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Geotechnical investigation and testing — Geohydraulic testing —

Part 2: Water permeability tests in a borehole using open systems

Reconnaissance et essais géotechniques — Essais géohydrauliques — Partie 2: Essais de perméabilité à l'eau dans un forage en tube ouvert

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22282-2 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, *Geotechnical investigation and testing*, in collaboration with Technical Committee ISO/TC 182, *Geotechnics*, Subcommittee SC 1, *Geotechnical investigation and testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 22282 consists of the following parts, under the general title *Geotechnical investigation and testing — Geohydraulic testing*:

- *Part 1: General rules*
- *Part 2: Water permeability tests in a borehole using open systems*
- *Part 3: Water pressure tests in rock*
- *Part 4: Pumping tests*
- *Part 5: Infiltrometer tests*
- *Part 6: Water permeability tests in a borehole using closed systems*

Geotechnical investigation and testing — Geohydraulic testing —

Part 2:
Water permeability tests in a borehole using open systems

1 Scope

This part of ISO 22282 specifies requirements for the determination of the local permeability in soils and rocks below and above groundwater level in an open hole by water permeability tests as part of the geotechnical investigation services according to EN 1997-1 and EN 1997-2.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14688-1, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description*

ISO 14689-1, *Geotechnical investigation and testing — Identification and classification of rock — Part 1: Identification and description*

ISO 22282-1: 2011, *Geotechnical investigation and testing — Geohydraulic testing — Part 1: General rules*

ISO 22475-1, *Geotechnical investigation and testing — Sampling methods and groundwater measurements — Part 1: Technical principles for execution*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22475-1 and ISO 22282-1 apply.

3.2 Symbols

For the purposes of this document, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbol	Designation	Unit
A_c	area of the inner cross-section of the casing	m^2
A_r	area of the water surface in the reservoir	m^2
D	borehole diameter, diameter of the test section	m
F	shape factor	m
h	hydraulic head of the test	m
h_1, h_2, h_3	applied hydraulic heads	m
h_o	distance of the water level from the ground level	m
Δh	change in hydraulic head	m
k	permeability coefficient	m/s
k_{fs}	field saturated permeability coefficient	m/s
L	length (height) of the test section	m
Q	flow rate	m^3/s
r	radius	–
S	storage coefficient	–
T	transmissivity	–
t_i	time needed to reach the equilibrium	s
t	time	s
t_o	time at start of test	s
$\dot{V}$	volume flow rate	

4 Test principle

The test is based on the assumption that the test section is isolated and located above or below the groundwater surface.

The results can vary depending on the test type chosen (water withdrawal or injection) according to the purpose of the test.

Three test methods are available:

a) Constant flow rate test method (suitable for k-value greater than 10^{-6} m/s)

This test consists of producing a change in hydraulic head in a section of a borehole by injecting or withdrawing a constant flow rate. The change in hydraulic head is measured against time.

b) Variable head test method (suitable for k-value between 10^{-6} m/s and 10^{-9} m/s)

This test consists of producing an instant change in hydraulic head in a section of a borehole. The change in hydraulic head is measured against time.

c) Constant head test method (suitable for k-value between 10^{-4} m/s and 10^{-7} m/s)

This test consists of maintaining a constant hydraulic head in a section of a borehole. The flow rate is measured against time.

5 Equipment

In addition to a casing or a piezometer, the following equipment is necessary:

a) water supply or plain rod for the falling head test;

b) pump or bail system for the rising head test;

c) device to determine the flow rate with an accuracy of 5 % of the measuring range for constant head and constant flow;

d) device to maintain the flow rate for constant flow;

e) perforated tube and/or filter material (for filter criteria see ISO 22282-1);

f) device to measure the water level in the casing or piezometer with an accuracy of 0,01 m;

g) a time measuring and/or recording device, reading in s.

All the equipment and measuring devices shall be calibrated according to their use, either periodically or before they are used.

6 Test procedure

6.1 Preparation of a test section

6.1.1 General

The test section shall be prepared in accordance with ISO 22282-1: 2011, Annex A.

