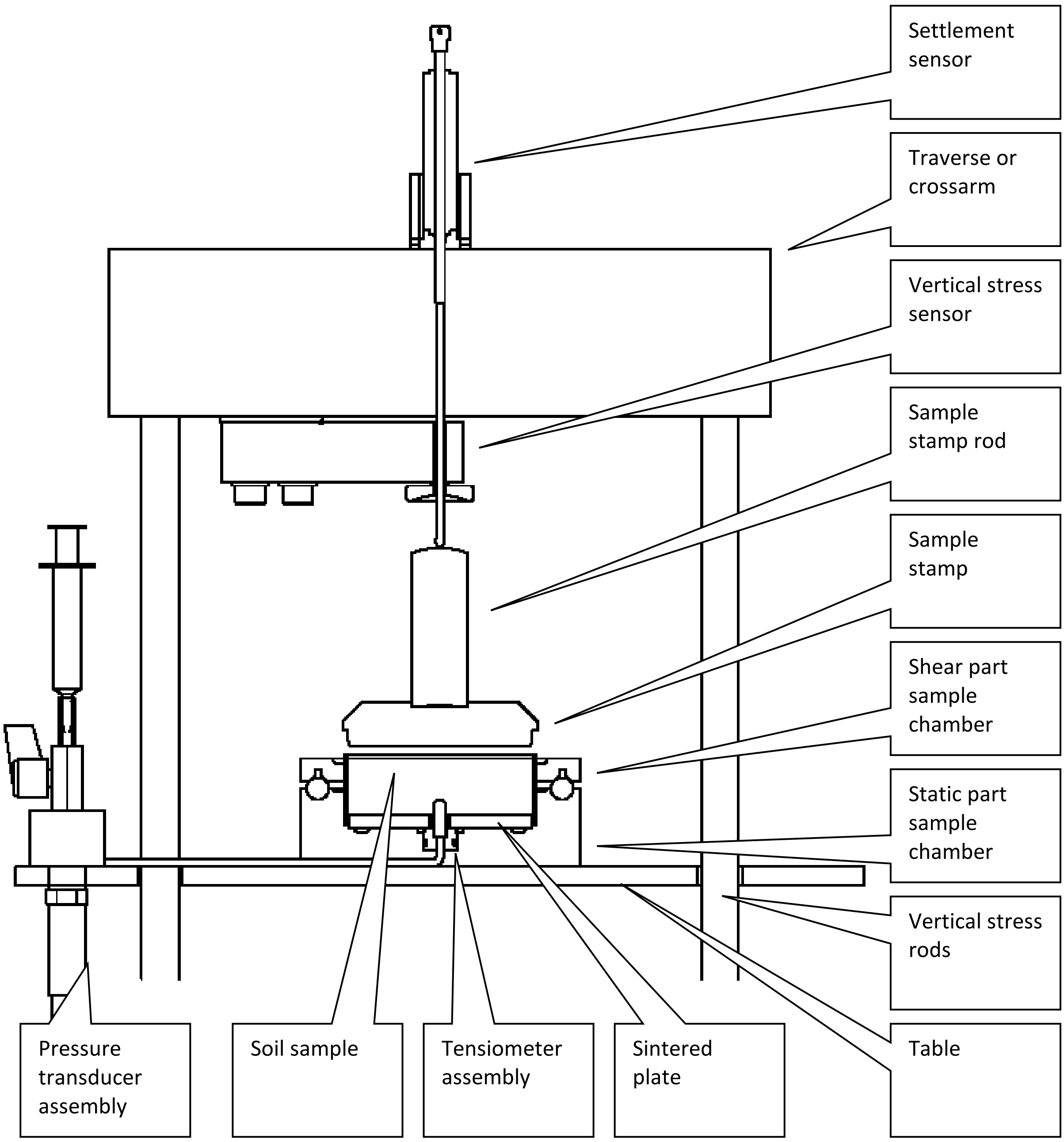
Item	**Range**	**Resolution**	**Accuracy**
Vertical stress	0-600 kPa	0.1 kPa	2 kPa
Response speed	<10 sec. @1% endvalue (adaptable by PID controller parameters)		
Horizontal stress *	0-400 kPa	0.1 kPa	2 kPa
Shear speed*	0-2 mm/min	0.01 mm/min	0.1 mm/min
Shear stroke *	20 mm		
Soil moisture	-1000 +1000hPa	0.1 hPa	2 hPa
Compression	0-30mm	0.001 mm	0.1mm
Sample log rate	0.1…60 sec.		
Pressure in max	0.7 Mpa / 7 bar		
Force max	5 kN		
Stress out max	600 kPa		
Adapter input			
Mains supply	100-250 Vac		
Mains frequency	47-63 Hz		
Power consumption	0.8 W		
Adapter output			
Supply voltage	30 Vdc		
Max current	1.2 A max		
Environmental conditions			
Ambient	For indoor use only		
Temperature	15-35 ºC		
Humidity	20-80% RH (non condensing)		
Dimensions	55 x 75 x 135 cm		
Weight 08.67	55 kg		
Weight 08.68	75 kg		
Software language	English		
PC connection	USB		
PC operating system	Windows7, 8 and 10 (administrator rights)		
PC performance	Vista processor system performance rating 5* or higher will operate up to 8 instruments Simultaneously.		

* Best way to show the spec and what Vista thinks of it is to browse to Control Panel -> System and Maintenance ->Performance Rating and Tools.

2.2 Schematic construction compression test apparatus



2.3 Schematic construction shear test apparatus



3 Installation

3.1 Requirements for installation

- Compressed-air: clean, stable (without drops/ impact), dry air must be available in the operating range of 6-7bar. Pressure regulator can be exposed to a maximum operating pressure of 1 MPa= 10 bar (set-pressure= 0.05-0.85 MPa).
- Connection plug and tube clamp to connect the delivered compressed-air tube (D=14x8 mm) to your compressor system.
- Mains supply near instrument: for connection of the adapter (Shear Strength Test Apparatus) and the connection of the PC/laptop.
- Up to date PC/laptop; a clean system with only the operating software and probably office software. PC operating systems: XP, Vista, Windows7 (administrator rights).
  PC performance Vista processor system performance rating 5* or higher will operate up to 8 instruments simultaneously.
  View the rate in Vista: browse to Control Panel -> System and Maintenance ->Performance Rating and Tools.
  Optional virus protection and internet access are preferred.
- Water, distilled or deionised, well degassed (-950 hPa); and the equipment to make this.
- Sample-rings d 103x100 h 30 mm).

3.2 Environment

Make sure that you place the apparatus in a clean, dry and non-direct sunlight surrounding (a conditioned room is preferred) for best operational performance and measurement results.
The apparatus should be well accessible from the operating front and left side to connect/ adjust the compressed air (accessible for maintenance; remove condensate). In case of multiple instruments they can be placed best side by side with the computer in the middle. Adjust the table surface height and levelness with a level by turning the footrests.

3.3 Preparation (unpacking, etc.)

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

3.4 Partlist 0867

Compression test apparatus

Art. no.:	Description
0867	**Soil compression test apparatus for measuring soil compression and (simultaneous) soil moisture tension with tensiometer on undisturbed Sample diam. 100 mm. Complete instrument**
086701	Compression test apparatus. Basic instrument in frame Complete with sample chamber, settlement sensor, pressure transducer and tensiometer assembly. Excl. Software
086812	2 Sintered plate with hole
086813	2 Sintered plate without hole
H700595	Sample compression rod
H700579	Sample compression stamp
086710	Tensiometer assembly for shear test and compression test apparatus.
H279800	Tensiometer filling set:
	4x Syringe 10 ml
	2x Filling tube with syringe tip
H700590	Tensiometer container reservoir
H279804	Gouge auger tool
H263542	Euro Mains cable 2.5 m
H263540	Mains adapter 100-250Vac 30V 1.2 A
H263546	USB 2.0 screened cable
H104510	Air supply hose with coupling for instrument only
	Mounting toolset consisting of:
H309103	Tensiometer tool
997506	Socket head wrench
995014	Spanner 13x14
995018	Spanner 18x19
H245915	Round spirit level
H276952	2x carrying rod
086830	Basic (multifunctional) software for executing measurement protocols and visualised data presentation, English
086732	Licence for compression test software for static multistep operation of instrument tests

Optional items:

086820	USB HUB 4 port, incl. power supply connector UK-EC
086734	Licence for compression test software for dynamic multistep operation of instrument tests
086890	Calibration test set for shear test and compression test apparatus, consisting of calibrated sensors, calibration certificates, calibration blocks and spare parts. In case.

3.5 Partlist 0868

Shear strength test apparatus

Art. no.:	Description
0868	**Shear strength test apparatus for measuring soil shear strength under compression, with (simultaneous) measuring of soil tension with tensiometer on undisturbed sample. Sample diam. 100 mm. Complete instrument.**
086801	Shear strength test apparatus. Basic instrument in frame. Complete with sample chamber settlement sensor, transducer and tensiometer pressure assembly. Excl. software.
086812	2 Sintered plate with hole
086813	2 Sintered plate without hole
H700595	Sample compression rod
H700579	Sample compression stamp
086810	Tensiometer assembly for shear test and compression test apparatus.
H279800	Tensiometer filling set:
	4x Syringe 10 ml
	2x Filling tube with syringe tip
H279802	Tensiometer container reservoir
H279804	Gouge auger tool
H263542	Euro Mains cable 2.5 m
H263540	Mains adapter 100-250 Vac 30 V 1.2 A
H263546	USB 2.0 screened cable
H104510	Air supply hose with coupling for instrument only
	Mounting toolset consisting of:
H309103	Tensiometer tool
997506	Socket head wrench
995014	Spanner 13x14
995018	Spanner 18x19
H245915	Round spirit level
H700675	Compression adapter ring
H700584	Sample holder upper plate
H276938	Sample holder fill plate
H700671	Sample holder lower ring
H700684	Sample transfer rod
H700604	Sample transfer stamp
H700672	Sample transfer ring
H700587	6 fixation pin red
H276952	2x carrying rod
086830	Basic (multifunctional) software for executing measurement protocols and visualised data presentation, English
086832	Licence shear test software for static multistep operation of instrument tests

Optional items:

086820	USB HUB 4 port, incl. power supply connector UK-EC
086834	License for shear test software for dynamic multistep operation of instrument tests
086890	Calibration test set for shear test and compression test apparatus, consisting of calibrated sensors, calibration certificates, calibration blocks and spare parts. In case.

3.6 Transport

Carefully transport and place the apparatus, although you are probably impatient to start, please take your time and precautions to prevent damage.
For easy moving and transporting the transport bars can be attached.
Remove the transport facilities after transport and place the black plastic profile strips.

3.7 Placement of the apparatus

Make sure that you place the apparatus in a clean, dry and not exposed to direct sunlight surrounding for best operational performance and measurement results. The apparatus should be well accessible from the operating front and in case of multiple instruments they can be placed best side by side with the computer in the middle. Adjust the table surface height and levelness with a level by turning the footrests.

3.8 Mounting the air pressure regulator

Mount the regulator to the frame and connect the black hose to the blue self locking coupling by pressing the hose firmly in and pull to test the fixation.

3.9 Connecting the air pressure

Clean, dry and stable pressured air is prescribed in the operating range of 6-7.5 bar. A pressure regulator on the instrument will restrict the pressure to the needed operating pressure of ca 7.0 bar for maximum stress load of 600 kPa or 5.599 bar for loads up to 400 kPa. Higher pressure than 7.0 bar will invoke the internal overpressure valve to operate. A stable air pressure supply is

Connect the supplied pressure hose fitted well to your pressure system and connect to the apparatus with the supplied Euro type safety connection. To connect the air supply, firmly push the self locking coupling on the connection.

The release of the air supply coupling is done in 2 steps , pullback the black ring, the air pressure then will be released and then pull further to disconnect.

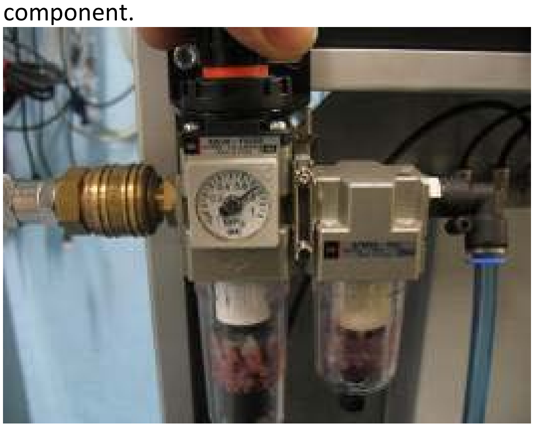
⚠ **Make sure that the hoses are qualified for the pressure, fitted well and are undamaged.**

☞ **Do not use air pressure below the minimum needed value to prevent wear out of the internal pressure controller.**

The instrument pressure is adjusted by pulling the black knob. Turning it clockwise will increase the pressure, turning contra clockwise decreases the pressure. Push the knob down in the locked position after adjustment.

⚠ **Do not exceed the maximum air pressure to prevent damage to human and apparatus. A loud noise may accompany the release of overpressure**.

Lower pressure will limit the maximum applicable stress. If despite a maximum stress is programmed then the electronic air pressure controller will try to accomplish the requested value with intensive action that will reduce the lifetime of this component.



⚠ **If the main supplied air-pressure is too low and the Stress settings for the apparatus are higher than can be reached at this air-pressure, the pressure regulator will make a humming noise. This should be avoided as it shortens the lifetime of this part.**

If the apparatus is not in use for longer time please disconnect the air pressure.

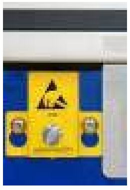
3.10 Connecting the apparatus to the computer

Connect the USB connector to your computer. Using up to 4 apparatus use the USB hub, for up to 8 apparatus use 2 USB hubs needing 2 USB ports on your computer. The USB hubs are powered by their own mains power.

3.11 Connecting the Power supply and switch on.

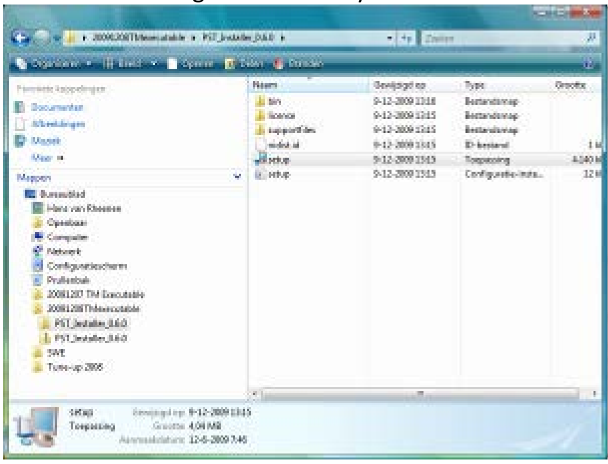
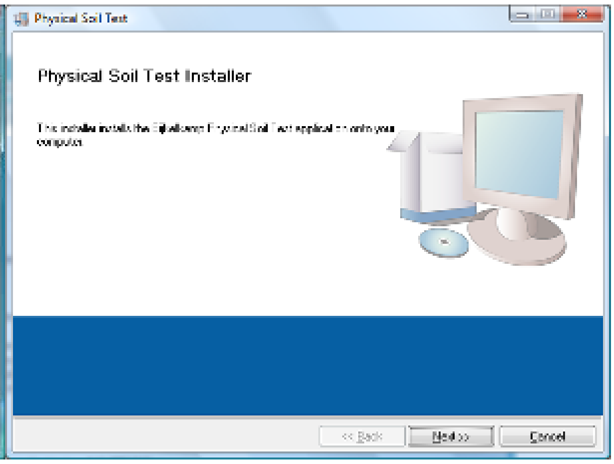
Check the correct mains specifications and pug type before connecting the mains cord of the power supply to the wallet. Connect the 30 Volt output plug into the socket at the back of the instrument. The instrument can be switched on by the illuminated front push button equipped with a protective cap. The white ON indicator lamp will light up when the power is connected and the instrument is switched on. If the apparatus is not in use for longer time please disconnect the mains plug from the wallet.

Optionally, o prevent electrostatic voltages build-up introduced into the metal frame, the instrument can be connected to a protective earth terminal .

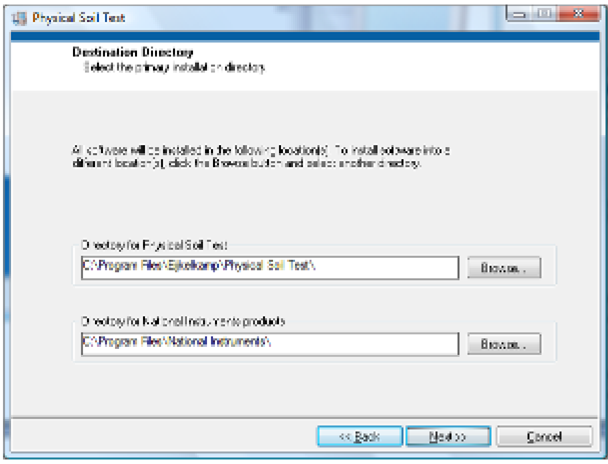


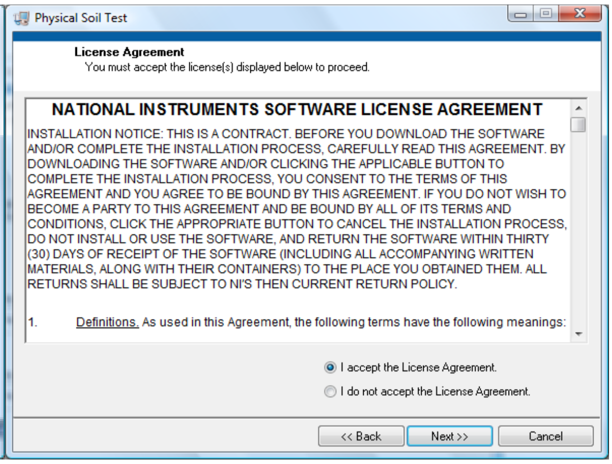
3.12 Installing the software

The software can be downloaded from the Royal Eijkelkamp internet site; in this way you are assured to use the latest software version. For download details contact your supplier. Alternatively a CD will be supplied.
After downloading the software you run SETUP.

