09.03 Hauben water permeameter

Operating instructions

Contents

All it takes for environmental research

Eijkelkamp Agrisearch Equipment
a Royal Eijkelkamp Company

P.O. Box 4, 6987 ZG Giesbeek,
The Netherlands
T +31 313 88 02 00 **E** info@eijkelkamp.com
F +31 313 88 02 99 **I** www.eijkelkamp.com

On 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.**

General safety precautions

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

⚠

- **This apparatus is for research applications only and needs to be operated by qualified operators.**
- **Other use then intended purposes should be avoided.**
- **Take care for personal hygiene and environmental precautions in case of operating contaminated samples.**
- **Apparatus is rated for indoor lab locations only.**
- **Servicing should be performed by Eijkelkamp trained QUALIFIED PERSONEL ONLY!**
- **Only original spare parts supplied by Eijkelkamp are allowed to service.**

1. Product Description

1.1 Introduction

The Hauben water permeameter apparatus is a laboratory test method to establish the coefficient of permeability or hydrologic conductance of water (vertically) through an undisturbed water saturated soil sample. The method is suitable for fine-grained soil, especially silt and clay. The principle of the measurement is based on the 'Falling Head Method'.
The saturated soil samples (especially silt and clay) are placed in the sample container filled with a constant head of water. The sample holder is placed over the core ring and is tight fixed around de sample ring by an inflatable rubber seal. The water filled burette is selected and it is emptied trough the sample using the falling head method, so the water will flow through the sample with a certain speed per unit time. A triple time measurement during falling head is used to calculate the permeability (k) according to Darcy's law.

The falling head method is suitable for soils with water permeability smaller than $1x10^{-3}$ cm/s (like fine sand; silt; sandy clay). Indicative; more than 10% (mass percentage) of the soil particles needs to have a diameter smaller than 0,063 mm.

This equipment measures the soil water permeability in accordance to NEN 5124, EN17892-11 and ASTM D5084 – 10 Laboratory determination of permeability of soil by the falling head method considering the following restrictions:

- No physical sample load restricting sample swelling
- Falling head height max 300 mm
- Scale interval reading 5 mm
- Please consult instrument specification for detailed information in case of accreditation

Soil water permeability is the property of the soil pore system that allows fluid to flow through. Generally the pore sizes and their connectivity determine whether a soil has high or low permeability. Water will flow easily through soil with large pores with good connectivity between them. Small pores with the same degree of connectivity would have lower permeability, because water would flow through the soil more slowly.

In many land use systems all over the world soil deformation is a major problem due to increasing land use intensity. Altered soil functions, in particular reduced hydraulic conductivities and impeded aeration, may decrease crop growth and productivity as well as the filtering and buffering capacity of soils. A commonly applied method for the influence of compaction on permeability is the determination of the hydrologic permeability before and after static loading in oedometer tests.

1.2 Applications

- Erosion, drainage, irrigation;
- Agriculture research;
- Geo-hydrologic research;
- Environmental research;
- Basic material research.

1.3 User groups

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

1.4 Features

- Easy manual operation;
- Proven accurate measurement principle;
- Efficient multi sample handling using the fast exchange sample holder;
- Excellent price quality ratio;
- Developed in cooperation with Christian Albrechts University Kiel.

2. Technical specifications

Supply container volume	:	~ 3 Litre
Burette height	:	300 mm
Burette scale interval	:	5 mm
Burette 1	:	Ø =5 mm (inner diameter)
Burette 2	:	Ø =4 mm (inner diameter)
Burette 3	:	Ø =3 mm (inner diameter)
Core ring size (standard)	:	Ø = 60x56 mm h= 40.5 mm (sample size Ø 56 h 40.5 mm; A= 2463 mm^2)
Core ring size (optional)	:	Ø = 53x50 mm h= 51mm (sample size Ø 50 h 51mm; A= 1963.5 mm^2)

Environmental conditions

Operating temperature	:	15-35 °C (constant temperature is highly recommended)	
Dimensions	:	instrument	30 x 25 x 90 cm (width x depth x height)
		sample container	61 x 40 x 23 cm (15 samples)
Weight	:	approx. 19 kg. (all-in)	

Eijkelkamp explicit informs you that these instructions are only for indicative purpose. Specifications can be changed without notice and no rights whatever can be claimed.