6.1.2 Preparation of a test section in non-stable soil and rock below the groundwater surface

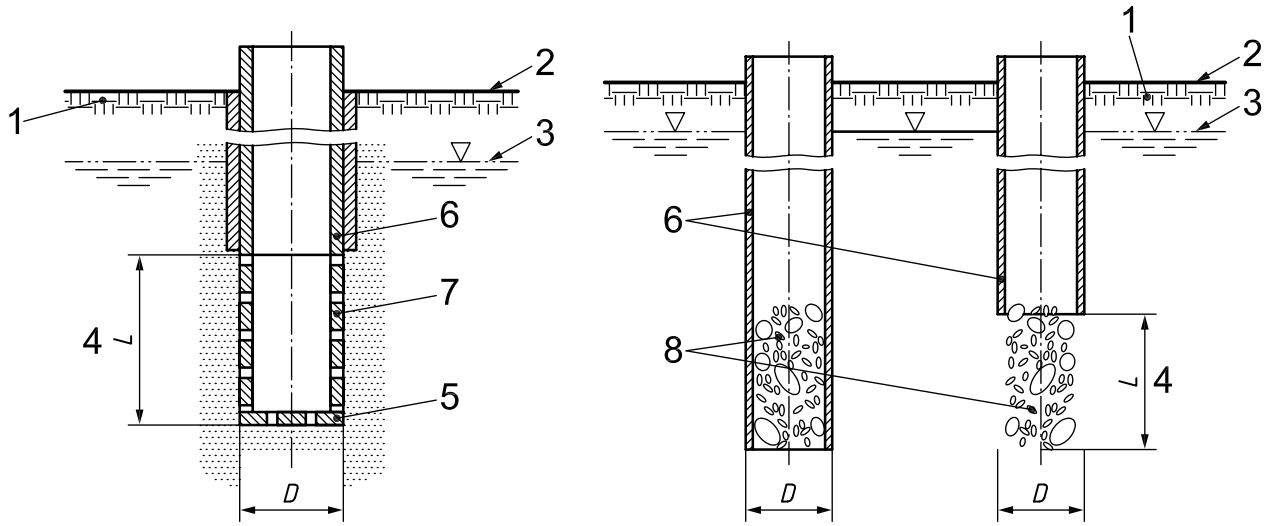
Drilling shall be executed with the use of a casing. After drilling the test section and cleaning the borehole, the test section shall be prepared according to one of these three alternatives (see Figure 1):

a) A perforated tube that is closed by a perforated or closed disc at the bottom shall be installed through the casing tube in the test section [Figure 1 a)]. After that the casing tube shall be withdrawn by the length L shortly above the upper end of the perforated section.

NOTE If the bottom of the boreholes cannot be cleaned, a full disc can be used at the bottom of the tube. In this case a specific shape factor is used (see ISO 22282-1).

b) Before withdrawing the casing tube, an appropriate filter material shall be filled into the test section. After that the casing tube shall be withdrawn up to the upper edge of the filter [Figure 1 b)].

c) Open end test: the test is performed at the bottom of the casing through the open section of diameter D [Figure 1 c)].

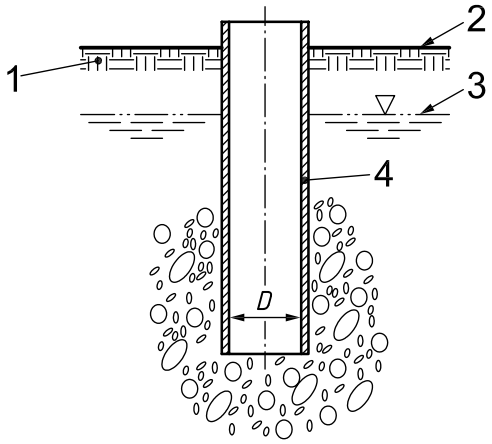


a) With perforated tube

b) With filter material

Key

1 ground
2 top surface
3 water table
4 test section
5 perforated or closed disc
6 casing
7 perforated tube
8 filter pack
L length of the test section
D diameter of the test section