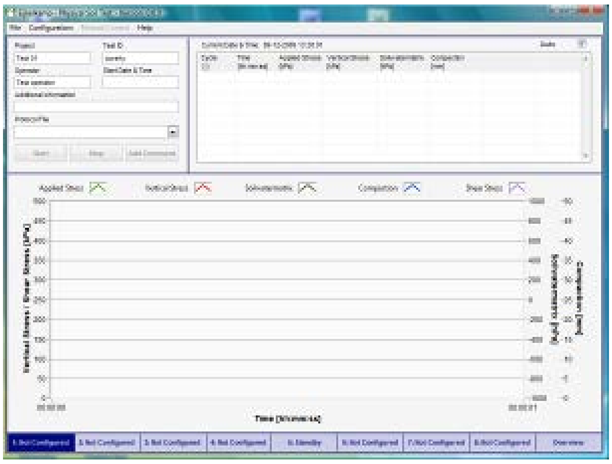



During installation the following menus will appear.





As the NI labview platform is used for software and hardware development you need to accept the license agreement, there are no costs or obligations involved.
After installing the main software the specific instrument files can be downloaded and installed by invoking the command “install”



After installation the program main screen will be showed and the connected instruments are recognised in the lower apparatus selection bar. The specific instrument liscence and configuration files are supplied separately.

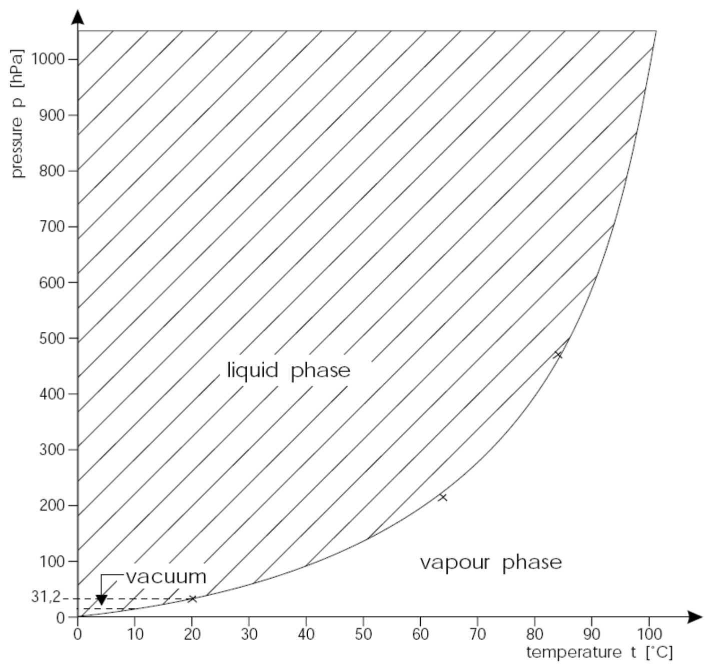
3.13 Tensiometer

The tensiometer measures the soil water matrix or soil water tension inside the soil sample. The soil water matrix is the suction pressure of the water bounded to the soil. It is expressed in expressed in hecta Pascal (hPa).
The tensiometer ceramic cup is placed in the middle of the sample chamber. It is connected by a hose tot the pressure sensor that measures the soil water matrix both positive as negative.

☞ **The ceramic cup assembly of the tensiometer is vulnerable so do not stress it mechanically and prevent it to get greased i.e. by touching it with bare hands. Wear out ceramic cups are performing slow moisture pressure response. It is advised to check and replace it regularly.**

3.13.1 Tensiometer assembly filling

Tensiometers should be filled with demineralised or distilled water. This water must be degassed.
The tensiometer water limits the measuring range, as can be seen from the two-phase diagram for water and water vapour.



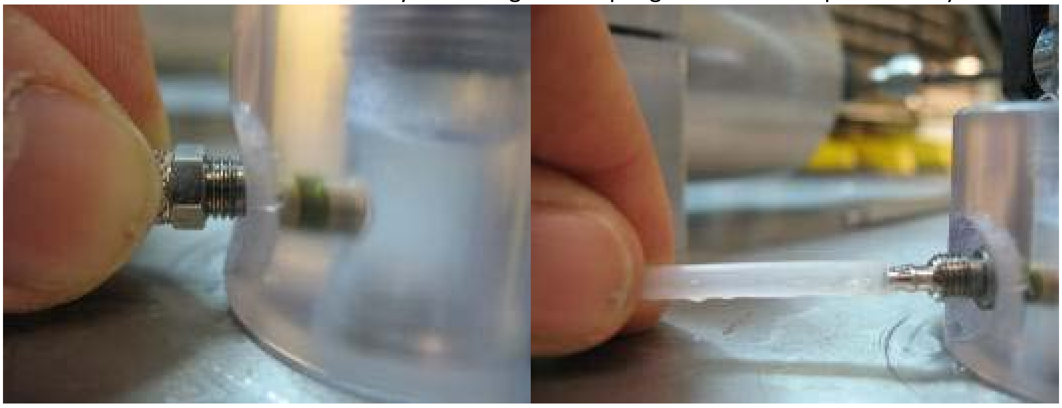
If the ceramic cup is completely dry, first put the ceramic cup into a beaker filled with the degassed deionised water for at least 1 hour to enable the ceramic to get saturated with water. The whole of the ceramic should be below the water level! Do not fill water into the ceramic cup as there is a danger of trapping of air in the ceramic.

If the tensiometer contains dissolved gases, the vapour point is raised, which restricts the measuring range considerably. Therefore care should be taken to degas the deionised water as completely as possible (e.g. by boiling). To degas, boil water for 5 minutes, then fill a suitable heat resistant container completely without air, seal tightly and place in refrigerator to cool.

An alternative method of de-gassing water is to heat the water to boiling, and then pull a vacuum for 15 minutes. Without heating the vacuum process takes 4 hours or more. During vacuum inductive steering or ultra-sonic stimulates the process.

3.13.2 Tensiometer installation

- Remove the tensiometer hose by loosening the coupling from the transparent body.



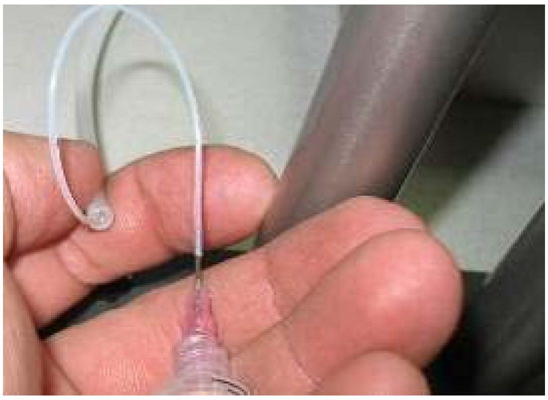
- Tightly grip the retraction tool into the slot of the black tensiometer body and slowly pull it out of the sample chamber.

- Put the ceramic cup into a beaker filled with the degassed deionised water for at least 1 hour
- Check if the water has entered the plastic transparent hose, if not the ceramic cup seems to be contaminated and must be replaced.

- Lead the plastic tensiometer hose trough the sample holder and fit the tensiometer pressing it gently into the sample holder. Use a small piece of hose to protect the ceramic being touched with bare hands.
- Place the tensiometer reservoir on the cup and fill it with degassed water.

- Fill the tensiometer assembly using the filling syringe. Insert the small hose completely into the tensiometer hose and fill it by emptying the syringe during slowly retracting it.

- Fill the transparent body using the filling syringe filled with degassed water. Lead the thin hose trough the valve, trough the plastic body carefully into the small hole of the metal pressure transducer and empty the syringe until the water comes out of the tensiometer hose coupling.

- Mount the tensiometer hose by pushing the tube over the hose coupling on the transparent body and fastening the coupling by hand. Be sure to tighten is firmly but only by hand so the plastic parts will not be overstressed. (do not use a wrench)


- Connect a syringe (with the plunger fully pushed in) to the transparent body , pull the plunger out and place the wooden stick to keep in this position. Syringes can create a rather high vacuum up to -980 hPa, if the water is not that much degassed then reduce the vacuum by minor plunger pulling i.e. 1 cm.

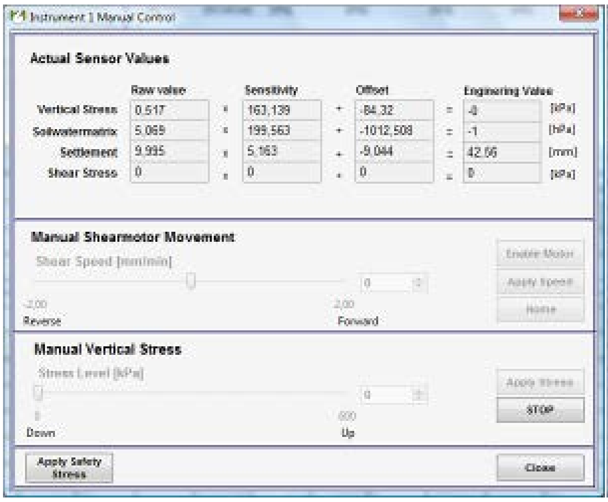
- Now open the valve (vertical position) and allow the system for some time to retract the air out.
- The reservoir should be refilled every few minutes to prevent it from emptying and pull air into the system.
- Also repeat the syringe vacuum procedure by closing the valve, loosen and empty the syringe, connect it again, pulling vacuum and open the valve.
- If all the air is purged close the valve and the tensiometer is ready for use after checking the calibration.
- If the filling keeps still unsatisfactory, air bubbles may have formed inside the ceramic cap, then completely degas the system again.

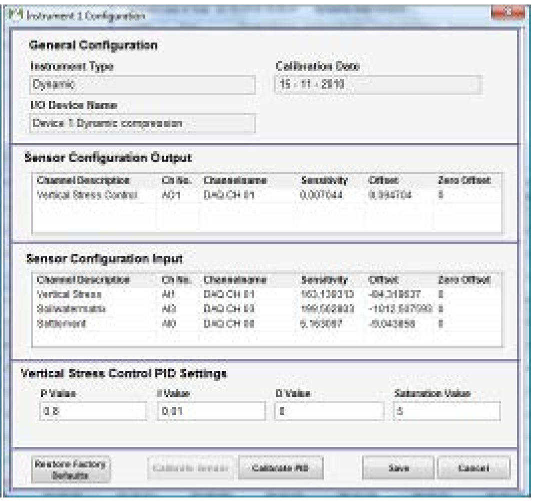
3.13.3 Tensiometer calibration

Temperature will mainly determine the accuracy of null point of the tensiometer. So a stable environment temperature will contribute to accurate measurements. The tensiometer can be calibrated at 2 points. One can choose calibration points freely in the range of -600 hPa up to +600 hPa but advisable is to choose these points around the range of interest i.e. +10 hPa and -400 hPa
In a well degassed tensiometer assembly apply an overpressure of 100 mm water by filling the tensiometer reservoir to the filling marker. Be sure to give the system enough time to equilibrate to the pressure.

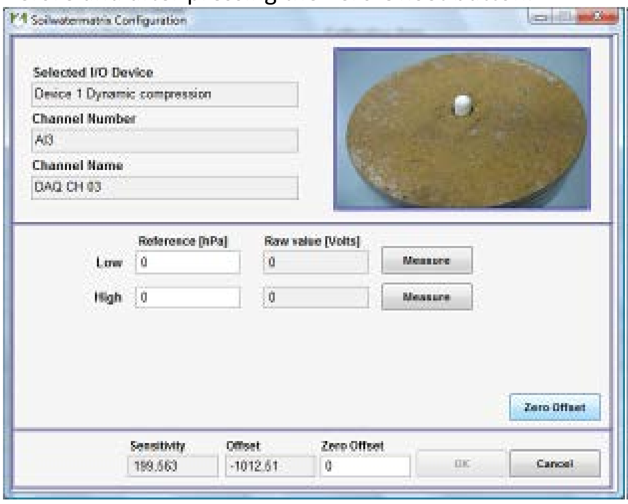
Small zero settings can be done in the instrument configuration menu, selecting the Soilwatermatrix sensor and pressing the Calibrate sensor button. The zero-ing of the sensor will not influence the zero and scale factors. A wet tensiometer without reservoir should measure about 0 hPa and can be zero-ed.

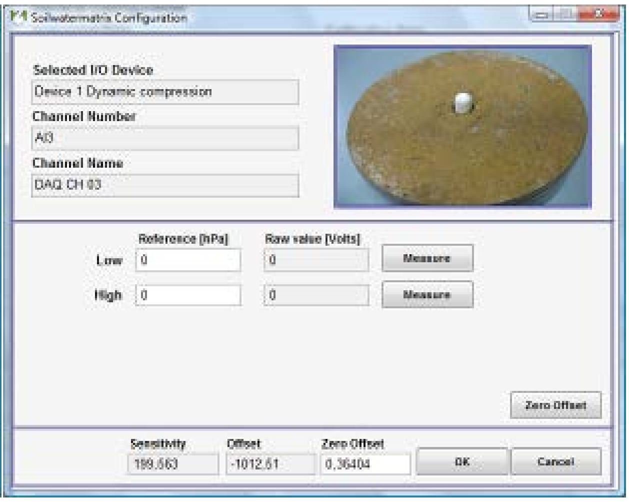
Example:
A small offset for the tensiometer of -1 hPa is corrected to 0 hPa using the Zero Offset button





Before and after pressing the Zero Offset button.

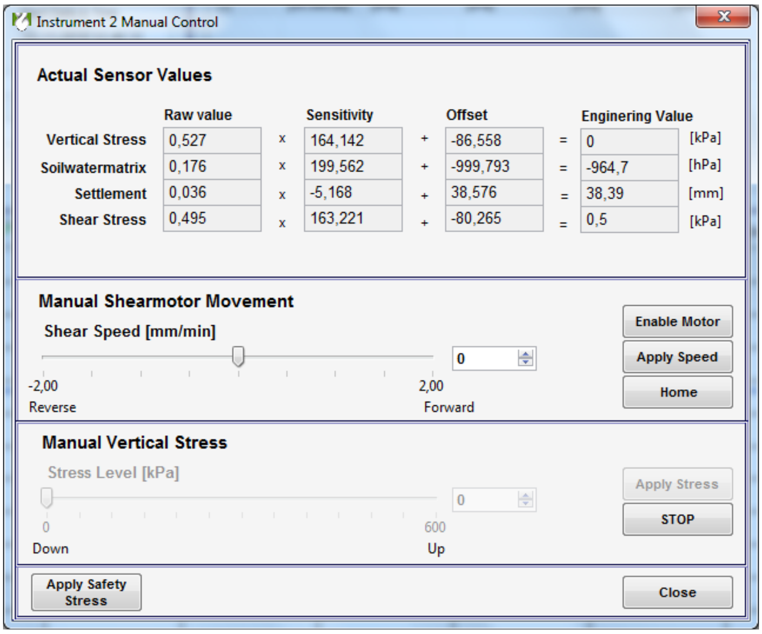




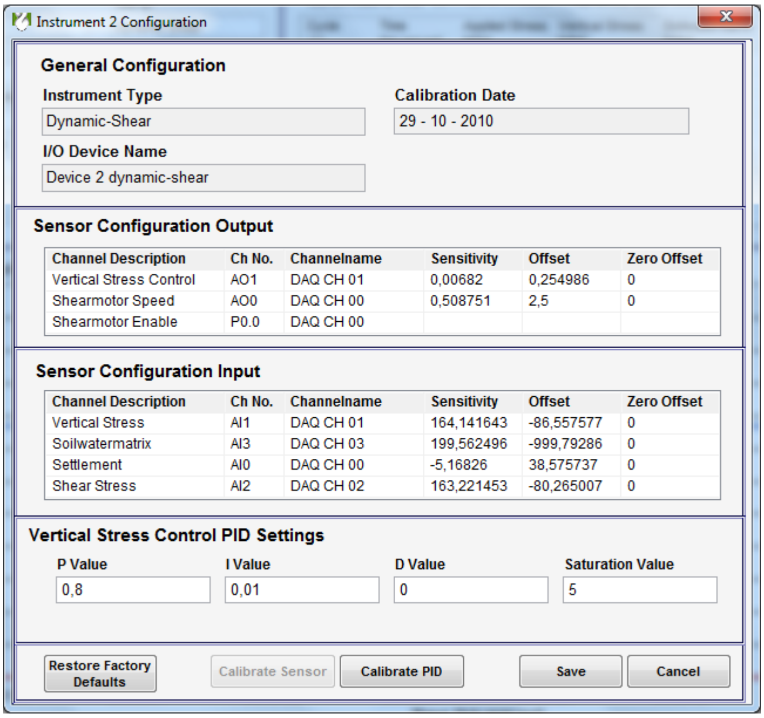
Be sure to press the Save button for storing the new setting on disk.

3.14 Checking and zeroing the instrument

Before measurements can be performed the instrument calibration and functionality must be checked using the software manual control option.
Make sure that the sensor reading values are within calibration accuracy.



If values are not outside accuracy limits, zero calibration can be performed using the instrument calibration option.
For vertical stress, soil water matrix, compaction and shear stress the actual value can be zero-ed at no load, using the sensitivity and scale factors. In case of problems the original factory calibration settings can be reloaded. For full sensor calibrations there is a calibration kit available or contact your supplier for calibration service.



4 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 using the hammering method; the most precise but costly method is using hydraulic sampling equipment; this is not further discussed here.