3. (Schematic) construction

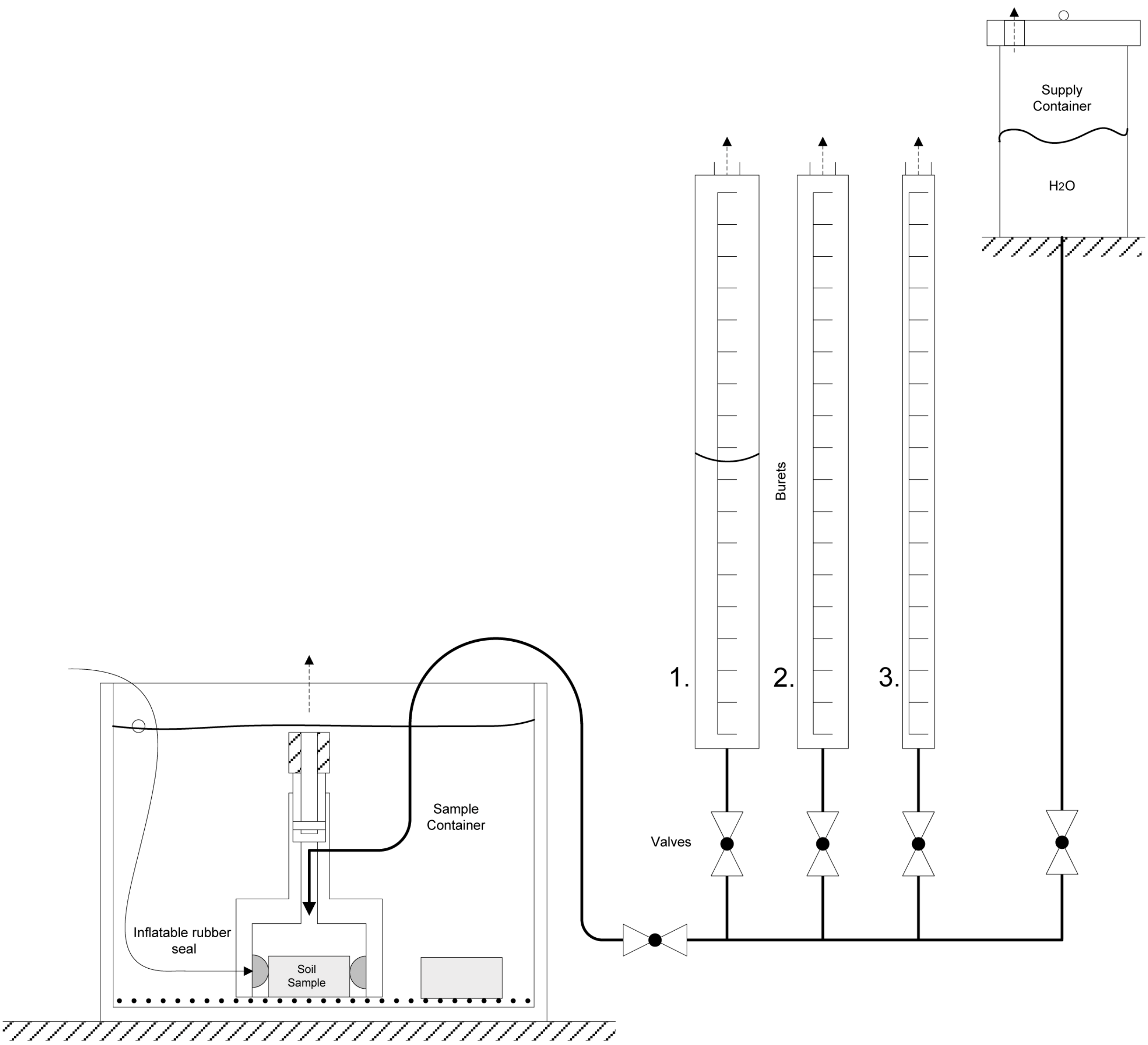


Fig. 2: Principle of apparatus to measure the water permeability of undisturbed soil samples.

4. Unpacking

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

Table 1: part list.

Hauben water permeameter, lab.		***09.03***	
Quantity:	*Description:*	*art. no.:*	
1	Sample holder 53/60mm Hauben permeameter	H279935	
	Venting-pin	H700603	(mounted)
	O-ring	H222585	(mounted)
1	Sample container Hauben permeameter	H279938	
2	Cover water supply reservoir	H700621	(mounted)
1	Pressure/ vacuum pump set	H254858	
1	Stainless steel welded wire mesh	H105695	
1	Filter paper diameter 90mm, 100 pieces	H105840	
1	Stopwatch (professional)	PD08856	
1 m	Tube (transparent; blue) 6mm	H103795	(mounted)
1 m	Tube (transparent; blue) 8mm	H103800	(mounted)
2 m	Tube (clear) …mm (overflow hose)	H102545	
1	Dummy block 60mm	H700693	

⚠ **Use only original Eijkelkamp spare parts !**

5. Installation

5.1 Placement of the apparatus

- Make sure that you place the apparatus in a clean; vibration free and non direct sunlight surrounding for best operational performance and measurement results. The apparatus should be well accessible from the operating front.

