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# Geotechnical investigation and testing — Geohydraulic testing —

## Part 5: Infiltrometer tests

*Reconnaissance et essais géotechniques — Essais géohydrauliques — Partie 5: Essais d'infiltromètres*



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# Foreword

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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 22282-5 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 5: Infiltrometer tests

## 1 Scope

This part of ISO 22282 establishes requirements for ground investigations by means of infiltrometer tests as part of geotechnical investigation services in accordance with EN 1997-1 and EN 1997-2.

It applies to the *in situ* determination of the water permeability of an existing geological formation or of treated or compacted materials.

The infiltrometer test is used to determine the infiltration capacity of the ground at the surface or shallow depth. It is a simple test for determining the permeability coefficient. The method can be applied using either steady-state or transient conditions, in saturated or unsaturated soils.

The principle of the test is based on the measurement of a surface vertical flow rate of water which infiltrates the soil under the influence of a positive hydraulic head.



Surface infiltration devices include single and double-ring infiltrometer designs of the open or closed type.

The measurement devices and measurement procedures are adapted to different ranges of permeability. Open systems are adapted to permeability ranges from $10^{-5}$ to $10^{-8}$ m/s and closed systems for permeability lower than $10^{-8}$.



Depending on the environmental conditions and the water permeability of the soil, a duration of a few minutes to a few days is needed to run the test.

This part of ISO 22282 defines the terminology and the measured parameters. It specifies the required characteristics of the equipment, defines the procedures of the tests relating to the different measurement techniques and specifies the tests results.

It is applicable to:

— civil engineering projects;

— hydrogeology studies; and

— waste storage.

## 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 22282-1, *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 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 |
|---|---|---|
| $D_1$ | diameter of the inner infiltrometer ring | m |
| $D_2$ | diameter of the outer infiltrometer ring | m |
| $h$ | hydraulic head | m |
| $h(t)$ | hydraulic head at time $t$ | m |
| $k$ | permeability coefficient | $m \cdot s^{-1}$ |
| $t$ | time | s |
| $Z_w$ | thickness of saturated zone | m |
| $Z_p$ | penetration depth of the cell | m |
| $v$ | flow rate velocity | $m \cdot s^{-1}$ |
| $V$ | volume | — |
| $\eta_T$ | dynamic viscosity at temperature T | mPa·s |
| $\theta$ | volumetric water content | — |
| $w$ | (gravimetric) water content | — |
| $\rho_d$ | density of dry soil | $kg \cdot m^{-3}$ |
| $\rho_s$ | density of solid particles | $kg \cdot m^{-3}$ |
| $\psi_f$ | suction at the infiltration front | m |



# 4 Equipment

## 4.1 General

The test equipment comprises:

a) a test cell for infiltrating the water into the soil;

b) a device for measuring pressure, water level and/or infiltrated volumes as a function of time. In some cases (e.g. with constant head procedure) equipment and piping connecting the pressure and volume controller to the test cell is also needed;

c) equipment for installation of the rings (pushing, anchoring, bonding and/or sealing);

d) water supply and pump (optional);

e) a time measuring and/or recording device, reading in seconds;

f) additional equipment, e.g. heat insulation device, equipment for sampling and preparing the test area.

All the equipment and measuring devices shall be periodically calibrated according ISO 22282-1.

## 4.2 Test cell

### 4.2.1 General

The test can be performed with an open system or a closed system.

### 4.2.2 Open system

The test cell comprises a single cylindrical ring or two coaxial cylindrical rings (see Figure 1).

In the case of the double ring, the outer diameter $D_2$ shall be at least twice the diameter of the inner ring $D_1$, with $D_1 \geq 200$ mm.

In the case of the single ring, its diameter $D_1$ shall be at least 200 mm.

The test device shall be designed to be pushed into the ground to a penetration depth $Z_p$ of at least 50 mm.

The rings shall be rigid and dimensionally stable. Their lower part shall be sharpened to facilitate penetration.