4.1 Field sampling

- Clear and prepare the soil surface to make sure 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 ca 2-5 mm of the sample ring both sides
- Cover the ring with transport caps preventing to dry out and compressing the soil sample
- Register the ring number and sample details

4.2 Lab sample preparation

- Carefully remove the surplus soil on both sides of the sample ring by stepwise vertical cuttings breaking horizontal parts soil away. In this way the pore structure will kept in original condition.
- Optional weigh the sample for volumetric soil moisture content of the field capacity
- Bring the soil moisture matrix to a predetermined value of i.e. 60 hPa. (Royal Eijkelkamp can supply the proper equipment for this)
- Weigh the sample for volumetric soil moisture content

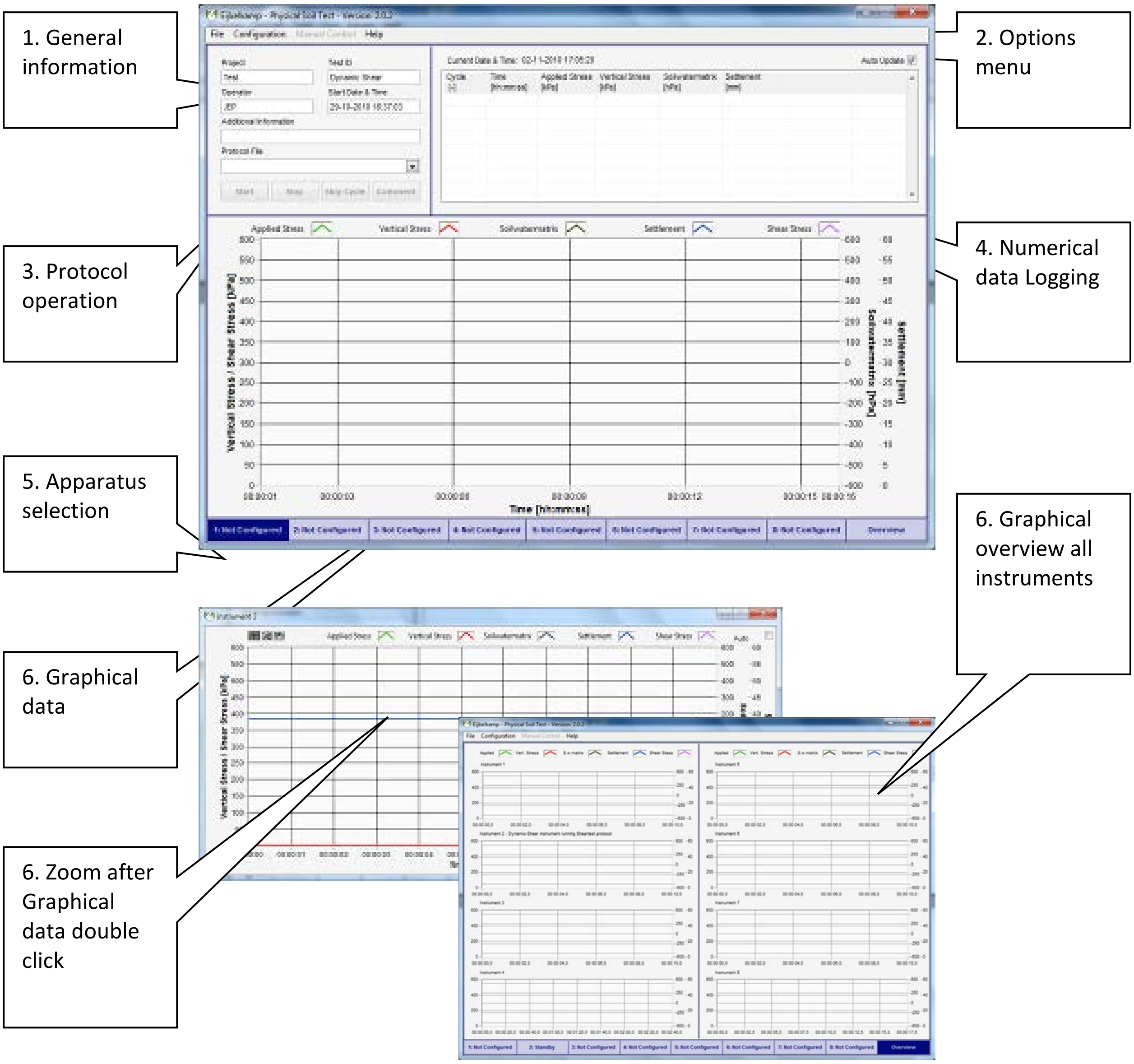
5 Software functions

The software can be evaluated even without an instrument connected.
Click the Eijkelkamp logo on your desktop to start the physical Soil Test program.

After the initialisation picture disappears, the main window will appear.

The screen is divided in 6 main parts:

1. **General information**
2. **Options menu (pull down)**
3. **Protocol operation**
4. **Data logging (numerical)**
5. **Apparatus selection**
6. **Graphical presentations**



☞ **The software supports both compression and shear test instruments, the instrument function static or dynamic are factory configured.**

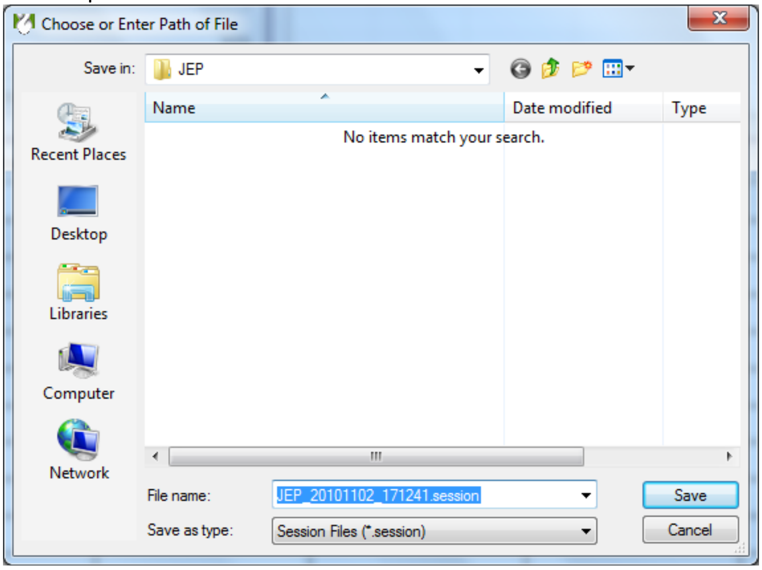
1 General information

- Project name
- Test ID
- Start date & time
- Operator name
- Additional information comments

2 Options menu

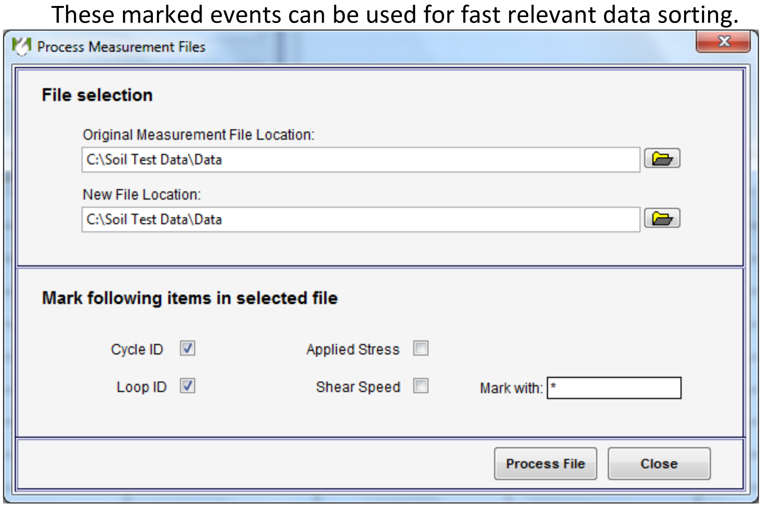
- **File**
  - **Load session**
  - **Save session**

  These options loads and saves the used instrument information used in this session.



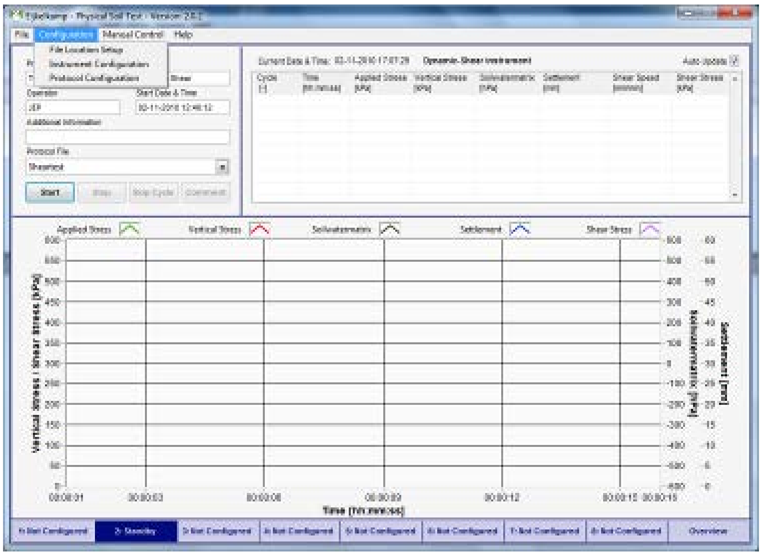
  - **Process file**

    This option adds characters to the data files for easy recognition of events in the data file. These marked events can be used for fast relevant data sorting.



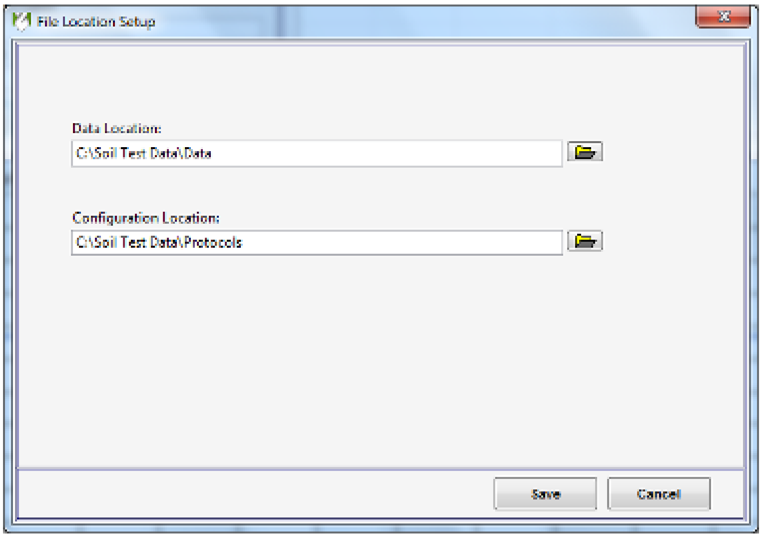
  - **Exit**
    - Exit ends the program and asks confirmation if this is wanted.

- **Configuration**



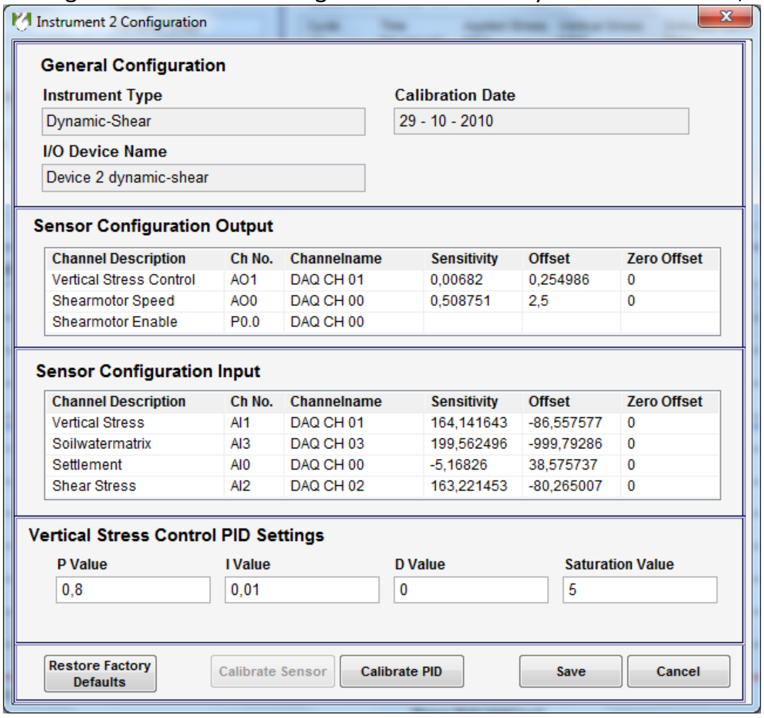
- **File location setup**

In the file location setup the destination of the user data is appointed. For every operator separate subdirectories will be created automatically for both data and protocols.



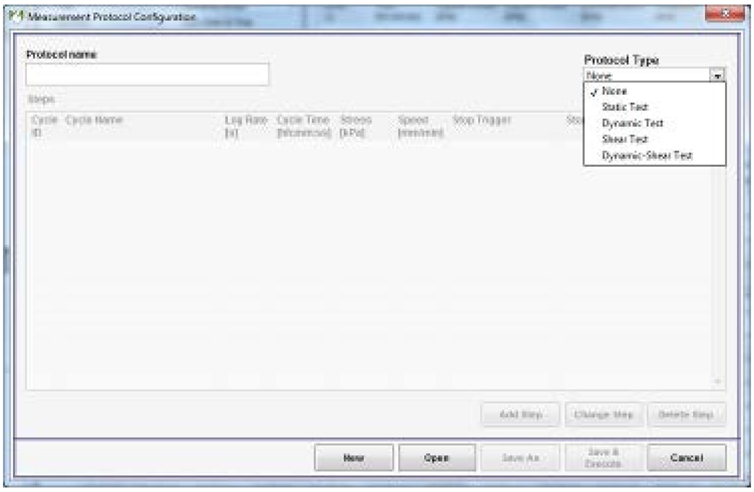
- **Instrument configuration**

Instrument configuration displays the settings of the selected instrument. The sensor settings can be chanced for calibration purposes or perform sensor zeroing using the zero offset. Factory settings can be restored using the Restore Factory Defaults function,



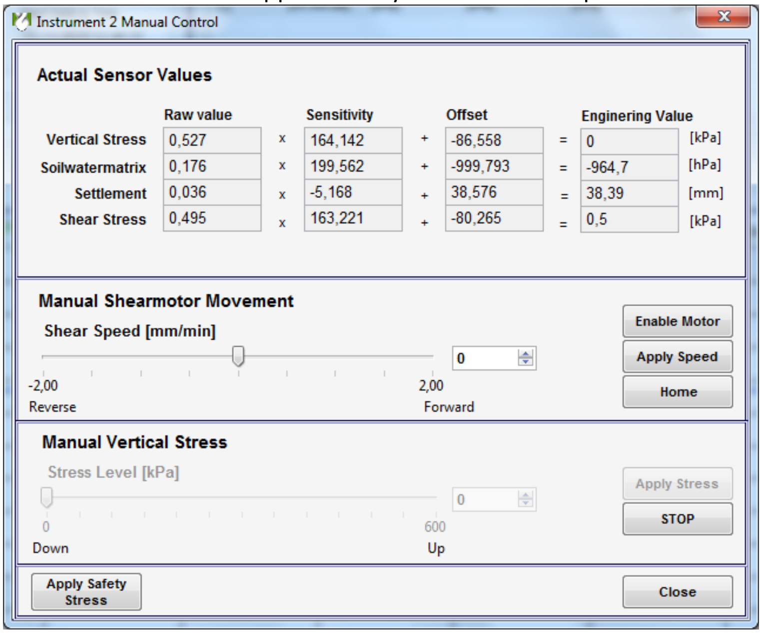
- **Protocol configuration**

Measurement protocols are written using predefined function tables. After the correct instrument type selection and a protocol name is defined the program steps table created using select boxes.



- **Manual Control**
  - **Actual Sensor Values**

The actual values of the sensor signals are displayed. Also the shear movement and vertical stress can be controlled. The applied safety stress has to be performed in

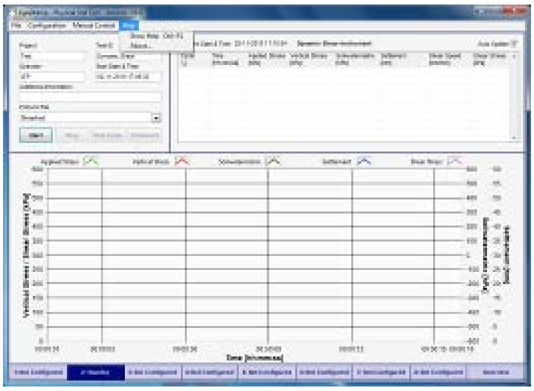


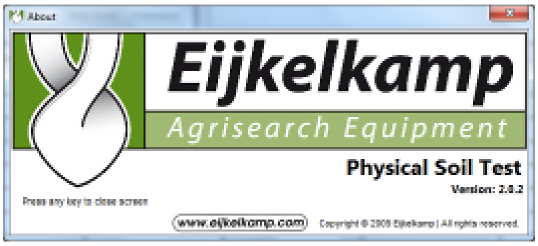
- **Help**
    - **Show help**

      Displays the user manual.

    - **About**

      Information about the software version

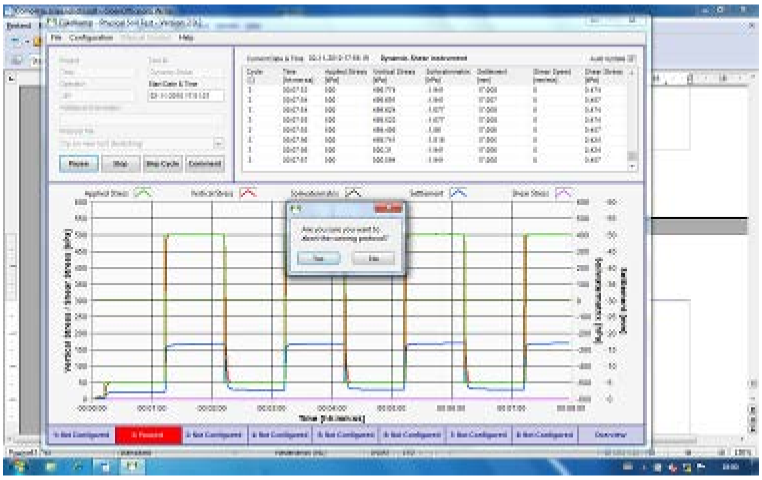




3 Protocol operation

- Protocol file name — The name of the protocol file that is executed
- Protocol operation — executing commands for measuring protocol

A measuring protocol can be started, paused, stopped, skip a protocol step or add a comment to the data file.