⚠ **Testing shall be carried out at approximately constant ambient temperature (±2 °C). The temperature of the specimen and water shall be in equilibrium.**

- Adjust the table surface height and levelness for ergonomic purposes. There are four adjusting screws underneath the frame.
  (Consider the water level of the sample container has to be equal to the zero level of the burettes. After filling the sample container and system of the apparatus, this level can be checked.)
- Install the sample container at the left side of the apparatus (for right-handed people) or vice versa.
- Connect the overflow-hose to the sample container by pushing the hose over the hose coupling.
- Use a bucket to catch the drain water from the overflow-hose.
- Put the welded stainless steel mesh to the bottom of the sample container.

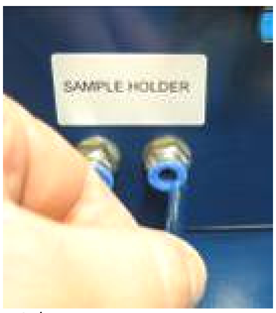
5.2 Connecting sample holder and hand pump:

- Sample holder:
  a) Push the transparent 8 mm tube (water supply) into the upper 'one touch' fitting of the sample holder and pull the tube a little to fix it (fig. 3a).
  b) Also connect the 6 mm tube (air supply) into the lower 'one touch' fitting of the sample holder, the same way like a). See fig. 3b.
  c) The apparatus has two fittings on the left side of the frame to mount the sample holder. The left fitting is to connect the 8mm tube for water supply. The right fitting is to connect the 6mm tube for air supply (fig. 3d).
- Pump:
  The apparatus has one fitting on the right side of the frame. Connect the hand pump with an 8mm tube (fig. 3e) to this fitting.


3a


3b


3c



3d

3e


3f

Fig. 3: Connecting sample holder and hand pump.

5.3 Filling the system

Be sure all ball valves are closed (horizontal position; turning CW).

- Fill the system using clean demineralised de-aerated water preventing e.g. algae built up inside the system. An anti-bacterial addition can be added to the water e.g. Aqua-Stabil (supplied by Julabo labortechnik GmbH). Normally this kind of addition has an indicating colour; this will make the readability of the water levels much easier.

Using contaminated water to fill the system will damage the instrument because of obstruction; corrosion; etc. This will void the warranty!

The covers of the two water supply containers have to be removed to fill the containers fig. 4. For about 1.5 litre is needed for each container.

Fig. 4: Filling the water supply container.

- Normally the sample container is partly filled during the sample preparation with standard tap water (USING DE-AERATED WATER IS PREFERRED!). See Appendix 1; sample preparation.
- Before starting the measurements, the sample container has to be filled until the overflow starts to work (USING DE-AERATED WATER IS PREFERRED!). This is zero-level! The zero level of the burettes has to be equal to this level. The adjusting screws underneath the frame of the apparatus can be used to realise this.

6. Checking the apparatus

Before measurements can be performed the instrument and functionality must be checked. For detailed information see appendix 2.

7. Operation of the apparatus

Before starting the measurement, the lab sample(s) and apparatus need to be prepared.

7.1 Lab sample preparation

☞ **Prevent transport of the sample container during and after sample preparation! Always try to prepare your samples on the same place your measurements will take place.**

- 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 be kept in original condition and smearing of the surface is prevented.
- Place e.g. filter papers on top of the welded stainless steel mesh (on the bottom of the water container) or cover the sample bottom with suitable screen gauze or cloth barrier to retain the soil in the core.

  In case of using porous filter plates (e.g. glass beads; sintered phosphor bronze); their permeability should be checked at regular intervals. The permeability of the filter block shall be at least 10 times bigger than the permeability of the sample so that the head loss across it will be negligible compared to that across the soil core.
  The filter plates shall be completely saturated by de-aired water.

- Place the soil samples on the different filter papers (sharp edge of core ring towards filter paper) or with the cloth-covered end down, in the white sample container.
- Fill the sample container slowly (e.g. by use of a hose and clear de-aerated water) for about 1 cm underneath the upper edge of the core rings. So the samples are able to soak.

☞ **As far as possible, water similar in type to the pore water shall be used, de-aired tap water generally being adequate.**

- Saturating will take for about 1-2 days, depending on the kind of soil. This time can be shortened by using tools like an excicator. Using a vacuum also reduces the chance of dissolved air. Air dissolved in the water passing through the specimen may be retained in the specimen and thus reduce the latter's permeability.

☞ **For partly saturated soil, the coefficient of permeability is always smaller than for fully water-saturated soil due to turbulence caused by air voids and non-function of capillary action.**

The soaking procedure described above to wet the samples will normally not completely saturate them. Air will be trapped in the pores and will tend to disappear slowly as de-aerated water is passed through the sample. The degree of saturation obtained can be estimated by comparing the volumetric water content with the total porosity calculated from the bulk and particle densities.
The degree of saturation obtained by soaking may be representative of that obtained in situ when a soil is flooded with water and may be called 'natural saturation'. The term satiated has also been used for this state of wetting. If the conductivity at total saturation is desired, a vacuum wetting procedure may be employed.

7.2 Using the sample holder

The sample holder seals the sample ring by an inflatable ring. So all water is forced to flow through the soil during the measurement.
A venting system is applied at the highest point of the sample chamber to release air before the measurement.