### 4.2.3 Closed system

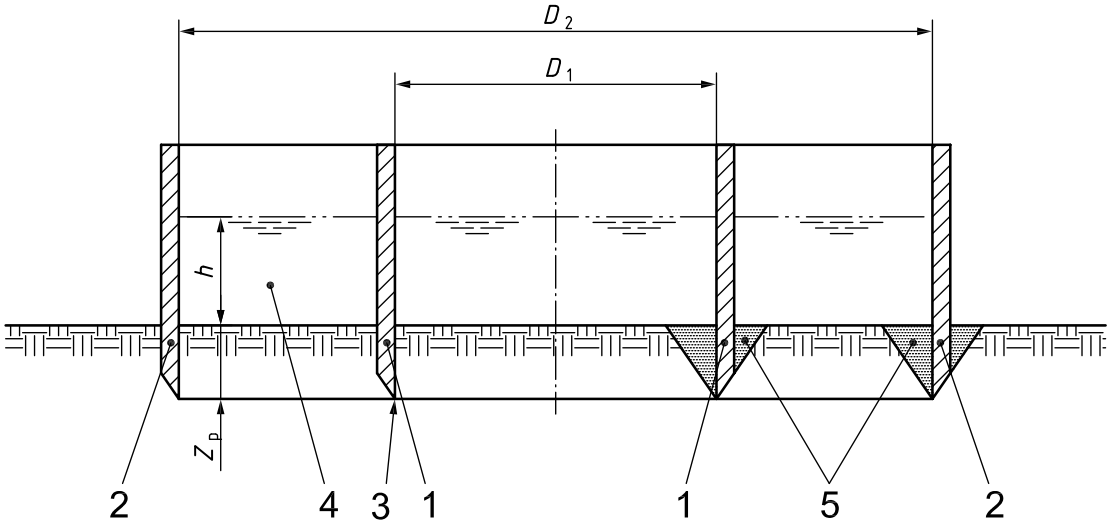
The test cell comprises a single cylindrical ring sealed by a tight rigid lid (see Figures 2 and 3). The diameter of the ring $D_1$ shall not be less than 200 mm.

The lid shall be equipped with drain valves and test fluid supply valves. A rigid, filtering, porous device resting on the ground and in contact with the lid (see Figure 2) should be included to confine the test area (to avoid swelling and soil alteration).



The test device shall be designed to be pushed into the ground to a penetration depth $Z_p$ of at least 50 mm.

To prevent the displacement of the test cell due to the forces generated by the applied pressure, a dead weight system or anchoring device shall be used. The possible displacement of the test cell shall be monitored with a resolution of at least 0,01 mm.




**Key**

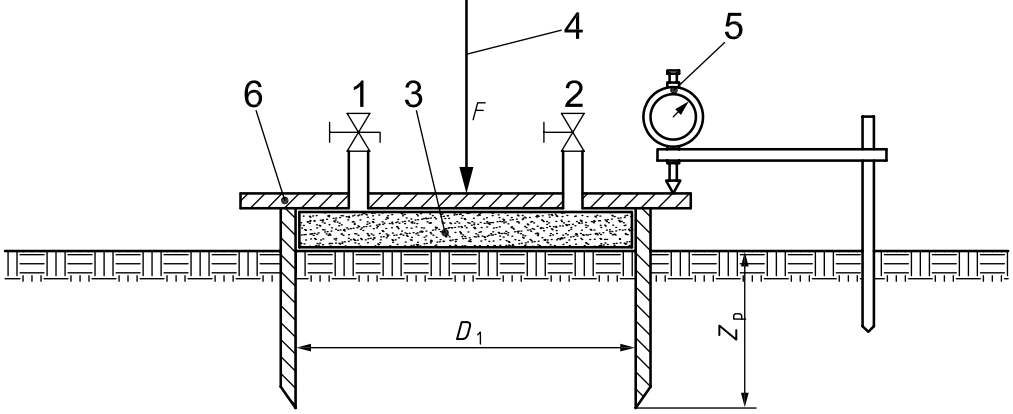
1 inner ring
2 outer ring
3 sharpened edge
4 water volume
5 sealing material
$Z_p$ penetration depth

See also Annex A.