c) Open end test

Key

1 ground
2 top surface
3 water table
4 casing
D diameter of the test section

Figure 1 — Test section in non-stable soil and rock

6.1.3 Preparation of a test section in stable soil and rock

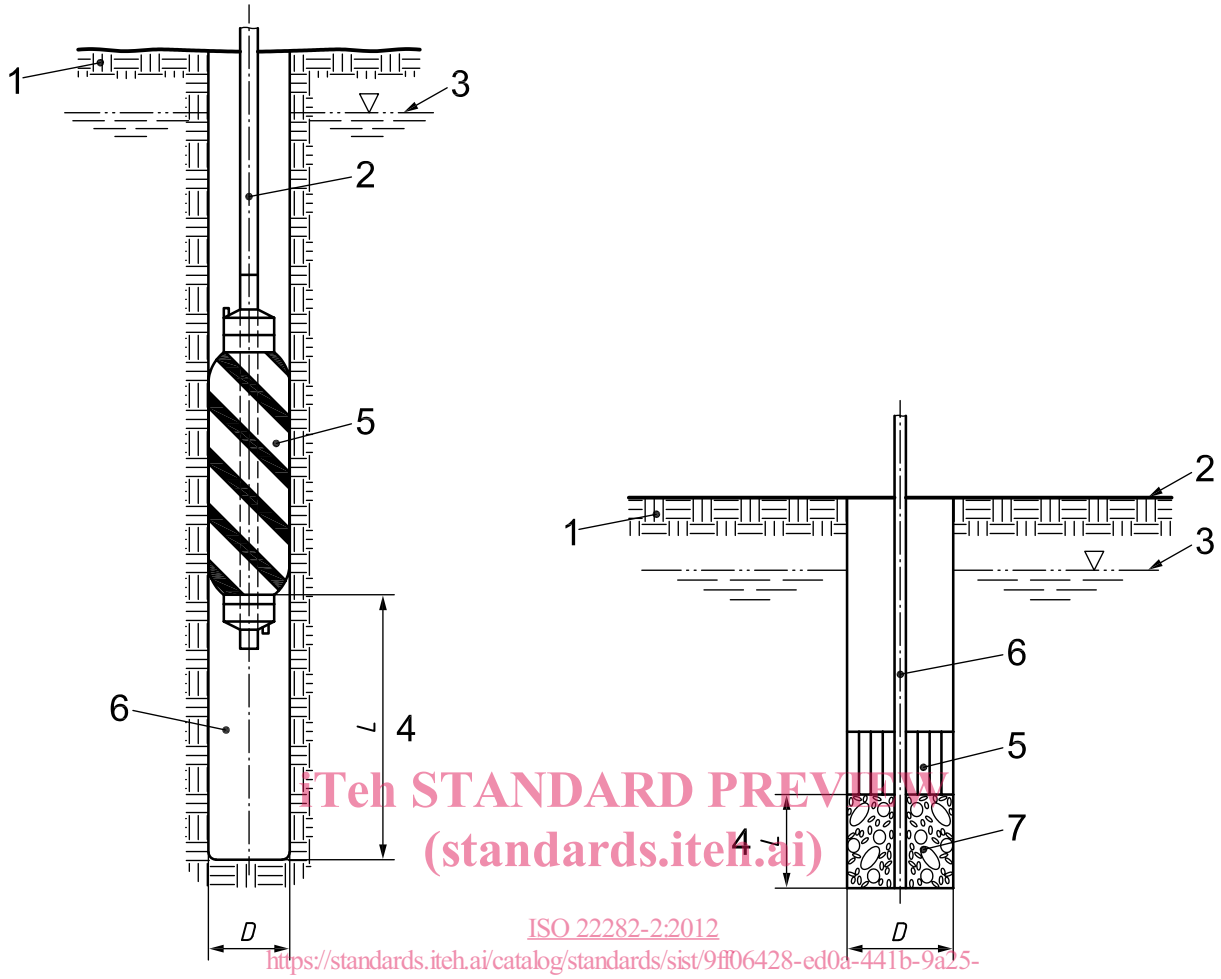
After drilling the test section and cleaning the borehole, the test section shall be prepared according to one of the following alternatives (see Figure 2):

a) A packer is inflated above the test section [Figure 2 a)]. A perforated tube can be used below the packer.