☞ **To pressurize or evacuate the inflatable seal a multifunctional hand pump is delivered.**

To pressurize or evacuate the inflatable seal a hand pump is delivered. First to pressurize the inflatable seal to seal the core ring; second to evacuate the inflatable seal before and during placement of the sample holder or during removing.
Sometimes the seal will stick to your core ring so evacuating will help to remove.
Place the sample holder carefully on the sample; to prevent soil parts contaminating the water.

Using the hand pump with sample holder

Never connect the hand pump directly to your sample holder or pressurize the inflatable seal without installed core ring; to prevent damage of the inflatable seal.

5a.

5b.

5c.

5d.

Fig. 5: Pressurizing/ evacuating by the hand pump.

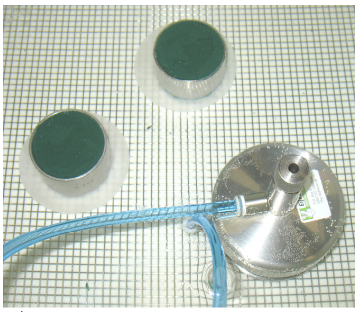
a) Be sure the hand pump and sample holder are correctly connected to the apparatus (see chapter 5; placement of the apparatus).

b) The hand pump has two positions; 'IN' and 'OUT'. To switch between these two positions, the serrated front has to be turned.
The 'IN'-position is used to evacuate the seal during placement of the sample holder around the core ring or during removal (see fig. 5a/b).

c) The 'OUT'-position is used to pressurize the sealing ALWAYS AFTER placement of the sample holder around the core ring (see fig. 5c/d). To prevent damage caused by overpressure, an overpressure valve is used. The maximum permitted pressure is for about 0,8 bar.

7.3 Filling the sample container

6a.



6b.

6c.

Fig. 6: Various steps for preparation of the sample container.

Make sure the core rings and inflatable rubber seal are not damaged, otherwise leaks will be inevitable and the measurement will be disturbed.

☞ **The complete sample holder and mesh are produced of stainless steel. So no corrosion will take place in case of salty or contaminated samples.**

a) Open the venting pin of the sample holder by turning it CCW (fig. 6a).
b) Carefully place the sample holder into the sample container beside the prepared water saturated soil samples (fig. 6b).
c) Before starting the measurement; fill the sample container slowly until the overflow point starts to work (fig. 6c).
d) Wait until the system is stabilised.

7.4 Levelling and set at zero

After filling the sample container the water level in the burettes has to be levelled and set to zero.

Procedure:

- The sample holder is without sample; the venting pin is opened.
- Check the burettes; they have to be free of enclosed air between little heads of water (fig. 7a). As soon as there is enclosed air, open the ball valve of the burette and play with the main valve (by quick opening and closing).

Fig. 7a: Enclosed air bubbles.

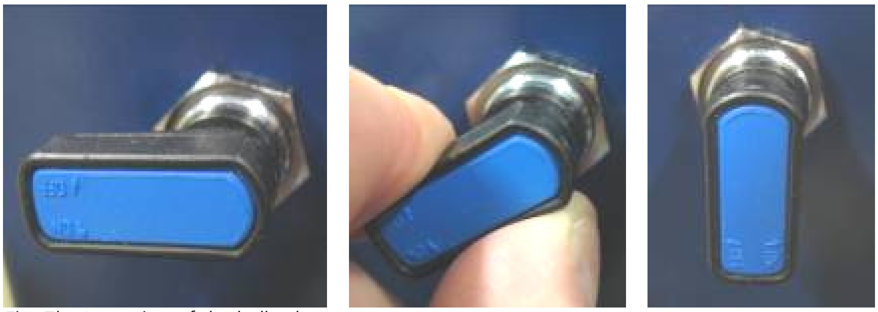
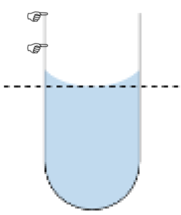


Fig. 7b: Operation of the ball valves.

Turn the main valve CCW to open and fill the system to above the enclosed air and turn the main valve CW to close it, so the water level will drop (fig. 7b). Play with the water level until the enclosed air is disappeared.

☞ **Sometimes it seems there's no flow of water inside the burettes. The reason for this can be inclusion of air inside the water column.**

- Open the valves of each burette.
- Slowly open the main valve of the water supply and fill the burettes (e.g. approximately 10 cmH_2O). As soon as the water level is at required level, the main valve has to be closed again.
- After closing the main valve, the water level will drop. Around zero level, the water level will drop very slowly so wait for about 5 minutes.
- After the water level in each of the burettes has dropped completely, all three levels have to be in line and needs to have the same deviation in relation to e.g. zero level. If this isn't the case, chance the level and height of the instrument by turning the adjusting screws underneath the frame (fig. 8).