4 Numerical Data logging

- Numerical presentation of logged data

The numerical data can be observed during measurements, looking in the previous displayed values the upper right check box auto update is disabled and using the right hand slide ruler the data can be scrolled.

5 Apparatus selection

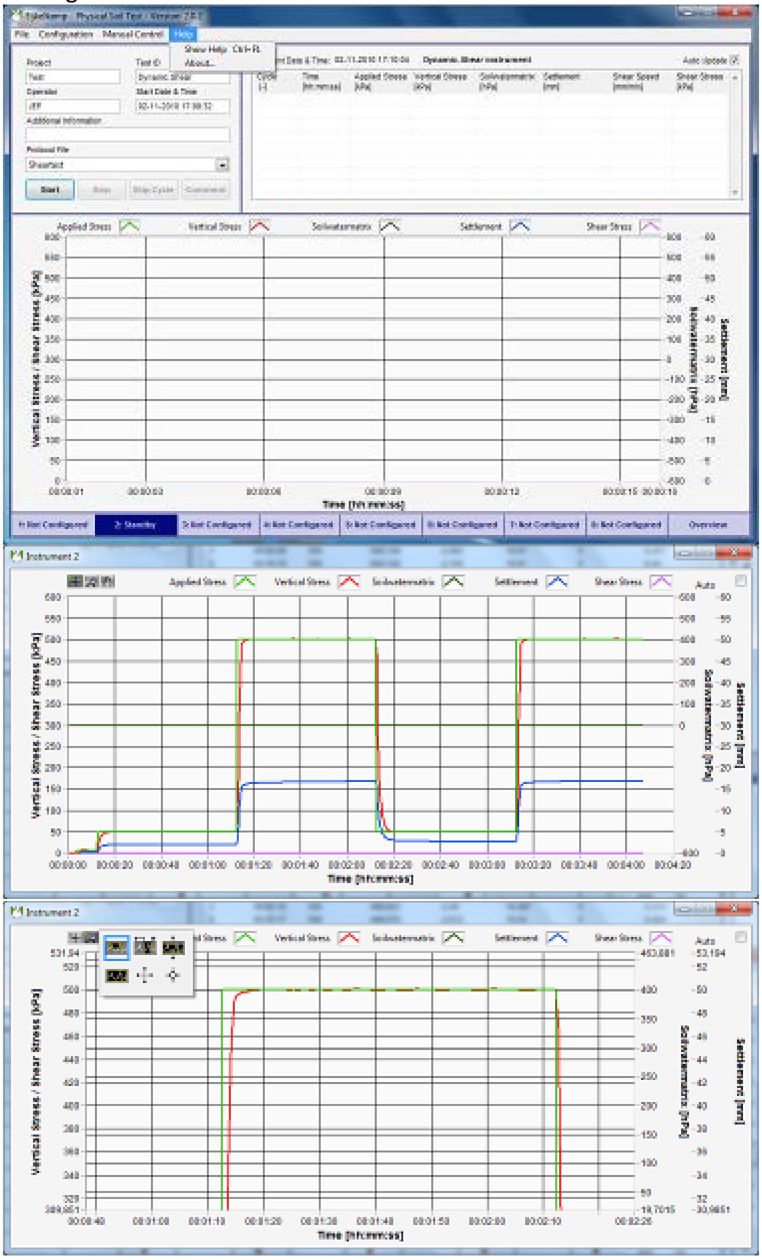
- Selection of instrument 1 up to 8 including instrument status.

Click on the bottom bar to select the instrument of interest. The right most button displays al the instruments graphs on one screen.

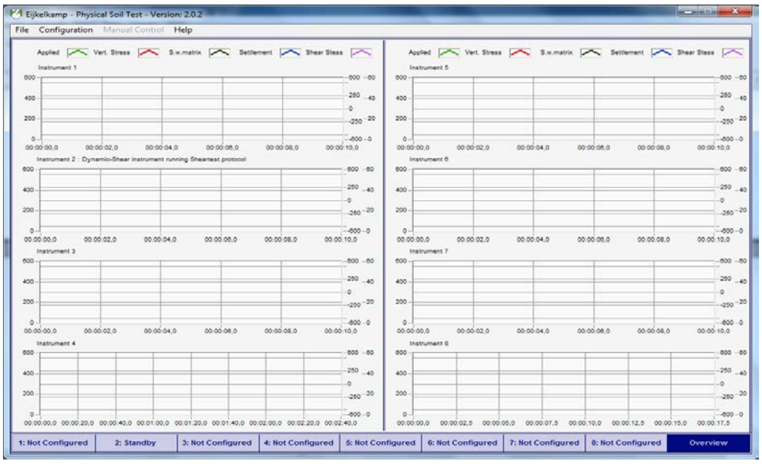
6 Graphical data

- **Graphical presentation of actual and logged data and zoom functions**

Double clicking when the mouse pointer is on the graph will invoke the zoom screen. The left-up pop- zoom option menu enables the different zoom functions on the part of interest. Double-click on the zoom screen enables the auto full scale zoom option. Graph scales can be user edited clicking the full scale number and editing it.

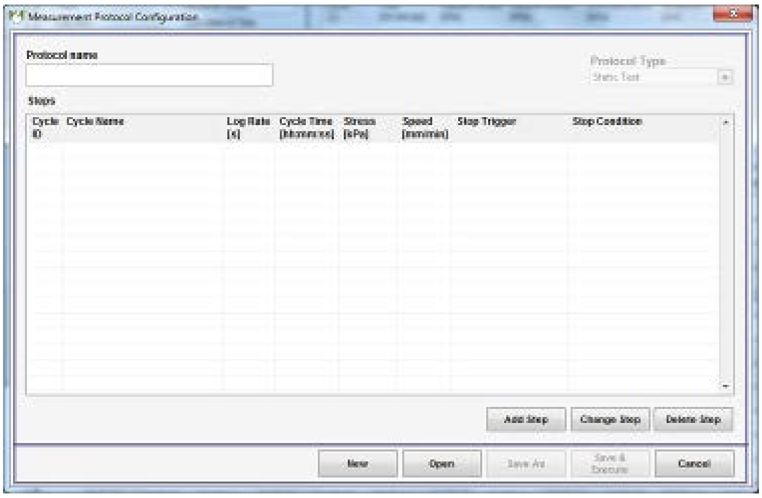


- **Graphical overview presentation of all instruments**



5.1 Measurement protocols

All measurement steps can be programmed by means of protocols. A protocol file is written using the measurement protocol configuration option.
User written or modified protocols are stored into the user directory name which is automatically generated upon entering the operator name.

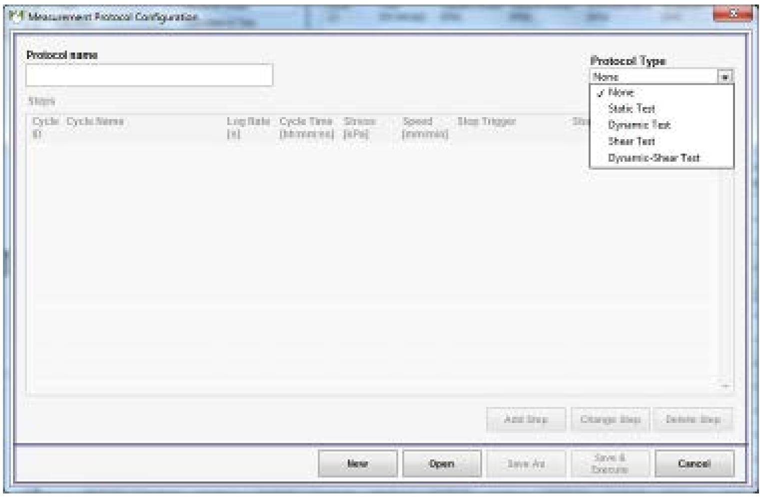


- *New*
  Starting a new file for saving the measurement protocol steps
- *Open*
  Opening an existing protocol file for execution or editing
- *Save as*
  Saving a protocol file with his specific name
- *Save & Execute*
  Saves and starts executing the protocol file on the instrument
- *Cancel*
  Discards the changes and returns to the main window

To program a protocol you can choose the kind of apparatus the program will be written for. Be sure to select the right apparatus as the options differ per apparatus. Only a protocol file written for the specific type instrument can be executed. The functionality of protocol steps and step conditions are specific for each type of instrument.

Available apparatus are

- Compression (static)
- Dynamic compression
- Shear (static)
- Dynamic shear

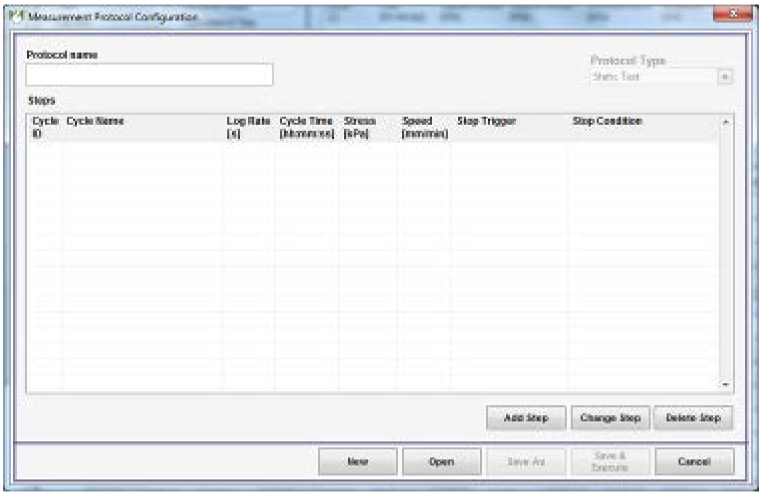


For static compression and static shear basic commands (cycle steps) are available, handling general measuring protocols. The dynamic compression and dynamic shear instruments can use more sophisticated functions as cycle step loops and advanced conditional cycle steps.

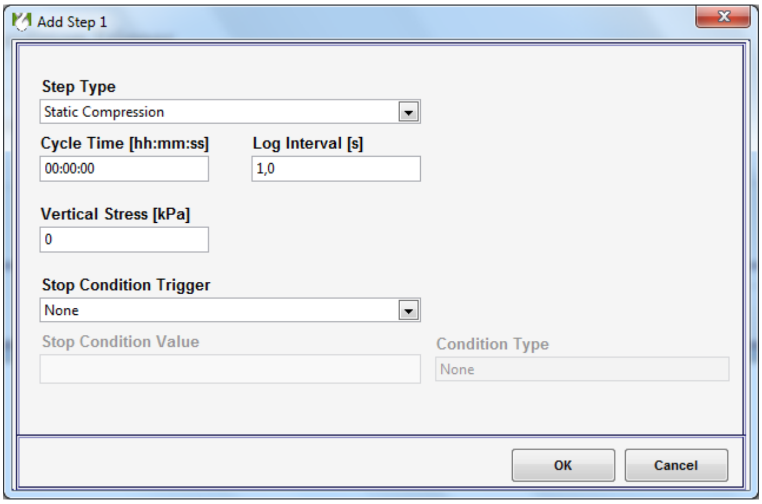
All protocol steps use the same step structure:

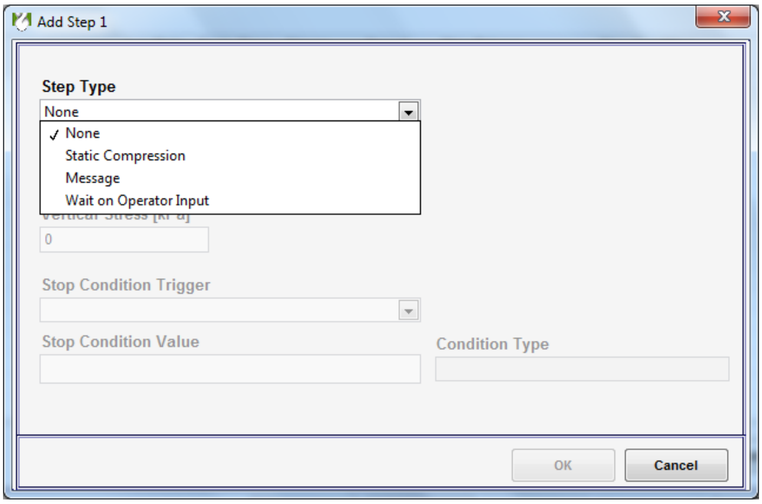
Cycle ID	cycle step number
Cycle name	type of cycle step command
Log rate	data logging interval on file
Cycle Time	Time for the cycle step to perform its action
Stress	vertical stress on the soil sample
Speed	shear speed, only for shear instruments
Stop trigger	stop condition to end the cycle step time in case of trigger event
Stop condition	the parameter value or text used by the trigger condition

5.2 Program steps for the compression apparatus



- ***Static compression***
  Vertical stress will be applied to the soil sample during a specified time or one of the predefined conditions: Stop condition is based on the time specified.

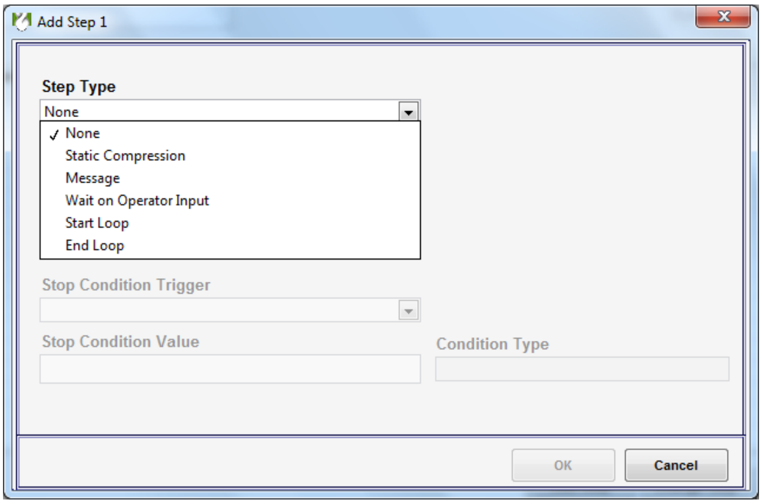


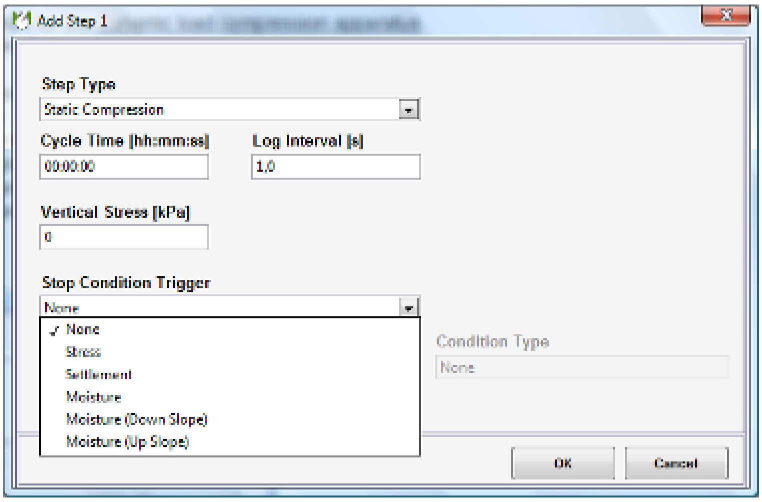


- ***Message***
  Display a message in a box during a specified time.

- ***Wait on operator input***
  Displays a message and wait until the operators acknowledges the message with the OK button.

5.3 Program steps for the dynamic load compression apparatus





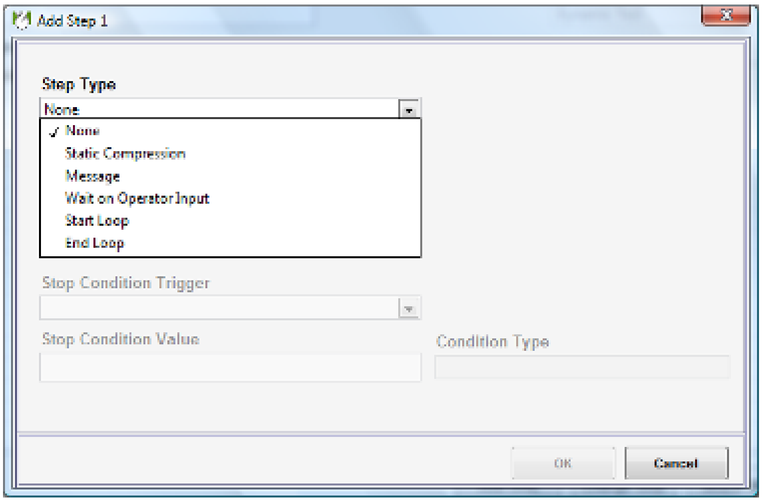
- ***Static compression***
  Stress the soil sample during a specified time or one of the predefined conditions:
  Stop conditions can be
  - ***Stress***
    Compression until a specific stress value is reached.
  - ***Settlement***
    Compression until a specific settlement value is reached.
  - ***Moisture (absolute value)***
    Compression until a specific moisture value is reached.
  - ***Moisture (down slope and value)***
    Normally a shear process waits using this condition for the soil moisture tension is reducing and below 0 hPa. This prevents faulty measurements due the ‘waterskiing’ effect.
  - ***Moisture (up slope and value)***
    Shear process waits using this condition for the soil moisture tension is increasing and above the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds; these values can be manual edited in the config.ini file.
  - ***Shear stress***
    This can be used driving the motor forward up to a position where shearing forces reaches the specified value.

  All stop conditions can be addressed to end the current program step or to end the loop. Therefore conditions will be marked with a letter S (Step end) or L (loop end)

- ***Message***
  Display a message in a box during a specified time.
- ***Wait on operator input***

Display a message and wait until the operator acknowledge the message with the OK button.