b) In a temporary open piezometer, a perforated tube shall be used in the test section. An appropriate filter material shall fill the space between the tube and the borehole wall into the test section. A sealing plug shall be installed above the filter pack [Figure 2 b)].

c) Before withdrawing the casing tube, an appropriate filter material shall be filled into the test section. After that the casing tube shall be withdrawn up to the upper edge of the test section [Figure 2 c)].

d) The same preparation as in c), but without filter material [Figure 2 d)].



a) With packer

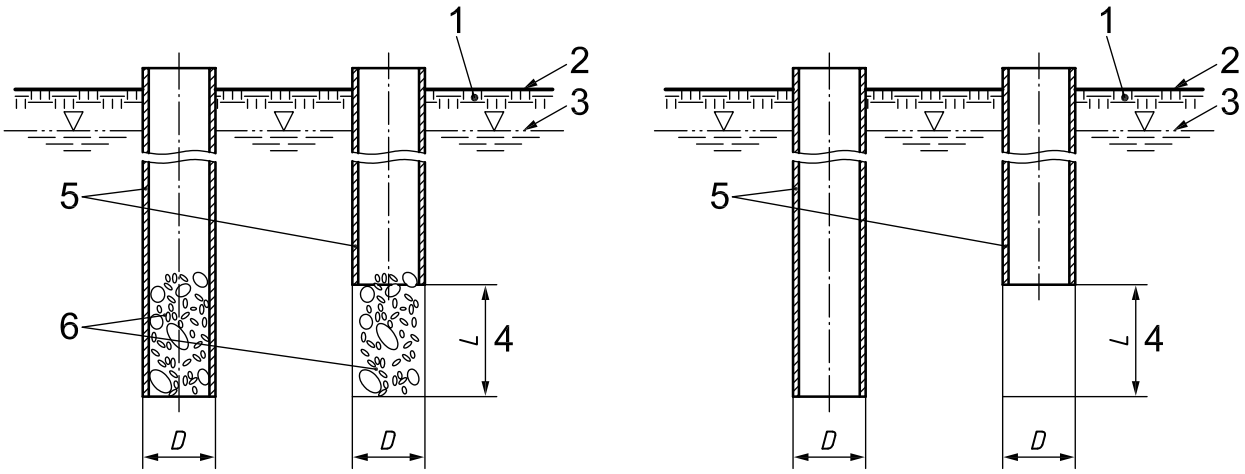
Key

1 ground
2 measuring tube
3 water table
4 test section
5 packer
6 cavity
L length of the test section
D diameter of the test section

b) Temporary piezometer

Key

1 ground
2 top surface
3 water table
4 test section
5 sealing plug
6 measuring tube
7 filter pack
L length of the test section
D diameter of the test section



c) With filter material

d) Without filter material

Key

1 ground
2 top surface
3 water table
4 test section
5 casing
6 filter material
L length of the test section
D diameter of the test section

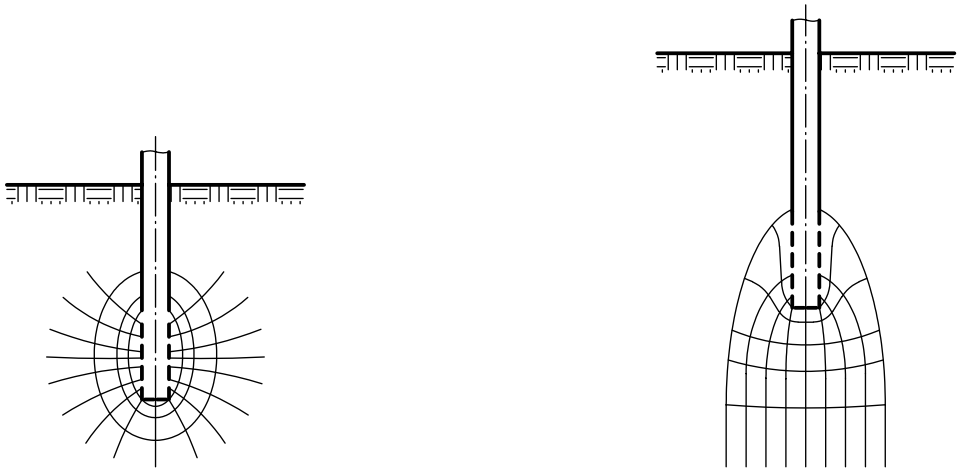
Figure 2 — Example of test section in stable soil and rock