☞ **Always read the burettes the same way so you can make a reliable comparison between different measured values.**

Fig. 8a: Not adjusted water level

Fig. 8b: Adjusted water level.

- After levelling the burettes, close all ball valves.

7.5 Venting the system and placement of the sample holder

Venting the system

a) Be sure the venting pin of the sample holder is still opened (turning CCW).
b) Be sure the sample holder is placed beside one of the saturated soil samples.

⚠ **Don’t place the sample holder around one of the core rings yet!**

1. Open the main ball valve to remove air out of the system.
2. Close the main ball valve (turn CW; horizontal position) as soon as there aren’t air bubbles anymore.

Placement of the sample holder

1. Evacuate the inflatable seal (chapter 7.1).
2. Carefully take the sample holder with two hands using the thumb and fingertips (fig. 9).

⚠ **Displace the de-aerated sample holder underneath the water level of the sample container to prevent air is coming into the system.**

3. Put the sample holder carefully around one of core rings with prepared soil sample (fig. 9).

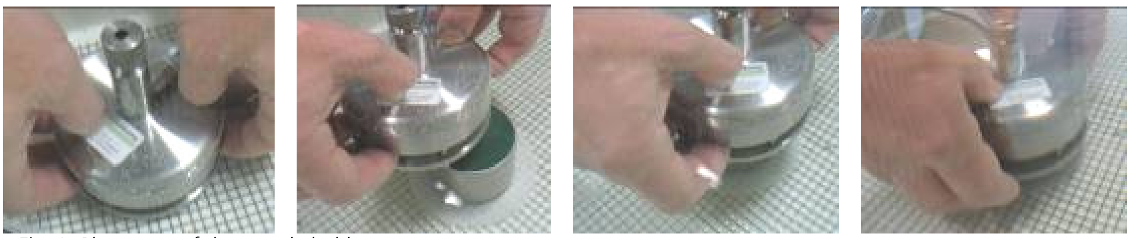


Fig. 9: Placement of the sample holder.

4. Pressurize the inflatable seal while venting pin is still opened (chapter 7.1).

8. Starting the measurement

After placement of the sample holder around one of the core rings and pre-filling the system the measurement can be started.

⚠ **Testing shall be carried out at approximately constant ambient temperature (±2 °C). The temperature of the specimen and water shall be in equilibrium.**
The quantity of water flowing through the specimen shall be measured at steady-state flow conditions.

a) Use a laboratory data sheet for sample identification noting the measurements; etc. (sample of form; see Appendix 4).
b) Check the water temperature into the sample container and the water supply container (maximum inaccuracy 1.0 °C); using a thermometer (maximum inaccuracy 0.5 °C).
In case of very impermeable soil, water flowing through the sample will take a long time. In this case the water temperature has to be measured at regular intervals. The arithmetic mean of the different temperatures has to be calculated to a round value of 1 °C.

☞ **Check the pressure of the inflatable seal daily, during a long-term measurement. The pressure needs to stay between 0.6-0.8 bar.**

c) All parts of the apparatus contacting the water have to be completely water filled and free of air.
d) Choose one of the burettes and open the concerned valve.

Left burette: internal diameter 5 mm.
Middle burette: internal diameter 4 mm.
Right burette: internal diameter 3 mm.

☞ **Burette choice depends on the kind of soil sample. Choose a burette with small internal diameter for nearly impermeable samples. If the decline in water level goes too fast for accurate measurement, choose a burette with larger internal diameter.**

e) Slowly open the main valve and fill the chosen burette to a certain level, e.g. 30 cmH_2O. As soon as the desired level is reached, close the valve of the chosen burette.
The main valve needs to be closed as soon as the overflow point of the sample container starts to work.

☞ **If the water level in one of the burettes becomes too high, the water will be drained into the water supply container at the backside of the apparatus.**
At low permeable samples, the decline in water level goes very slow. If the water level is too high (above scale level) after filling, the level can be lowered by slowly opening the valve of one of the other burettes with lower water level.

f) Stopwatch:
The stopwatch needs to have the opportunity for measuring lap/ split times.
Select the stopwatch function and (re)set the stopwatch to zero (operating instructions; see Appendix 6).
g) Note the starting point and the measurement intervals.

☞ **Depending on the permeability of the soil, the water will flow rather fast or slow. Normally a minimum descent of 50 mm during the measurement period is practically accurate enough. Starting e.g. at 30 cmH_2O, measurements can be done from 25-20; 20-15; 15-10 cm. The first few centimetres (30-25 cm) are necessary to fully open the burette-valve and starting the stopwatch.**

h) To start the measurement; fully open the ball valve (CCW) of the selected burette and start the stopwatch.
i) Register the different water levels and points of time. A minimum of three measurements is required!

☞ **Always read the burettes the same way so you can make a reliable comparison between different measured values. See chapter 7.3.**

⚠ **Avoid movement of the sampleholder, the waterhoses and/or apparatus during measurements as this will lead to fluctuations of the waterlevel in the burette.**

j) Compare the three measurements. The difference in amount of water flowing through per unit time, between two consecutive registrations, may not exceed 10%.