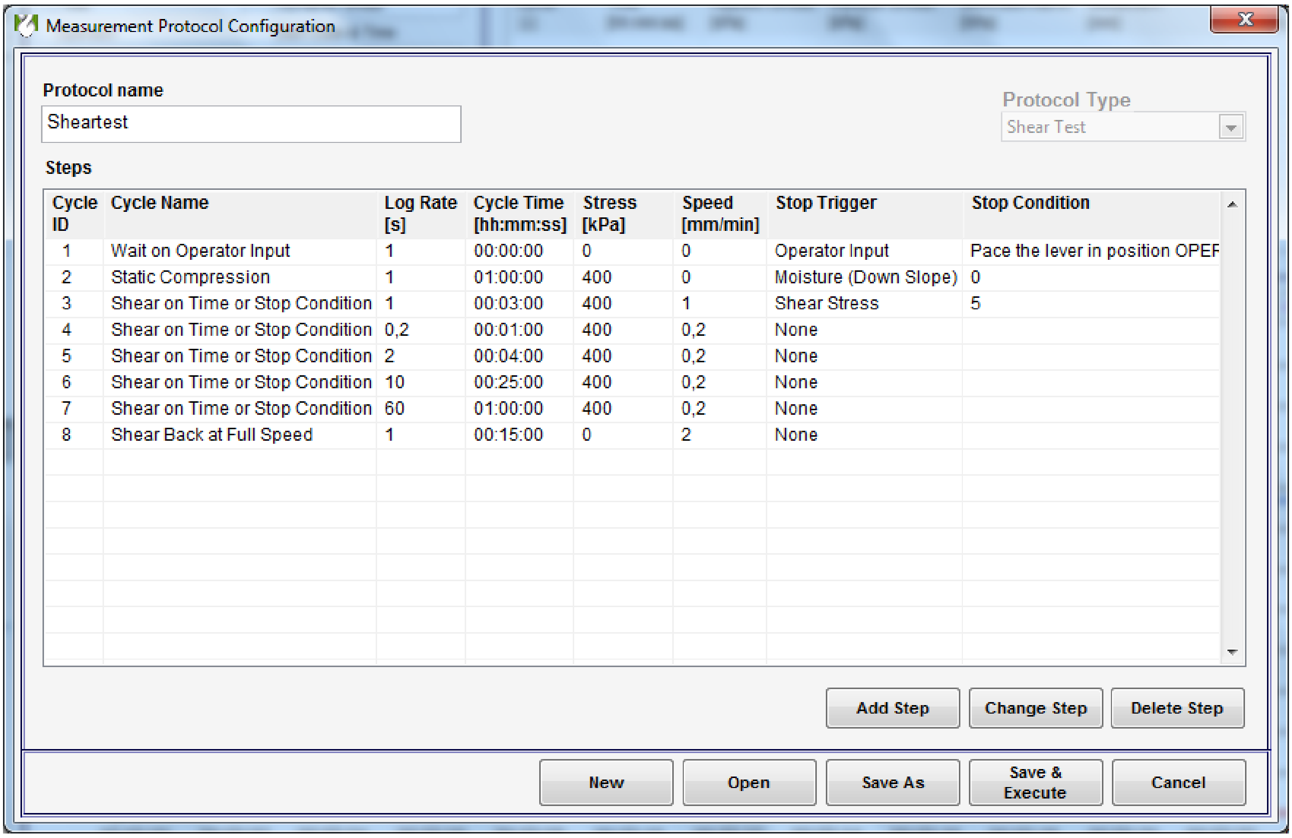
- ***Start loop***
  Starting a number of program steps that are repeated for the number of loops specified or until the stop condition of one of the program lines is reached. More then 1 loop can be used sequential but no loop in loop (recursive loops) are allowed.
- ***End Loop***
  Ending the program-step loop after the stop condition is fulfilled by number of loops or individual program line stop condition.



5.4 Example shear protocol

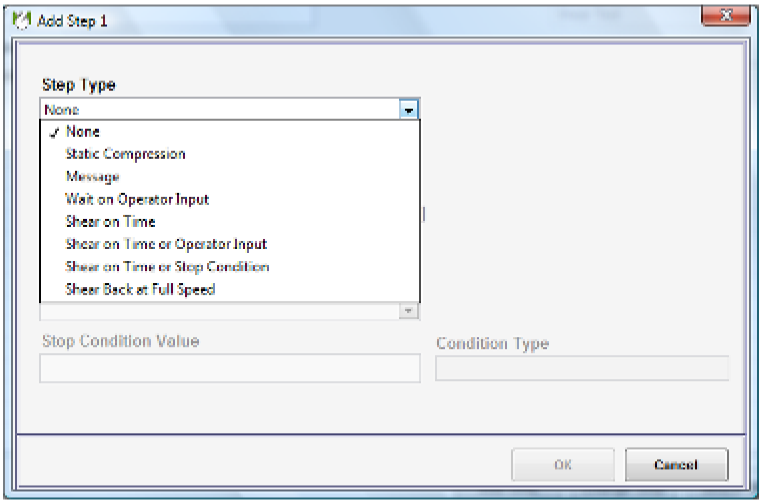
Explanation of the ‘sheartest’ example
message to operator ‘place lever in position OPERATE’
start compressing at 400 kPa during 1 hour or until the soil moisture is negative and declining
shear the motor forward with a speed of 1 mm/min during 3 minutes (3 mm) or until the shear force exceeds the 5 kPa (shear process starts), maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 1 minutes with a log interval of 0.2 sec, maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 4 minutes with a log interval of 2 sec, maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 25 minutes with a log interval of 10 sec, maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 60 minutes with a log interval of 60 sec, maintaining the vertical stress at 400 kPa
shear back at full speed for 15 minutes (30 mm) to start position

Example program Shear test instrument



Cycle ID	Cycle Name	Log Rate [s]	Cycle Time [hh:mm:ss]	Stress [kPa]	Speed [mm/min]	Stop Trigger	Stop Condition
1	Wait on Operator Input	1	00:00:00	0	0	Operator Input	Pace the lever in position OPEF
2	Static Compression	1	01:00:00	400	0	Moisture (Down Slope)	0
3	Shear on Time or Stop Condition	1	00:03:00	400	1	Shear Stress	5
4	Shear on Time or Stop Condition	0,2	00:01:00	400	0,2	None	
5	Shear on Time or Stop Condition	2	00:04:00	400	0,2	None	
6	Shear on Time or Stop Condition	10	00:25:00	400	0,2	None	
7	Shear on Time or Stop Condition	60	01:00:00	400	0,2	None	
8	Shear Back at Full Speed	1	00:15:00	0	2	None	

5.5 Program steps for the shear apparatus



(Per protocol step both cycle time and log interval are programmable.)

- ***Static compression***
  Vertical stress will be applied the soil sample during a specified time or one of the predefined conditions:
  Stop conditions can be
  - ***Stress***
    Compression until a specific stress value is reached.
  - ***Settlement***
    Compression until a specific settlement value is reached.
  - ***Moisture (absolute value)***
    Compression until a specific moisture value is reached.
  - ***Moisture (down slope and value)***
    Normally a shear process waits using this condition for the soil moisture tension is reducing and below 0 hPa. This prevents faulty measurements due the 'waterskiing' effect.
  - ***Moisture (up slope and value)***
    Shear process waits using this condition for the soil moisture tension is increasing and above the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds, these values can be manual edited in the config.ini file.
  - ***Shear stress***
    This can be used to drive the motor forward to a position where shearing forces reach the specified value.

- ***Message***
  Display a message in a box during a specified time

- ***Wait on operator input***
  Display a message and wait until the operator acknowledges the message with the OK button.

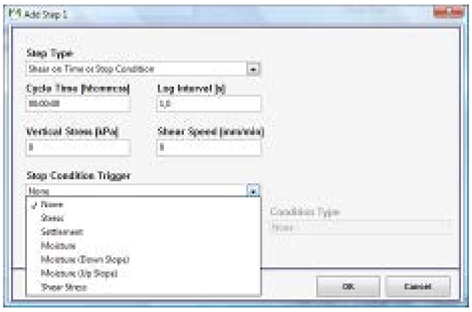
- ***Shear on time***
  Shear the sample during a specified time only or until the end position is reached. At the normal shear speed of 0.2mm/min the shear process will take 100 minutes, (1:40hour)

- ***Shear on time and operator input***
  Shear the sample during a specified time or stopped before by the operator

- ***Shear on time or stop condition***
  Shear the sample during a specified time or one of the predefined conditions:
  Stop conditions can be:
  - ***Stress***
    Shear until a specific stress value is reached.
  - ***Settlement***
    Shear until a specific settlement value is reached.
  - **Moisture (absolute value)**

Shear until a specific moisture value is reached.

- ***Moisture (down slope and value)***
  Shear process stops for the soil moisture tension is decreasing and below the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds, these values can be manual edited in the config.ini file.
- ***Moisture (up slope and value)***
  Shear process stops for the soil moisture tension is increasing and above the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds, these values can be manual edited in the config.ini file.



- ***Shear stress***
  This can be used to drive the motor (fast) forward to the stage position where the shearing process begins.

- ***Shear back at full speed***
  Driving at 2 mm/min the motor will be sheared back until the specified time or the end switch of the motor that disables this movement. Typically the shear back time is 15 minutes.

5.6 Program steps for the dynamic load shear apparatus

(extra steps in addition of the standard version)
These options makes it possible to perform all actions for the dynamic compression apparatus tests.

- ***Start loop***
  Starting a number of program steps being repeated for the number of loops specified or until the stop condition of one of the program lines is reached. More than 1 loop can be used sequential but no loop in loop (recursive loops) are allowed.
- ***End Loop***
  Ending the program-step loop after the stop condition is fulfilled by number of loops or individual program line stop condition.

6 Measuring procedure compression test

In prior, switch on the instrument, apply the proper air pressure and start the program PST.
Check the proper functioning using the manual control option

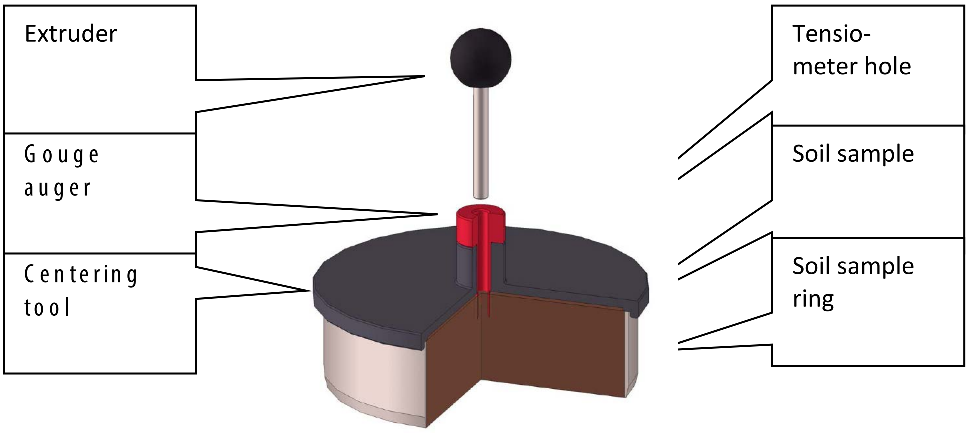
1 Empty the tensiometer reservoir by sucking it with a syringe with a short hose.

2 Remove the tensiometer reservoir with a rotating motion.

3 Place the sintered plate with the tensiometer spare hole on the sample chamber. Optional place a high flow filtration paper with tensiometer spare hole preventing smearing of the sintered plates.

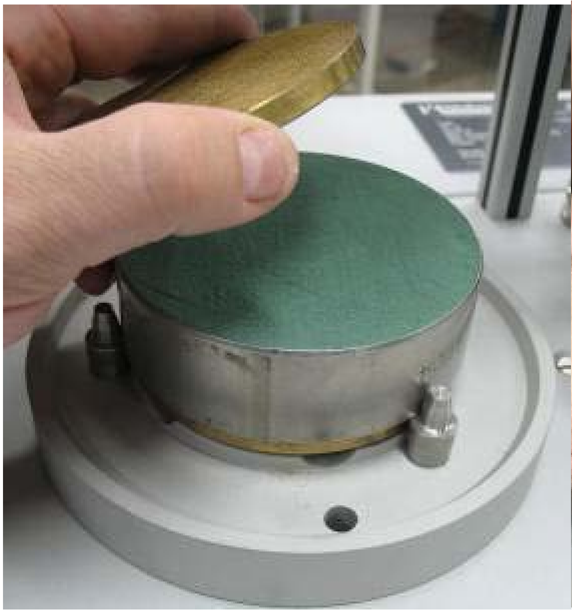
4 Turn the soil sample with blunt side of sample ring for tensiometer hole preparation.

5 Make a spare hole in the soil sample for the tensiometer using the gouge auger tool to make sure that the tensiometer will fit precise as possible.



6 Place the soil sample with the tensiometer hole downwards on the sample holder .

7 Place the upper sintered plate optional using filtration paper and the sample stamp. During long tests cover the sample with a foil to prevent drying out the sample due to evaporation.




8 Lift the height sensor and place the rod and centre them carefully.



9 Close the safety cover.
10 Place the handle in position OPERATE
11 Press the yellow RESET button.

12 Start the measurement protocol pressing the software START button

During the measurement protocol the measurements can be stopped, paused, skip the executed cycle or add a comment to the logfile.

13 Take out the soil sample by placing the handle in UP position.
14 Clear the sample chamber and tensiometer carefully i.e. using a vacuum cleaner and a soft brush.

15 Replace the tensiometer reservoir on the tensiometer cup and refill the reservoir with degassed demineralised water to prevent it of drying out.

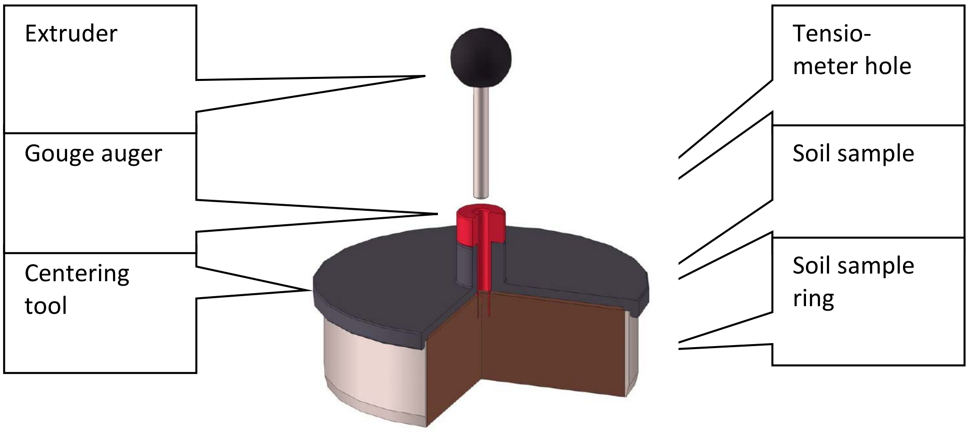
7 Measuring procedure shear test

In prior, switch on the instrument, apply the proper air pressure and start the program PST.
Check the proper functioning using the manual control option

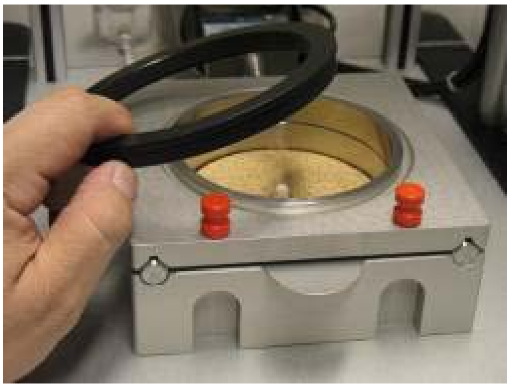
1 Place the traverse in the backwards position for optimal accessibility of the sample chamber.
2 Empty the tensiometer reservoir by sucking it with a syringe with a short hose.
3 Remove the tensiometer reservoir with a rotating motion.



4 Turn the soil sample with blunt side of sample ring for tensiometer hole preparation.
5 Make a spare hole in the soil sample for the tensiometer using the gouge tool to make sure that the tensiometer will fit precise as possible.



6 Place the lower shear ring into the sample chamber .
7 Place the sintered plate with the tensiometer spare hole in the sample chamber. Optional place a high flow filtration paper with tensiometer spare hole preventing smearing of the sintered plates.
8 Place the upper part of the sample chamber positioning it with the red fixation pins.
9 Place the transfer ring for precise transfer of the sample into the sample chamber.

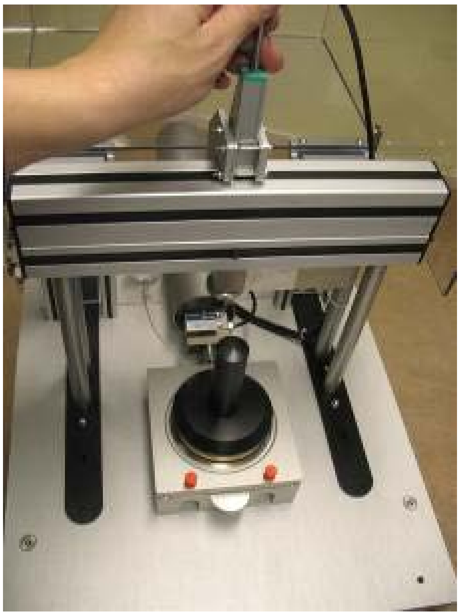


10 Place the sample with the tensiometer hole downwards on the transfer ring. Place the upper sintered plate optional using filtration paper.

11 Place the sample transfer stamp **(thick)** and the rod **(short)** and centre it carefully.
12 The sample can be transferred from sample ring to sample chamber pushing it gently by hand with minimal compression until completely transferred. Alternatively one can use the manual control using the software and the handle in position OPERATE or even write an automatic transfer protocol.

13 Remove the empty sample ring and the transfer ring.

15 Place the sample holder fillplate. Lift the height sensor and place the sample transfer stamp **(thin)** and the sample transfer rod **(long)** and centre them carefully.