6.1.4 Preparation of the test section in unsaturated conditions

Measurement of permeability in unsaturated soils is made by injecting water into the test section.

During infiltration created by the permeability test, a field-saturated condition develops around the test section. Full saturation does not occur due to entrapped air remaining in the soil or provided by the injected fluid. This may reduce the permeability measured in the field.

When testing unsaturated coarse soils (typically gravels and sands), the flow of water is not spherical or ellipsoidal as observed below water table in homogeneous soils (Figure 3). The flow net is affected by gravity and shall be described by specific equations such as those provided in B.5.



a) Saturated conditions

b) Unsaturated conditions

Figure 3 — Water flow in coarse soils

In low permeability soils (silts and clays) the effect of suction at the wetting front can affect the test results, particularly if the initial saturation of the soil is low. In order to avoid or limit the effect of suction, the soil around the test section should be pre-saturated prior to proper permeability measurement. This phase creates a saturated bulb around the test section wall. The equations used to compute the test data in saturated conditions may be used.

The duration of the saturation phase depends on the permeability of the soil in the test section (Figure 4). The total amount of infiltrated water during the saturation phase shall be recorded.

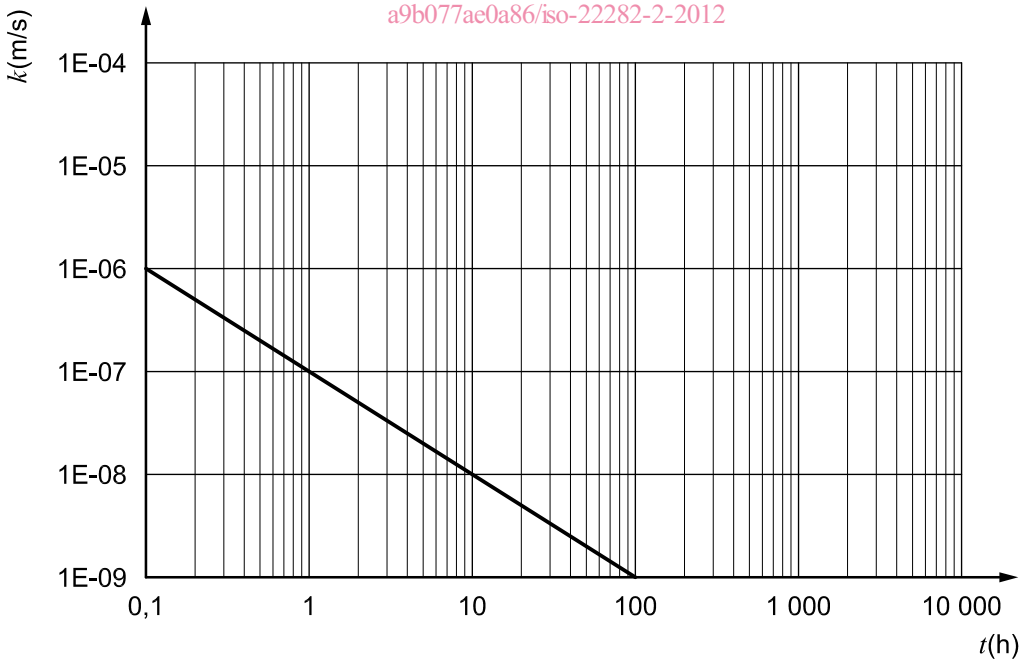


Figure 4 — Recommended duration of saturation phase