☞ **The arithmetic mean of the records for the amount of water passed through has to be determined, rounded to 10 mm^3.**

9. Theory of operation

The measured values can be entered into a permeameter spreadsheet performing automatically the permeability calculation using Darcy's law.

The falling head method is suitable for soils with water permeability smaller than $1x10^{-3}$ cm/s (like fine sand; silt; sandy clay; see fig.1). Indicative; more than 10% (mass percentage) of the soil particles needs to have a diameter smaller than 0,063mm.

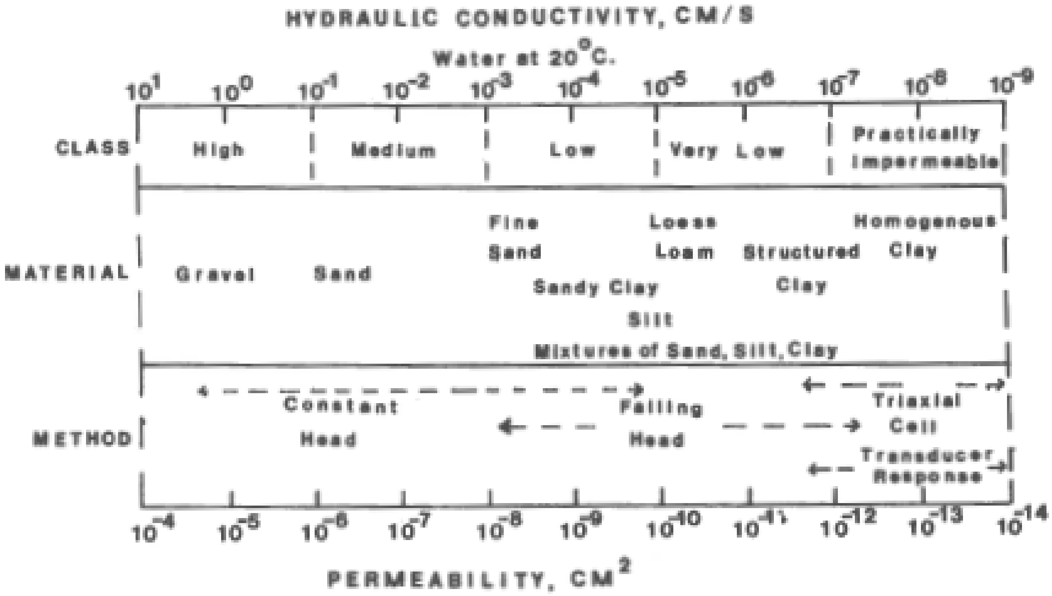
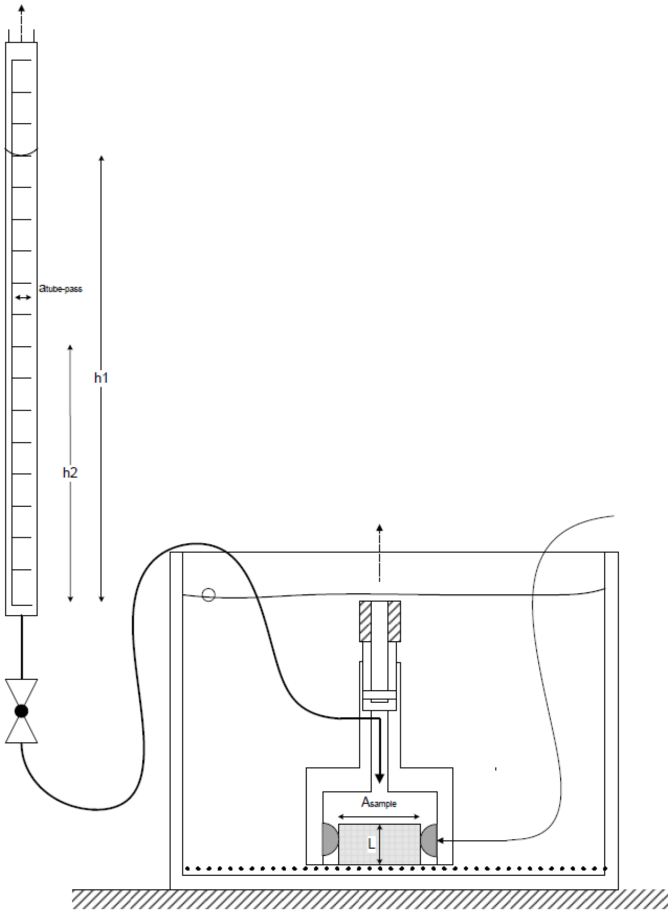


Fig. 1: Hydraulic conductivity of various materials at saturation ('Methods of Soil Analysis'; Part1')

The method of calculation of the permeability is based in accordance with Darcy's law for laminar flow.