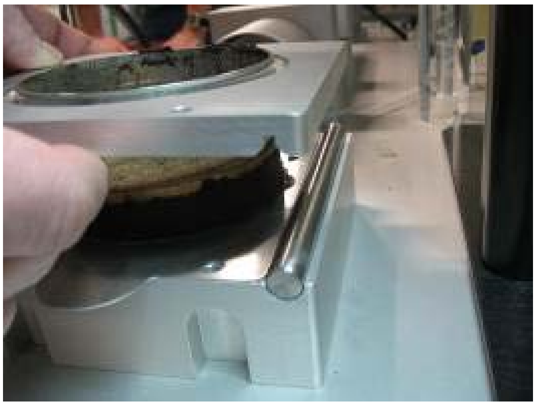
14 Place the traverse in the centre position using the red fixation pins.

15 Remove the red fixation pins !

17 Close the safety cover.
16 Place the handle in position OPERATE
18 Press the yellow RESET button.

19 Start the measurement protocol pressing the software START button

During the measurement protocol the measurements can be stopped, paused, skip the executed cycle or add a comment to the logfile.



20 Take out the soil sample by placing the handle in UP position and shifting the traverse in backwards position.
21 Clear the sample chamber and tensiometer carefully i.e. using a vacuum cleaner and a soft brush.

22 Replace the tensiometer reservoir on the tensiometer cup and refill the reservoir with degassed demineralised water to prevent it of drying out.

Appendix 1 Theory of operation soil compaction

Preface.

Soil formation including aggregate development involves changes in both physical and mechanical properties, and therefore, requires the exact definition of the limits within which properties are quantified. This is true, because in situ soil formation processes have to be linked to internal and external conditions (climatic, mechanical, thermal, hydrological, or chemical aspects) for a particular situation. Thus, all properties such as soil strength, stress attenuation, changes in soil structure or pore distribution, water fluxes, gas exchange are material functions with well-defined and quantified limits. Consequently, in order to deal with soil properties, stress, strain and strength definitions are initially required to later define the limits of the material functions with respect to the application of external stresses.

Definitions:

Force applied to a soil-per-unit area is defined as stress.
Stresses working along the surface will also induce stresses in the soil, which may result in a three- dimensional deformation of the soil volume or will be transmitted as a rigid body. The mechanical behavior of a soil (volume change and shear strength) can be described in terms of the soil stress state. The number of stress state variables required to define the stress state depends primarily upon the number of phases involved. The effective stress σ' can be defined as a stress variable for saturated conditions and is the difference between the total (σ) and the neutral stress (u_w) which is equal to the pore water pressure:

$$\sigma' = \sigma - u_w$$

where σ' is transmitted by solid and (u_w) by the liquid phase, respectively. In unsaturated soils stresses are transmitted by the solid, liquid and gaseous phases. Thus, Equation [3.1] becomes:

$$\sigma' = (\sigma - u_a) + X(u_a - u_w)$$

where u_a and u_w are pore air and water pressures, respectively, and X is a factor which depends on the degree of saturation. At saturation ($u_w = 0$), X = 1, while at $u_w = -10^6$ kPa, X = 0.

Compression refers to a process that describes the increase in soil mass-per-unit volume (increase in bulk density) under an externally applied load or under changes of internal pore water pressure. Examples of externally applied static or dynamic loads are vibration, rolling, trampling, etc. while internal forces-per-unit area include such factors as pore water pressure or suction caused by a hydraulic gradient.
In saturated soils, compression is called consolidation, while in unsaturated soils, it is called compaction. Consolidation, therefore, depends on the drainage of excess soil water determined by hydraulic conductivity and gradient. However, during compaction, less compressible air will be expelled as a function of air permeability, pore continuity and water saturation in the profile. Consolidation tests are, mainly used in civil engineering (e.g., road construction).
Soil compressibility described by the shape of the stress strain curve is defined as a resistance to a volume decrease, when the soil is subjected to a mechanical load. Compaction tests are used both for laboratory and for field soil compression characterizations.
In laboratory compaction, the optimum diameter to height ratio of the test cylinder should be 3- 5 in order to minimize the effect of friction between cylinder wall and sample. Compaction tests to determine soil strength can be carried out on homogenized, undisturbed or bulk soil samples or single aggregate samples at different pore water pressure (i.e. water suction).
Compactability is the difference between the initial and maximum densities to which a soil can be compacted by a given amount of energy at defined water content.

Measurements of soil strength

The determination of soil strength parameters requires measurements under well-defined laboratory conditions

Uniaxial compression test

The uniaxial compression test is used to define the pressure at which soil begins to fail at a given water content. A vertical normal stress (σ_1) is applied to the soil sample, while the stresses on the planes mutually perpendicular to the σ_1 direction ($\sigma_2 = \sigma_3$) are zero. The uniaxial compression test is often used to determine the tensile strength of single aggregates (crushing test).

Confined compression test

Soil stress-strain relationships of undisturbed structured and homogenized soils with respect to volume change are quantified in confined compression test (*oedometer* tests). In contrast to uniaxial compression tests, stresses in the σ_2 and σ_3 direction are undefined (rigid wall of the soil cylinder). Both time and load dependent changes in soil deformation are measured (recorded as settlement). The slopes in a void ratio *e* versus *log* σ-plot of the virgin compression line and the re-compression line are referred to as the compression index ($C_c = -\delta e / \sigma log\sigma$) and swelling index ($Cs = -\delta e / \delta log\sigma$). The transition from the region of over-consolidation (re-compression) to normal consolidation (virgin compression) is defined by the pre-compression stress which separates the stress range where soil deformation is considered fully elastic (i.e. reversible) from the stress range where soil deformation is elasto-plastic (i.e. partly irreversible).

The precompression stress is defined as the stress value at the intersection of the less steep recompression curve and the virgin compression line. The latter straight line portion has a steeper slope if plotted on a semilog scale. Many methods are available to determine the precompression stress but that of Casagrande is most frequently used. Generally, the stress strain tests can be performed under 3 different boundary conditions:

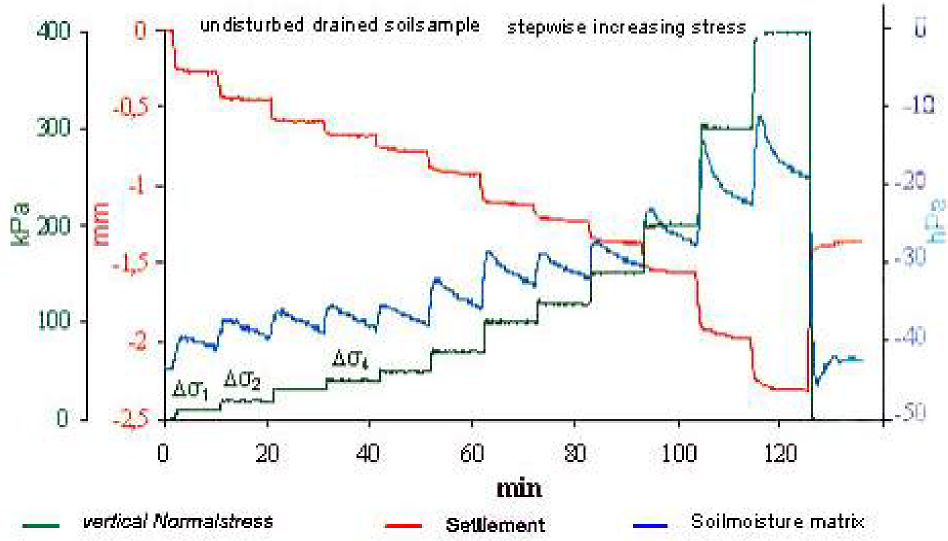
A) In the consolidated drained test (CD), the soil sample is equilibrated with the mean normal stresses prior to an increase in the vertical stress (σ_1); the pore water drains off when the decrease in volume exceeds the air-filled pore space. Therefore, the applied stresses are assumed to be transmitted as effective stresses via the solid phase.

B) In the consolidated undrained test (CU), pore water cannot be drained off the soil as vertical stress increases. Thus, high hydraulic gradients occur and the pore water reacts as a lubricant with a low surface tension. Thus, in the CU test, shear parameters are much smaller and pore water pressure values are much greater than those in the CD test.

C) The highest neutral stresses and, therefore, the lowest soil strength is measured in the unconsolidated undrained test (UU), where neither the effective nor the neutral stresses are equilibrated with the applied stress at the beginning of the test.

Figure shows the stress strain device which enables the testing and quantification of the internal soil strength, the stress induced height changes which also affect the hydraulic and pneumatic soil functions .

Undisturbed or well defined homogenized soil samples within the soil cylinders will be fixed, the tensiometer at the bottom connected with the gauge and the initial pore water pressure registered. The top capping will be placed on the sample, the strain gauge linked with the capping and the data recording controlled. In dependence of the intended test procedure either the pre-equilibration of the soil samples will be waited in order to get a defined pore water pressure controlled stress strain experiment or the stresses will be applied immediately.
The stress application and the induced strain (height and pore water pressure changes will be recorded with a frequency which can be defined according to the specific research experiments in between x/min to y/min.)



A typical graph of the experiment

The time steps as well as the normal stresses applied can be varied according to the specific requirements of the experiments between x-minutes per stress applied within the stress range of 0-400 kPa, as well as it can be controlled either by the still occurring strain at a given stress applied or the allowed pore water pressure variations defined by the posed research question.
The analysis of the stress strain and stress change in pore water pressure behavior can result in the determination of the precompression stress, the determination of the effective stresses, soil resilience (related to the height gain after stress release), compression index Cc (= slope of the virgin compression line). (for more detailed information see the attached literature)

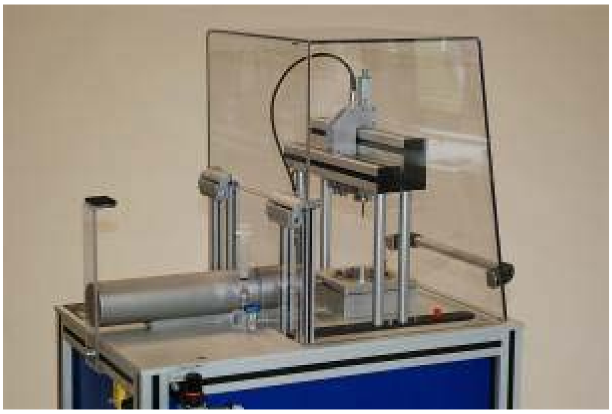
Shear strength parameters

The shear strength parameters cohesion (*c*) angle of internal friction (φ) describe the relation between the normal stress applied and the shear resistance which can be mobilized against any kind of deformation or strain and are defined according to the Mohr Coulomb equation:

$\tau = \tan \varphi \, \sigma_n + c$.

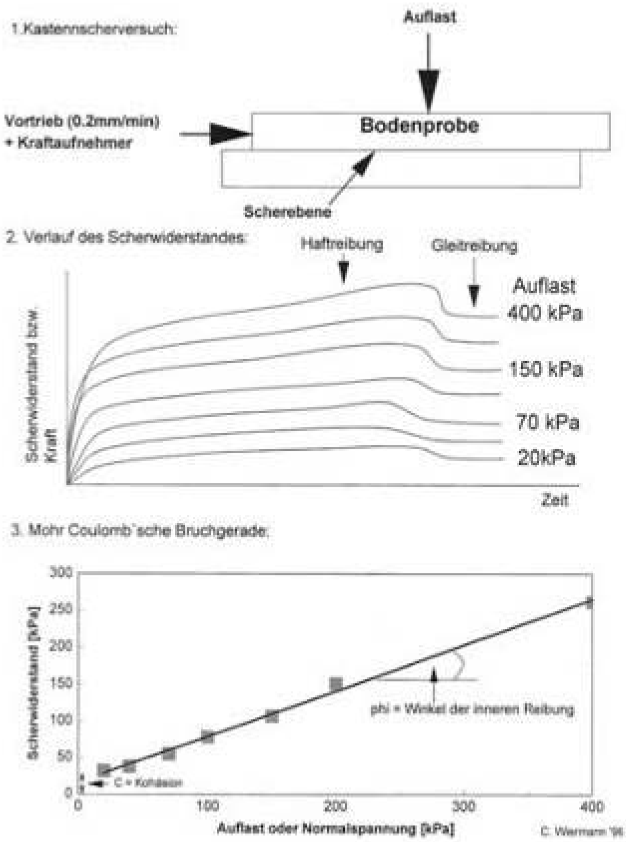
3 different tests (uniaxial compression test, triaxial test, and direct shear test) can be carried out to obtain the shear parameters which according to the boundary conditions give more or less precise and defined results. The uniaxial compression test only informs about the cohesion, while the triaxial test is the most defined but also most time consuming and expensive one, which leads to only very seldom application of this test approach. Thus, primarily results of the direct shear test are presented in the literature and may be also compared with only rarely used triaxial test results.

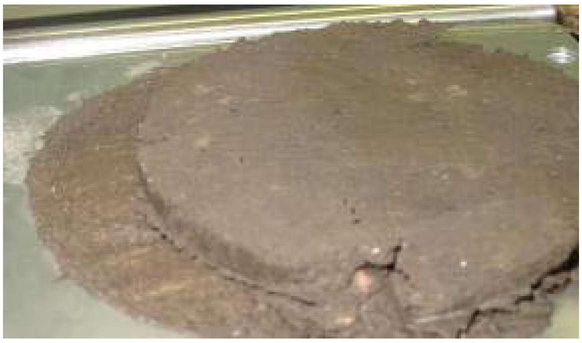
This direct shear test is carried out under confined conditions: i.e. type and direction of the shear plane, which is assumed to be affected only by normal and shear stresses, are fixed. Normal stress is applied to the specimen in the vertical and shear stress in the horizontal direction (see figure). Compared with the confined compression device also the direct shear machine allows to analyse the time, shear speed and pore water pressure dependency during the tests.

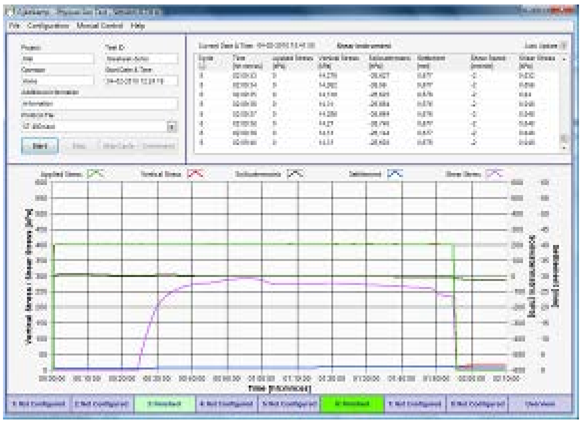


Measurement procedure:

To determine the Mohr-Coulomb failure line at least 4-5 samples need to be tested each with a different normal stress. The maximum shear resistance (τ_{max}) is determined from a shear stress-displacement curve and plotted against the corresponding normal stress (σ_n). Plotting all pairs of τ_{max} versus σ_n gives the Mohr-Coulomb failure line in which the slope and intercept are the angle of internal friction (φ) and cohesion (c), respectively. soil stability against shear or tensile stresses is related to strength distribution in failure zones (Fig. 2). As it is true for the confined compression test device also the direct shear test can be carried out under well pre-compressed and completely drained (CD) , or as consolidated undrained (CU) or as uncompressed and undrained (UU) conditions and can be furthermore affected by the shear speed and time of preloading. Thus, the boundary conditions can be defined very flexible according to the posed experimental questions.







Schematic diagram of shear strain curves and the derivation of the Mohr Coulomb failure line

Discussion of data:

In principle, soil structure will be stable if the applied stress is smaller than the strength of the failure zone, i.e., if the bond strength at the points of contact exceeds the shear or tensile stresses generated by external loads. If the resisting forces are smaller than the active forces stresses are in disequilibrium and hence soil deformation will occur to generate more contact points until stress equilibrium is reached again. Reorientation of particles is accompanied by a change of soil structure and consequently functions. In extreme stress situations (especially high shear stresses) or when soil is subject to mechanical loads in unfavorable moisture conditions (near the liquid limit) soil structure may be almost completely returned to an immature state (homogeneous soil). In contrast to shear stresses that lead to volume constant deformation, normal stresses result in volume change, i.e. compression which is plastic as soon as the soils stability is exceeded. In situ stress conditions during field operations (traffic, soil-tool interactions) are generally characterized by a combination of both shear and compressive stresses. For comparable grain size distribution, bulk density and pore water pressure, soil strength increases with aggregation (i.e., coherent < prismatic < blocky < subangular blocky < crumbly). In the case of a platy structure the strength depends on the direction of shear forces relative to the preferred orientation of the particles. In the direction of the elongated axes of aligned particles shear strength is lower than perpendicular to it.

Literature

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Peth,S., Horn, R., Fazekas,O., Richards,B. 2006: Heavy soil loading and it consequences for soil structure, strength and deformation of arable soils. J.Plant Nutrition and Soil Science, 169, 775-783,

Vossbrink, J., R.Horn 2004. Modern forestry vehicles and their impact on soil physical properties. Eur.J.Forest Res. 123.259-267

Horn, R., Fleige, H. 2003.A method of assessing the impact of load on mechanical stability and on physical properties of soils. Soil Till.Res. 73, 89 – 100

Horn, R. and T. Baumgartl 1999: Dynamic Properties of Soils. In: Sumner (Hersg): Handbook of Soil Science, A19 – A 53, CRC Press.

Horn,R., J.J.H. van den Akker, J.Arvidsson 2000: Subsoil Compaction – Distribution, Processes and Consequences. Advances in Geoecology 32, ISBN 3-923381-44-1, 462 S

Royal Eijkelkamp expresses thanks to the scientific contributions of Prof. R. Horn and J.Rostek

Appendix 2 Maintenance & service

Problem solving, tips and tricks

Q The software screen is not completely covering my monitor screen

A The screen resolution is fixed for compatibility reasons, full screen coverage can be obtained only by adjusting the screen resolution in Windows.

Q The instrument makes an internal sissing sound

A Check for the input air pressure, the maximum is 7 Bar and possibly the overpressure safety regulator is venting. Reduce the input pressure

Q The system makes a ticking noise and the maximum stress is not available.

A Make sure that the handle is in position operate, check for input pressure on the pressure regulator.

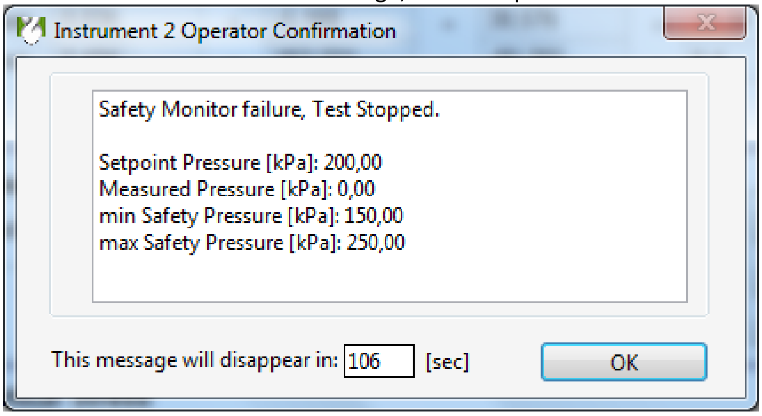
- Check handle for position Operate
- Check safety cap in position
- Check pressing the yellow reset button after opening the safety cap
- Check air pressure supply

Q Message safety monitor failure

A The measured force is not within expected limits invoking a safety procedure:

- Check handle for position Operate
- Check safety cap in position
- Check pressing the yellow reset button after opening the safety cap
- Check air pressure supply

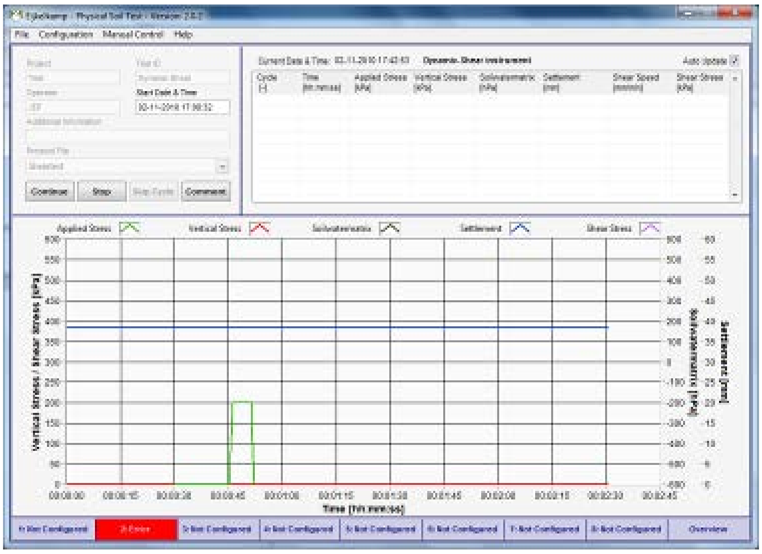
Press OK for removal of the massage, clear the problem and restart the test

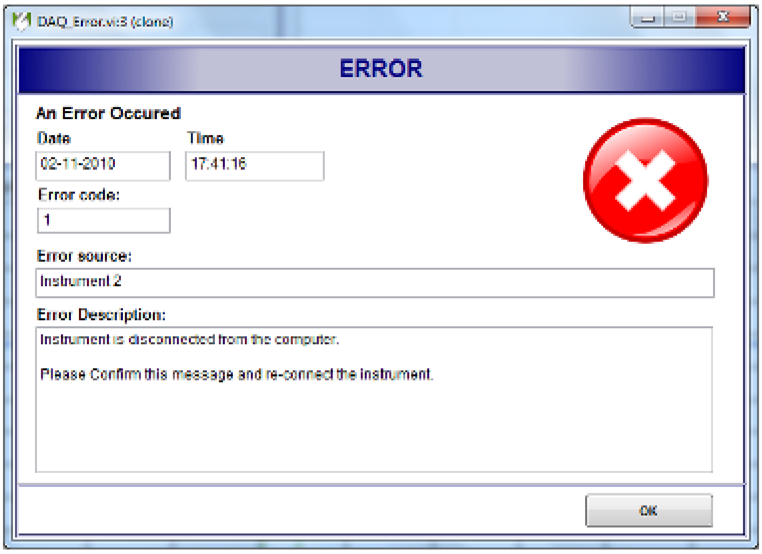


Q The maximum stress is not available.

A check for input air pressure on the pressure regulator.

Q An instrument is not responding, indicating a red instrument selection button.
A Remove the instrument USB cable on the computer, if the error message appears confirm the OK button and reconnect the USB cable





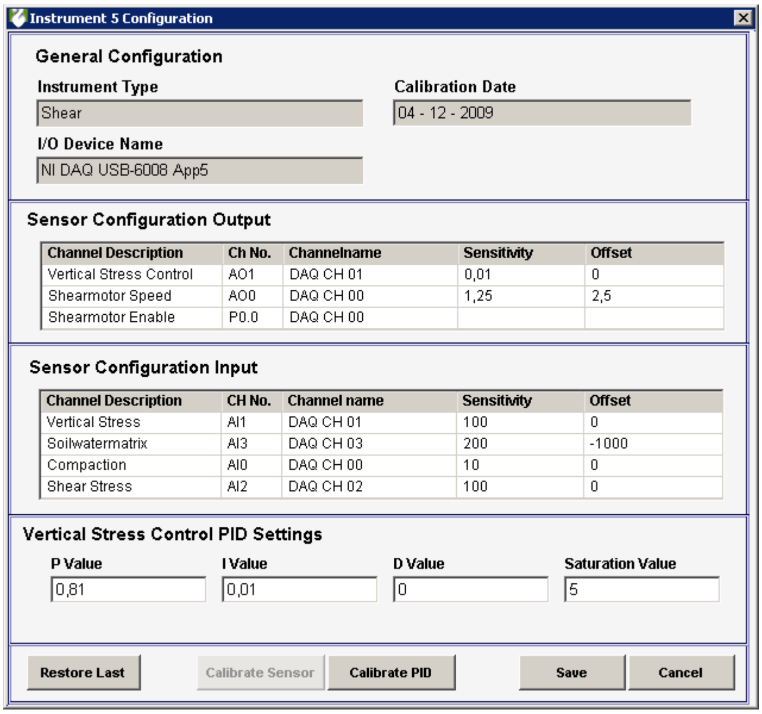
Q An instrument is not responding, due to disturbed internal electronic controller
A Check in manual control for analog values Remove the instrument USB cable on the computer , if the error message appears confirm the OK button then reconnect the USB cable.

Q The tensiometer is reacting slow.
A Check for air in the system, refill it. If it does not fix the problem replace the tensiometer assembly.

Calibration Maintenance and Service

Before measurements can be performed the instrument calibration must be checked bij the Manual control option and in case of inaccuracy performed using the Configuration, option instrument configuration.
By clicking the channel and calibrate sensor the individual calibration screens become available. If the calibration is unsuccessful the last known calibration can be restored.
Often only tensiometer and force sensors need justification in offset, this can be done in

☞ **It is strongly advised to copy the factory calibration for backup purposes.**


Instrument 5 Configuration

General Configuration

Instrument Type: Shear

Calibration Date: 04 - 12 - 2009

I/O Device Name: NI DAQ USB-6008 App5

Sensor Configuration Output

Channel Description	Ch No.	Channelname	Sensitivity	Offset
Vertical Stress Control	AO1	DAQ CH 01	0,01	0
Shearmotor Speed	AO0	DAQ CH 00	1,25	2,5
Shearmotor Enable	P0.0	DAQ CH 00		

Sensor Configuration Input

Channel Description	CH No.	Channel name	Sensitivity	Offset
Vertical Stress	AI1	DAQ CH 01	100	0
Soilwatermatrix	AI3	DAQ CH 03	200	-1000
Compaction	AI0	DAQ CH 00	10	0
Shear Stress	AI2	DAQ CH 02	100	0

Vertical Stress Control PID Settings

P Value	I Value	D Value	Saturation Value
0,81	0,01	0	5

Restore Last | Calibrate Sensor | Calibrate PID | Save | Cancel

Often only tensiometer or force sensors need justification in offset due to temperature fluctuation. This can be done using the zero button, inserting a zero offset for the sensor without changing the sensor calibration parameters.

Service interval schema

This interval schema based on regular use and are only as indication. Based on local conditions and experience the intervals can be altered.

- Sensors offset — 1 week
- Remove condensate from air filters and compressor — 1month
- Ultrasonic cleaning sintered plates — 3 months
- Calibration check — 3 months
- Recalibration — 1 year
- Ceramic assembly replacement — 1 year
- Air filter check — 1 year
- General maintenance** — 3 year
    - Specifications check
    - Functionality check
    - Wear-out check, mechanical, pneumatic incl hoses, electric
    - Recalibration against traceable standards
    - Repair

****Please consult Royal Eijkelkamp for service contract proposals**

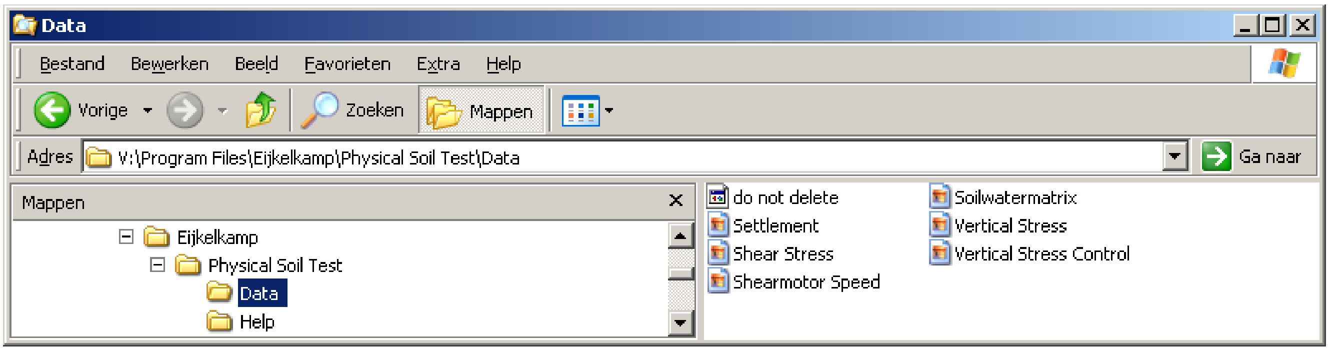
Appendix 3 Software file structure

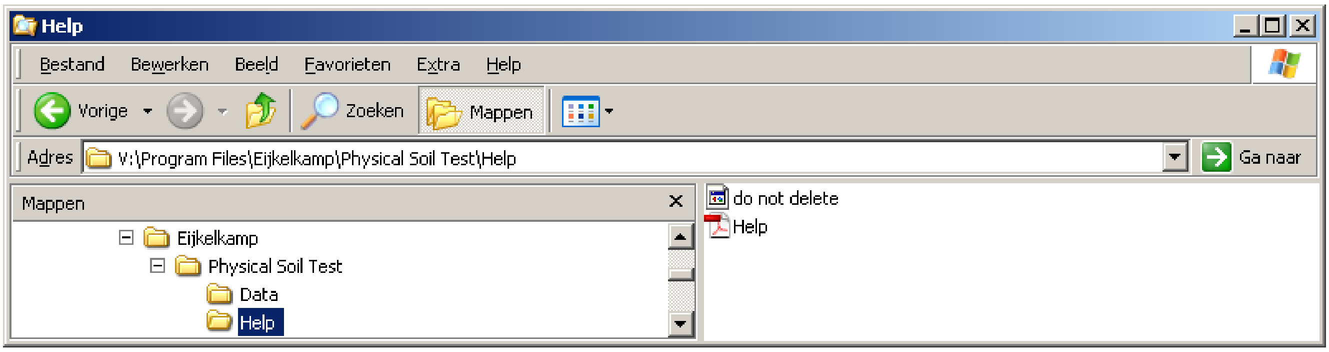
Program system files

The main program is located at drive C: Program Files\Eijkelkamp\Physical Soil Test\ PST.exe
The User data is located at C:\soil Test Data
Other user specified location can be selected during installation of the software or using the menu Configuration, option File location setup

C:

- **Program Files**
  - **Eijkelkamp**
    - **Physical Soil Test** (executable PST.exe)
      - **Data** (program specific filest)
      - **Help (**user manual files pdf format)





Program configuration files

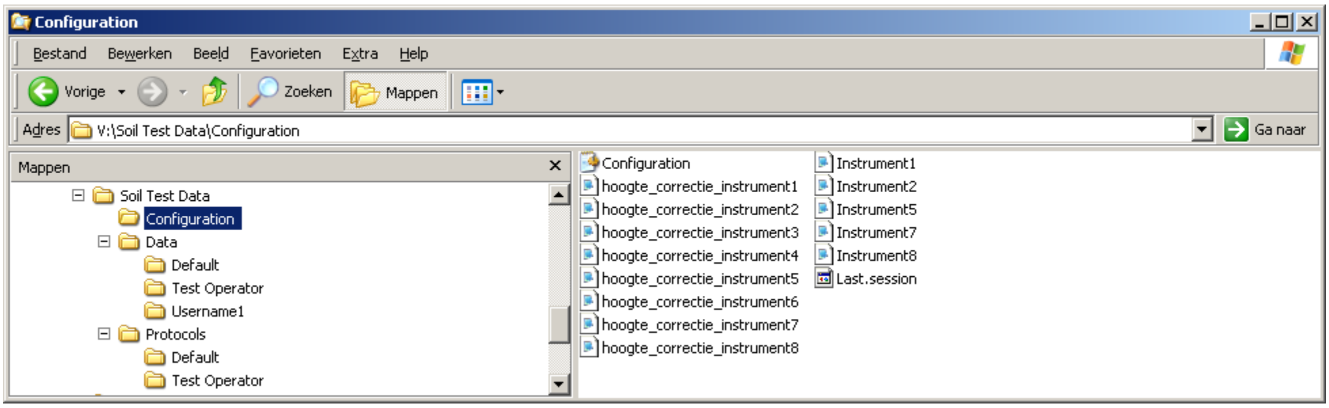
Only the DATA Username files containing measurement result data in CSV format are of primary interest to the user. All configuration and protocol files are stored in text format , it is not recommended to edit these files by hand as the program user interface helps to prevent typing or other mistakes.

C:

Soil Test Data

Configuration

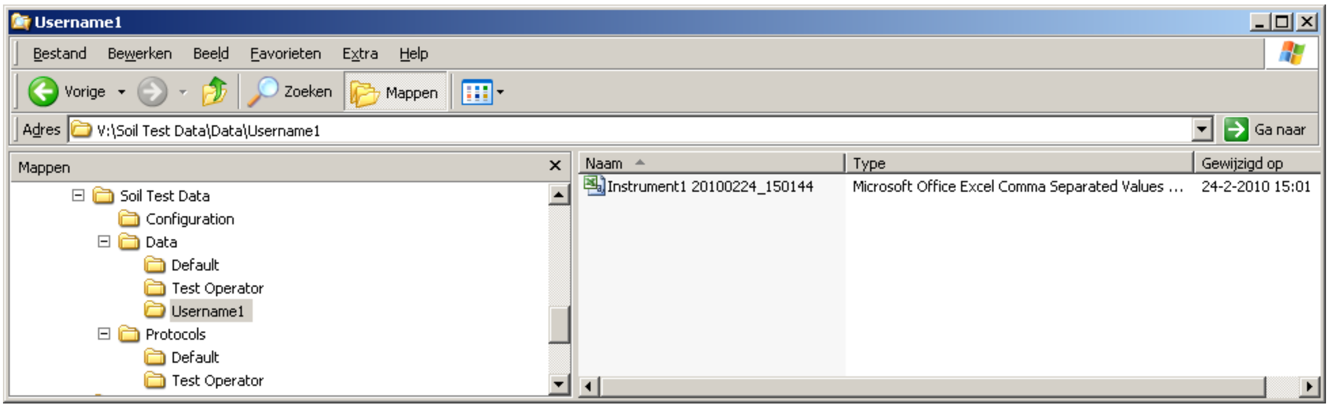
- Configuration (general settings file)
- Hoogte_correctie_instrumentx (instrument specific calibration file)
- Instrumentx (instrument specific calibration file)



Program data files

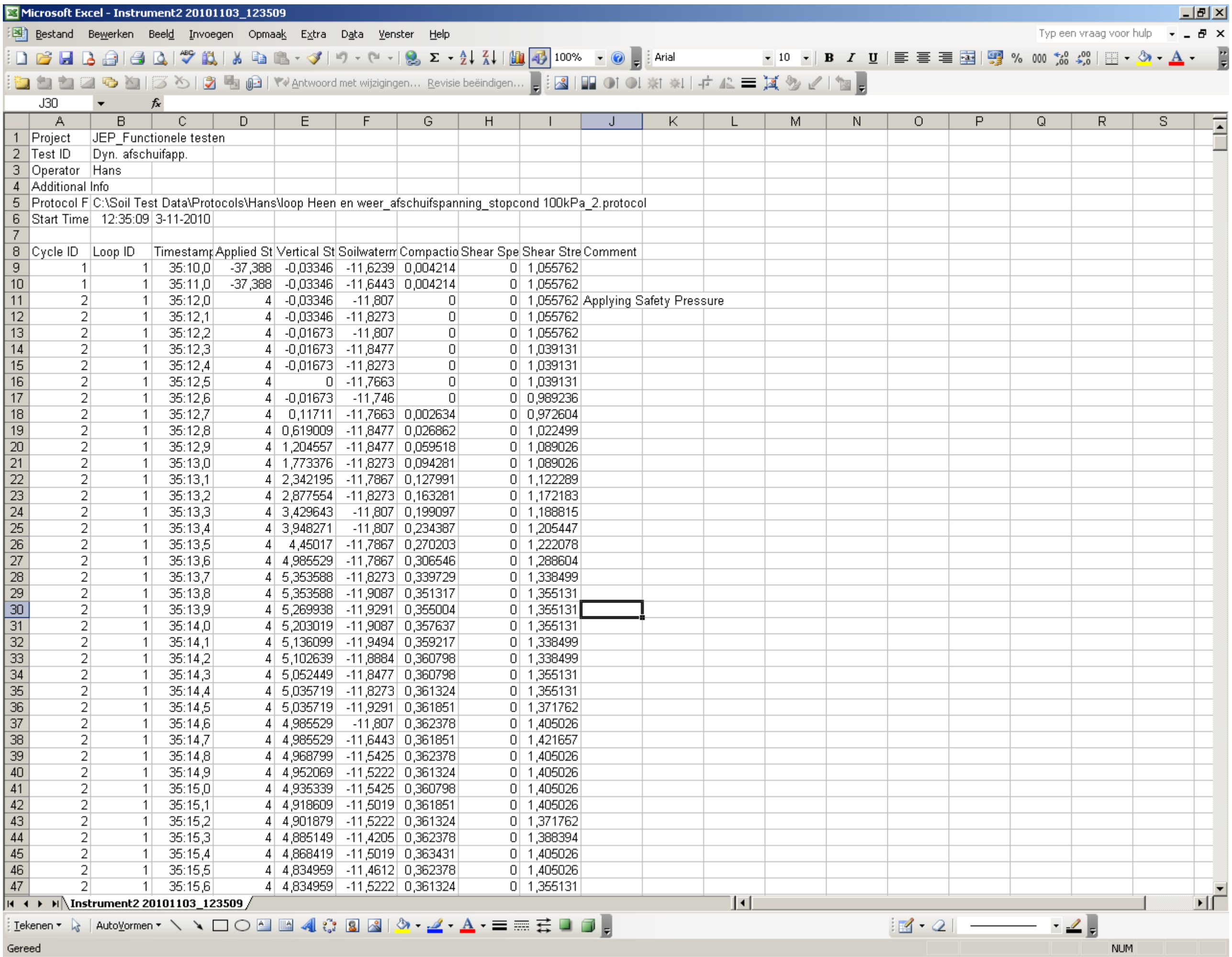
C:

- **Soil Test Data**
  - **Data**
    - **Default**
    - **Username1**(data result files CSV format User1)
    - **Username 2**(data result files CSV format User2)
  - **Protocols**
    - **Default** (common protocol files All Users)
    - **Username 1** (protocol files User1)
    - **Username 2** (protocol files User2)



Data file format

The data files can be read into general spreadsheet programs. The file naming is based on instrument, date and time.