Darcy's law (for laminar flow) is a simple proportional relationship between the instantaneous discharge rate through a porous medium, the viscosity of the fluid and the pressure drop over a given distance.

☞ **The flow behaviour of coarse-grained soil deviates from laminar flow as described by Darcy's law, if the hydraulic gradient exceeds a certain level, i.e. the discharge velocity increases non-linearly with increasing hydraulic gradient due to the influence of inertial forces. For fine-grained soil the discharge velocity decreases non-linearly with decreasing hydraulic gradient when passing a certain lower level.**



A graph of change of head (ln *h*1/*h*2) versus time shall be made.

The coefficient of permeability (*k; cm/s)* shall be determined from the linear part of the curve by equation:

$$k = \frac{a \times l}{A \times t} \times \ln \frac{h_1}{h_2}$$

Where:
a is the cross-sectional area of the piezometric tube (cm^2);
l is the specimen height during the test (cm);
A is the cross-sectional area of the specimen (cm^2);
t is the interval between measurements (s);
h_1 is piezometric head at the start of the selected interval (cm) (see note);
h_2 is the piezometric head at the end of the selected interval (cm) (see note).

NOTE h_1 and h_2 are measured with reference to the outlet head. Always calculate with cumulative values relative to h_1.

To obtain reproducible results, the value of *k* as determined in the test shall be converted to a reference temperature of 10 °C using the following empirical equation from Poiseuille:

$$k_{10} = \alpha \times k_T$$

$$\alpha = \frac{1{,}359}{1 + 0{,}0337 \times T + 0{,}00022 \times T^2}$$

Where:
T is the water temperature (°C) throughout the test;
k_T is the coefficient of permeability at ambient temperature (m/s);
α is a correction factor, to be calculated or taken from the Table (below). For intermediate values linear interpolation is allowed.

A reference temperature of 10 °C* equals the average temperature of groundwater. A different temperature may be used where required.

Table 1: correction factor to allow for the viscosity of water.

Temperature T [°C]	5	10	15	20	25
Correction factor α [–]	1,158	1,000	0,874	0,771	0,686

*) *The average soil temperature into the Netherlands, between 7m and 50m below ground level, is for about 10-12°C.*

Eijkelkamp expresses her thanks to the scientific contributions of R.Horn, S.Gebhart and J.Rostek.

C | A | U
Christian-Albrechts-Universität zu Kiel

10. Literature

- 'Methods of Soil Analysis' Part1: Physical and Mineralogical Methods; Second Edition; Editor: A. Klute.
- NEN 5124 (Dutch) Geotechnics- Laboratory determination of permeability of soil by the falling head method. December 2003.
- ISO/TS 17892-11 Geotechnical investigation and testing – Laboratory testing of soil Part 11: Determination of permeability by constant and falling head. First edition 2004-10-15.

Appendix 1: Taking soil samples

To determine the characteristic of a specific soil, *undisturbed* core samples must be collected. This is because of the major influences of both pore size distribution and soil structure on moisture retention, especially at the high matrix potentials of the operating range of suction tables.
There is no explicit prescription in literature for recommended sample sizes. Optimal sizes for core rings are determined by the size of structural elements in the soil. To obtain representative data, sample sizes should be large with respect to the size of soil aggregates, cracks, root channels or animal holes. From a practical point of view, sample diameters should not be too large as not to reduce the amount of simultaneously analysable samples, and sample height should be constrained to several centimeters; so that equilibrium conditions are reached in a reasonable period of time.
According to the Dutch NEN 5787 standard, samples with a volume between100 and 300 cm^3 are usually used for the suction tables, while samples with a height of more than 5 cm are discouraged, because the time needed to establish equilibrium will be long, and the accuracy of determination of pF-values near saturation will be low.
In the procedures for soil analyses of the International Soil Reference and Information Centre (ISRIC), sample rings with a diameter of 5 cm and a volume of 100 cm^3 are recommended, while in other publications heights of 2 or 3 cm are preferred.
Eijkelkamp Agrisearch Equipment recommends the use of a 100 cm^3 volume core ring, with an inner diameter of 56 or 50 mm (outer diameter 60 or 53 mm) and a height of 40,5 or 51 mm.
When pressing the core rings into the soil, care should be taken not to disturb the original setting of the soil and to completely fill the ring. Sampling conditions are best when the soil is approximately at field capacity. Ring holders may be used to facilitate insertion, especially in the subsoil. After insertion to the desired depth, the rings are carefully dug out (e.g. using the spatula provided with the Eijkelkamp sample ring set), at some centimeters below the ring itself. The surplus of soil is reduced to a few millimeters, trimming it carefully with a fine iron saw, and the caps are placed on the ring for protection and to minimise evaporation losses. The remaining surplus of soil will protect the sample during transport and will be removed in the laboratory, prior to analysis. Transport the core rings in a protective case.
Since soil structure and pore size distribution have significant influence on permeability, several replicate samples are needed to obtain a representative value. Depending on natural variability of the study area, three to six replicate samples per unit are advised.
In case the samples cannot be analysed on short notice, store the samples in a non freezing refrigerator to reduce microbial activity which might cause non-representative changes in soil structure.

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 (example of equipment see fig. 1); the most precise but costly method is using hydraulic sampling equipment; this is not further discussed here.

Fig. 1: Various tools for field sampling.

Field sampling (fig. 2):

- Clear and prepare the soil surface to make sure representative samples can be taken.

  ☞ *To prevent bypass of seepage between the specimen and the wall of the core ring, it's possible to use some silicone grease at the inside of the core ring. This depends on the structure of soil.*

- Place several core 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 core rings with transport caps preventing to dry out and compressing the soil sample.
- Register the core ring number and sample details.

Fig. 2: Various steps for field sampling.

Appendix 2: Calibration

Calibration
The apparatus must be calibrated for volume specification of the burette.
Fill the water supply and make sure that the temperature is in equilibrium and measure this with a thermometer

Remove the sample holder water supply tube and fit a fine drop point i.e. pipette tip. Attach an hose valve to shut off the outlet.
To fill the tubing with water without air bubbles keep the point on the tube upwards and open the main supply valve until the hose is completely filled.
Now place the tubing above a beaker on a scale.

1) Close the hose valve.
2) Fill the first burette slowly by opening the main valve and opening the burette valve just enough for slowly filling without air bubbles ca. 1 cm above the top of the burette scale.
3) Close the main supply valve and the burette valve.
4) Open the outlet hose valve.
5) Open the burette valve just enough for slowly emptying the burette until exact the top of the burette scale.
6) Tare the weighing scale on reading 0.000.
7) Open the burette valve just enough for slowly emptying the burette until exact the top of the burette scale.
8) Read the weighing and calculate the burette volume according: volume mm^3 = weight

Appendix 3: Maintenance and service

It is advised to check the apparatus periodical at least before first use and at least once a year (depending on the usage interval; check the apparatus more frequently).

Functionality check
The apparatus can be tested against any leakage, using the dummy sample-block and applying a small overpressure at the system (e.g. 30 cmH_2O).
The burette water level needs to be constant for e.g. 24 hours, otherwise there will probably be leakage.

If some leakage is detected; first check the sealing around the core ring. The pressure of the inflatable seal needs to stay constant between 0,6-0,8 bar (see manometer of hand pump).

Secondary check if there's no leakage underneath or at the backside of the apparatus, otherwise contact 'Service Department' of Eijkelkamp.

Maintenance
- Clean the instrument regularly with non abrasive materials. A soft brush and clean water can be used e.g. Always be sure the sample holder is cleaned well after use of silt/ salty/ contaminated samples.
- Check on wear out of the inflatable seal of the sample chamber.

Indication of maintenance interval scheme *

• Replace water filling, cleaning and functional testing	3 months
• Check inflatable seal sample holder	1 month
• General maintenance**	1 year
o Functionality check	
o Repair	

* The intervals are only as indication and can be adapted based on local conditions and use.
**Please consult Eijkelkamp for service contract proposals.

Spare and maintenance parts

Normally there are no spare parts needed, in case of questions please contact Eijkelkamp.

Appendix 4: Sample of laboratory data sheet.

Eijkelkamp

HYDRAULIC CONDUCTIVITY OF GRANULAR SOIL
UNDER FALLING HEAD
LABORATORY DATA SHEET

I. GENERAL INFORMATION

Tested by:	Date/time tested: *start* *end*
Lab partners/organization:	
Client:	Project:
Boring no.:	Recovery depth:
Recovery date:	Recovery method:
Soil description:	

II. TEST DETAILS

Specimen diameter, *D*:	Specimen area, *A*:
Burette area, *a*:	Specimen length, *L*:
Dry mass of soil, M_s:	Volume of soil, *V*:
Specific gravity of soil solids, G_s:	Dry unit weight, γ_d:
Void ratio, *e*:	Scale type/serial no./precision:
Saturation method:	Constant head Saturation duration: hours
Specimen preparation method:	
Notes and observations: * Room temperature (°C): * Water temperature (°C): sample container and water supply	

III. MEASUREMENTS AND CALCULATIONS

Test No. Initial Head *(H_0)*	Initial Hydraulic Gradient *(ii)*	Final Head *(H_1)*	Time *(t)*	Hydraulic Conductivity *(k)*

Appendix 5: Problem solving, tips and tricks

Q How to remove enclosed air between the water column of the burettes?
A Fill the burette(s) to above the enclosed air and open/close the ball valve of the burette(s) until enclosed air is disappeared.

Q The decline in water level goes too fast (and vice versa).
A Choose a burette with a larger diameter (and vice versa).

Q The inflatable seal of the sample-holder is damaged/ not working well.
A Contact Eijkelkamp service department.