	A	B	C	D	E	F	G	H	I	J
1	Project	JEP_Functionele testen								
2	Test ID	Dyn. afschuifapp.								
3	Operator	Hans								
4	Additional Info									
5	Protocol F	C:\Soil Test Data\Protocols\Hans\loop Heen en weer_afschuifspanning_stopcond 100kPa_2.protocol								
6	Start Time	12:35:09	3-11-2010							
7										
8	Cycle ID	Loop ID	Timestamp	Applied St	Vertical St	Soilwaterm	Compactio	Shear Spe	Shear Stre	Comment
9	1	1	35:10,0	-37,388	-0,03346	-11,6239	0,004214	0	1,055762	
10	1	1	35:11,0	-37,388	-0,03346	-11,6443	0,004214	0	1,055762	
11	2	1	35:12,0	4	-0,03346	-11,807	0	0	1,055762	Applying Safety Pressure
12	2	1	35:12,1	4	-0,03346	-11,8273	0	0	1,055762	
13	2	1	35:12,2	4	-0,01673	-11,807	0	0	1,055762	
14	2	1	35:12,3	4	-0,01673	-11,8477	0	0	1,039131	
15	2	1	35:12,4	4	-0,01673	-11,8273	0	0	1,039131	
16	2	1	35:12,5	4	0	-11,7663	0	0	1,039131	
17	2	1	35:12,6	4	-0,01673	-11,746	0	0	0,989236	
18	2	1	35:12,7	4	0,11711	-11,7663	0,002634	0	0,972604	
19	2	1	35:12,8	4	0,619009	-11,8477	0,026862	0	1,022499	
20	2	1	35:12,9	4	1,204557	-11,8477	0,059518	0	1,089026	
21	2	1	35:13,0	4	1,773376	-11,8273	0,094281	0	1,089026	
22	2	1	35:13,1	4	2,342195	-11,7867	0,127991	0	1,122289	
23	2	1	35:13,2	4	2,877554	-11,8273	0,163281	0	1,172183	
24	2	1	35:13,3	4	3,429643	-11,807	0,199097	0	1,188815	
25	2	1	35:13,4	4	3,948271	-11,807	0,234387	0	1,205447	
26	2	1	35:13,5	4	4,45017	-11,7867	0,270203	0	1,222078	
27	2	1	35:13,6	4	4,985529	-11,7867	0,306546	0	1,288604	
28	2	1	35:13,7	4	5,353588	-11,8273	0,339729	0	1,338499	
29	2	1	35:13,8	4	5,353588	-11,9087	0,351317	0	1,355131	
30	2	1	35:13,9	4	5,269938	-11,9291	0,355004	0	1,355131	
31	2	1	35:14,0	4	5,203019	-11,9087	0,357637	0	1,355131	
32	2	1	35:14,1	4	5,136099	-11,9494	0,359217	0	1,338499	
33	2	1	35:14,2	4	5,102639	-11,8884	0,360798	0	1,338499	
34	2	1	35:14,3	4	5,052449	-11,8477	0,360798	0	1,355131	
35	2	1	35:14,4	4	5,035719	-11,8273	0,361324	0	1,355131	
36	2	1	35:14,5	4	5,035719	-11,9291	0,361851	0	1,371762	
37	2	1	35:14,6	4	4,985529	-11,807	0,362378	0	1,405026	
38	2	1	35:14,7	4	4,985529	-11,6443	0,361851	0	1,421657	
39	2	1	35:14,8	4	4,968799	-11,5425	0,362378	0	1,405026	
40	2	1	35:14,9	4	4,952069	-11,5222	0,361324	0	1,405026	
41	2	1	35:15,0	4	4,935339	-11,5425	0,360798	0	1,405026	
42	2	1	35:15,1	4	4,918609	-11,5019	0,361851	0	1,405026	
43	2	1	35:15,2	4	4,901879	-11,5222	0,361324	0	1,371762	
44	2	1	35:15,3	4	4,885149	-11,4205	0,362378	0	1,388394	
45	2	1	35:15,4	4	4,868419	-11,5019	0,363431	0	1,405026	
46	2	1	35:15,5	4	4,834959	-11,4612	0,362378	0	1,405026	
47	2	1	35:15,6	4	4,834959	-11,5222	0,361324	0	1,355131	

Appendix 4 Conversion table Newton to kPa

Based on 98 mm diameter sintered plates.

Calculation table Newton <-> kPascal

N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa	N	kPa
5	0,7	255	33,8	510	67,6	1010	134,0	1510	200,3	2010	266,6	2510	332,9	3010	399,2	3510	465,6	4010	531,9	4510	598,2	5010	664,5
10	1,3	260	34,5	520	69,0	1020	135,3	1520	201,6	2020	267,9	2520	334,3	3020	400,6	3520	466,9	4020	533,2	4520	599,5	5020	665,9
15	2,0	265	35,1	530	70,3	1030	136,6	1530	202,9	2030	269,3	2530	335,6	3030	401,9	3530	468,2	4030	534,5	4530	600,9	5030	667,2
20	2,7	270	35,8	540	71,6	1040	137,9	1540	204,3	2040	270,6	2540	336,9	3040	403,2	3540	469,5	4040	535,9	4540	602,2	5040	668,5
25	3,3	275	36,5	550	73,0	1050	139,3	1550	205,6	2050	271,9	2550	338,2	3050	404,6	3550	470,9	4050	537,2	4550	603,5	5050	669,8
30	4,0	280	37,1	560	74,3	1060	140,6	1560	206,9	2060	273,2	2560	339,6	3060	405,9	3560	472,2	4060	538,5	4560	604,8	5060	671,2
35	4,6	285	37,8	570	75,6	1070	141,9	1570	208,2	2070	274,6	2570	340,9	3070	407,2	3570	473,5	4070	539,8	4570	606,2	5070	672,5
40	5,3	290	38,5	580	76,9	1080	143,3	1580	209,6	2080	275,9	2580	342,2	3080	408,5	3580	474,9	4080	541,2	4580	607,5	5080	673,8
45	6,0	295	39,1	590	78,3	1090	144,6	1590	210,9	2090	277,2	2590	343,5	3090	409,9	3590	476,2	4090	542,5	4590	608,8	5090	675,1
50	6,6	300	39,8	600	79,6	1100	145,9	1600	212,2	2100	278,5	2600	344,9	3100	411,2	3600	477,5	4100	543,8	4600	610,1	5100	676,5
55	7,3	305	40,5	610	80,9	1110	147,2	1610	213,6	2110	279,9	2610	346,2	3110	412,5	3610	478,8	4110	545,2	4610	611,5	5110	677,8
60	8,0	310	41,1	620	82,2	1120	148,6	1620	214,9	2120	281,2	2620	347,5	3120	413,8	3620	480,2	4120	546,5	4620	612,8	5120	679,1
65	8,6	315	41,8	630	83,6	1130	149,9	1630	216,2	2130	282,5	2630	348,8	3130	415,2	3630	481,5	4130	547,8	4630	614,1	5130	680,4
70	9,3	320	42,4	640	84,9	1140	151,2	1640	217,5	2140	283,9	2640	350,2	3140	416,5	3640	482,8	4140	549,1	4640	615,5	5140	681,8
75	9,9	325	43,1	650	86,2	1150	152,5	1650	218,9	2150	285,2	2650	351,5	3150	417,8	3650	484,1	4150	550,5	4650	616,8	5150	683,1
80	10,6	330	43,8	660	87,5	1160	153,9	1660	220,2	2160	286,5	2660	352,8	3160	419,1	3660	485,5	4160	551,8	4660	618,1	5160	684,4
85	11,3	335	44,4	670	88,9	1170	155,2	1670	221,5	2170	287,8	2670	354,2	3170	420,5	3670	486,8	4170	553,1	4670	619,4	5170	685,8
90	11,9	340	45,1	680	90,2	1180	156,5	1680	222,8	2180	289,2	2680	355,5	3180	421,8	3680	488,1	4180	554,4	4680	620,8	5180	687,1
95	12,6	345	45,8	690	91,5	1190	157,8	1690	224,2	2190	290,5	2690	356,8	3190	423,1	3690	489,4	4190	555,8	4690	622,1	5190	688,4
100	13,3	350	46,4	700	92,8	1200	159,2	1700	225,5	2200	291,8	2700	358,1	3200	424,5	3700	490,8	4200	557,1	4700	623,4	5200	689,7
105	13,9	355	47,1	710	94,2	1210	160,5	1710	226,8	2210	293,1	2710	359,5	3210	425,8	3710	492,1	4210	558,4	4710	624,7	5210	691,1
110	14,6	360	47,8	720	95,5	1220	161,8	1720	228,1	2220	294,5	2720	360,8	3220	427,1	3720	493,4	4220	559,7	4720	626,1	5220	692,4
115	15,3	365	48,4	730	96,8	1230	163,1	1730	229,5	2230	295,8	2730	362,1	3230	428,4	3730	494,8	4230	561,1	4730	627,4	5230	693,7
120	15,9	370	49,1	740	98,2	1240	164,5	1740	230,8	2240	297,1	2740	363,4	3240	429,8	3740	496,1	4240	562,4	4740	628,7	5240	695,0
125	16,6	375	49,7	750	99,5	1250	165,8	1750	232,1	2250	298,4	2750	364,8	3250	431,1	3750	497,4	4250	563,7	4750	630,0	5250	696,4
130	17,2	380	50,4	760	100,8	1260	167,1	1760	233,4	2260	299,8	2760	366,1	3260	432,4	3760	498,7	4260	565,1	4760	631,4	5260	697,7
135	17,9	385	51,1	770	102,1	1270	168,5	1770	234,8	2270	301,1	2770	367,4	3270	433,7	3770	500,1	4270	566,4	4770	632,7	5270	699,0
140	18,6	390	51,7	780	103,5	1280	169,8	1780	236,1	2280	302,4	2780	368,7	3280	435,1	3780	501,4	4280	567,7	4780	634,0	5280	700,3
145	19,2	395	52,4	790	104,8	1290	171,1	1790	237,4	2290	303,7	2790	370,1	3290	436,4	3790	502,7	4290	569,0	4790	635,4	5290	701,7
150	19,9	400	53,1	800	106,1	1300	172,4	1800	238,8	2300	305,1	2800	371,4	3300	437,7	3800	504,0	4300	570,4	4800	636,7	5300	703,0
155	20,6	405	53,7	810	107,4	1310	173,8	1810	240,1	2310	306,4	2810	372,7	3310	439,0	3810	505,4	4310	571,7	4810	638,0	5310	704,3
160	21,2	410	54,4	820	108,8	1320	175,1	1820	241,4	2320	307,7	2820	374,0	3320	440,4	3820	506,7	4320	573,0	4820	639,3	5320	705,7
165	21,9	415	55,0	830	110,1	1330	176,4	1830	242,7	2330	309,1	2830	375,4	3330	441,7	3830	508,0	4330	574,3	4830	640,7	5330	707,0
170	22,5	420	55,7	840	111,4	1340	177,7	1840	244,1	2340	310,4	2840	376,7	3340	443,0	3840	509,3	4340	575,7	4840	642,0	5340	708,3
175	23,2	425	56,4	850	112,7	1350	179,1	1850	245,4	2350	311,7	2850	378,0	3350	444,3	3850	510,7	4350	577,0	4850	643,3	5350	709,6
180	23,9	430	57,0	860	114,1	1360	180,4	1860	246,7	2360	313,0	2860	379,4	3360	445,7	3860	512,0	4360	578,3	4860	644,6	5360	711,0
185	24,5	435	57,7	870	115,4	1370	181,7	1870	248,0	2370	314,4	2870	380,7	3370	447,0	3870	513,3	4370	579,6	4870	646,0	5370	712,3
190	25,2	440	58,4	880	116,7	1380	183,0	1880	249,4	2380	315,7	2880	382,0	3380	448,3	3880	514,6	4380	581,0	4880	647,3	5380	713,6
195	25,9	445	59,0	890	118,1	1390	184,4	1890	250,7	2390	317,0	2890	383,3	3390	449,7	3890	516,0	4390	582,3	4890	648,6	5390	714,9
200	26,5	450	59,7	900	119,4	1400	185,7	1900	252,0	2400	318,3	2900	384,7	3400	451,0	3900	517,3	4400	583,6	4900	649,9	5400	716,3
205	27,2	455	60,4	910	120,7	1410	187,0	1910	253,3	2410	319,7	2910	386,0	3410	452,3	3910	518,6	4410	584,9	4910	651,3	5410	717,6
210	27,9	460	61,0	920	122,0	1420	188,4	1920	254,7	2420	321,0	2920	387,3	3420	453,6	3920	520,0	4420	586,3	4920	652,6	5420	718,9
215	28,5	465	61,7	930	123,4	1430	189,7	1930	256,0	2430	322,3	2930	388,6	3430	455,0	3930	521,3	4430	587,6	4930	653,9	5430	720,2
220	29,2	470	62,3	940	124,7	1440	191,0	1940	257,3	2440	323,6	2940	390,0	3440	456,3	3940	522,6	4440	588,9	4940	655,2	5440	721,6
225	29,8	475	63,0	950	126,0	1450	192,3	1950	258,7	2450	325,0	2950	391,3	3450	457,6	3950	523,9	4450	590,3	4950	656,6	5450	722,9
230	30,5	480	63,7	960	127,3	1460	193,7	1960	260,0	2460	326,3	2960	392,6	3460	458,9	3960	525,3	4460	591,6	4960	657,9	5460	724,2
235	31,2	485	64,3	970	128,7	1470	195,0	1970	261,3	2470	327,6	2970	393,9	3470	460,3	3970	526,6	4470	592,9	4970	659,2	5470	725,5
240	31,8	490	65,0	980	130,0	1480	196,3	1980	262,6	2480	328,9	2980	395,3	3480	461,6	3980	527,9	4480	594,2	4980	660,6	5480	726,9
245	32,5	495	65,7	990	131,3	1490	197,6	1990	264,0	2490	330,3	2990	396,6	3490	462,9	3990	529,2	4490	595,6	4990	661,9	5490	728,2
250	33,2	500	66,3	1000	132,6	1500	199,0	2000	265,3	2500	331,6	3000	397,9	3500	464,2	4000	530,6	4500	596,9	5000	663,2	5500	729,5

Appendix 5 CE declaration of conformity

CE Declaration of conformity

The undersigned, representing the manufacturer:

Royal Eijkelkamp
Nijverheidsstraat 9
6987 EN Giesbeek
The Netherlands

Herewith declare that the products:

Type: **Compression test apparatus**
Art.nr.: 0867
Function: Measuring soil compression strength and simultaneous measuring of soil suction and displacement

And

Type: **Shear strength test apparatus**
Art.nr.: 0868
Function: Measuring soil shear strength under compression and simultaneous measuring of soil suction and displacement

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is in conformity with the essential requirements of the following EC Directive(s) when installed in accordance with the installation instructions contained in the product documentation:

2006/42/EC Machinery Directive
2004/108/EC EMC Directive

2002/96/EC Waste Electrical and Electronic Equipment (WEEE)
2002/95/EC RoHS Directive

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and that the standards and/or technical specifications referenced below have been applied:

NEN-EN-ISO12100-1: 2003 Safety of machinery – Basic concepts, general principles for design – Part 1&2
NEN-EN 983: 1996+A1:2008 Safety of machinery: Pneumatics

EN 61000-6-1- Generic immunity standard
EN 61000-6-2- Generic emission standard

Giesbeek,

Manufacturer:

Signature

Huug Eijkelkamp
CEO