**Figure 1 — Cross-section of an open double ring — Example**



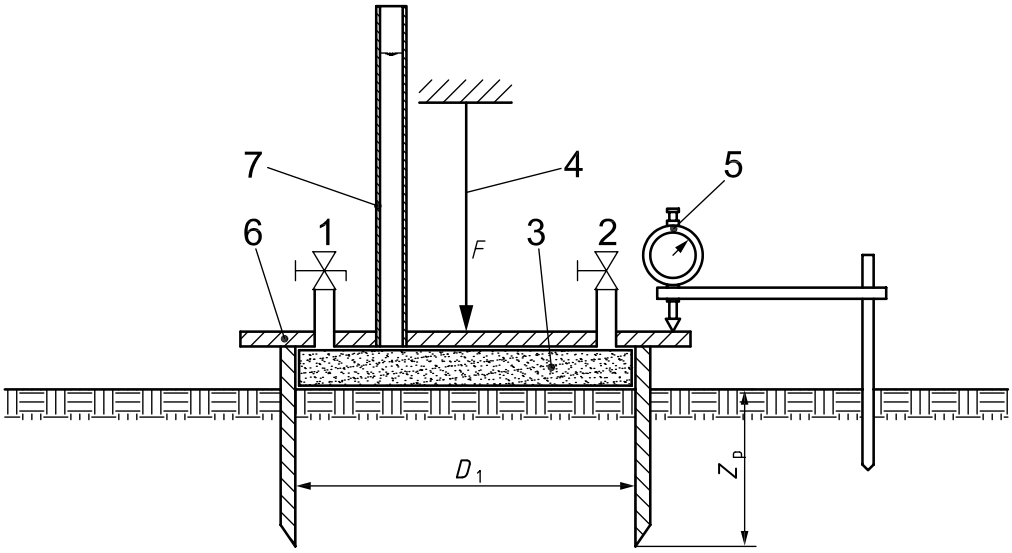



**Key**

1 drain valves
2 water supply valves
3 confining device (optional)
4 confining force
5 displacement gauge
6 infiltrometer cell
$F$ force
$Z_p$ penetration depth

See also Annex A.

**Figure 2 — Cross-section of a closed single ring (example) — Constant-head type**




**Key**

1 drain valves
2 water supply valves
3 confining device (optional)
4 confining force
5 displacement gauge
6 infiltrometer cell
7 measuring tube
$F$ force
$Z_p$ penetration depth

See also Annex A.



**Figure 3 — Cross-section of a closed single ring (example) — Variable-head type**

## 4.3 Measuring system for hydrostatic pressure or infiltrated volume

### 4.3.1 Open system

The system for measuring the changes with time of the hydraulic head and therefore the infiltrated water volume depends on the permeability of the soil and shall have a resolution better than 1 % of the measured change.

When the double ring is used, the hydraulic head shall be the same in both rings.

### 4.3.2 Closed system

For the constant head procedure, a pressure-volume controller shall be used to impose and to maintain constant the hydrostatic pressure in the measurement ring. The infiltrated volume variations shall be measured with the pressure-volume controller with a resolution of at least 0,1 ml. For the variable head procedure, a pressure gauge or transducer shall be used for the measurement within the measuring tube of the hydraulic head variations with an uncertainty of 1 mm or better.

## 4.4 Temperature measuring device

If viscosity corrections are required, a temperature measuring device shall be used to record water temperature with a resolution of at least 0,5 °C.

### 4.5 Material requirements

Only clean water, free of suspended solids, shall be used.

If sealing material is required for installation of the ring, its composition shall be determined according to site conditions.

## 5 Test procedure

### 5.1 Preparation of the test surface

The test area shall be sufficiently larger than the infiltrometer to allow any leakage to be observed. This surface shall be horizontal, smooth, clean and undisturbed.

### 5.2 Installation of the ring or rings

The rings shall be installed such that no undesired lateral leakage occurs and the area of infiltration is clearly defined.

One of the following methods should be used:

— placing the ring in an excavated slot, which is then backfilled with sealant (see Figure 1);

— pushing the ring at least 5 cm into the ground by hammering or applying downward pressure (see Figure 2).

### 5.3 Conducting the test



#### 5.3.1 General

During the test, observations shall be made to detect any lateral leakage. If lateral leakages occur, the test shall be terminated, the sealing shall be improved and a new test shall be performed.



The duration of the test depends on the permeability and the water content and degree of saturation of the soil, as well as on the applied hydraulic head.

#### 5.3.2 Constant head procedure

The following successive operations shall be carried out:

a) installation:

   — of the temperature sensor placed in the water of the inner ring (optional);

   — of the heat insulation device above the appliance (optional);

   — of the system for application and measurement of the hydraulic head and of the infiltrated volume;

b) filling the test cell with clean water. The test cell and the connecting pipes shall be fully saturated;

c) application of the hydraulic head $h$ of generally less than 1 m. The pressure measurement reference is the soil level;

d) measurement of the infiltrated volume.

The first step of the test is intended to ensure that the soil is saturated. The minimum duration of this saturation phase should be estimated.

The infiltrated volumes in each ring or at least in the central ring shall be measured after the saturation phase until the infiltration velocity is nearly constant.

NOTE Recommended durations of saturation phase and measuring phase are given in Annex C, as a function of permeability coefficient range.

The infiltrated volume and temperature measurements shall be carried out:

— either manually;

— or by recording by means of a data logging unit.

Each reading shall include the time elapsed since the start of the test, the value of the infiltrated volume, the temperature and the value of the applied head. These measurements should be presented graphically.

#### 5.3.3 Variable head procedure

The following successive operations shall be carried out:

a) installation:

   — of the temperature sensor placed in the water of the inner ring (optional);

   — of the heat insulation device above the appliance (optional);

   — of the system for application and measurement of the hydraulic head and of the infiltrated volume;

b) filling the test cell with clean water. The test cell and the connecting pipes shall be fully saturated;

c) application of the hydraulic head $h$ to a value which takes into account the water supply and the permeability of the soil. The head measurement reference is the soil level;

d) measurement of the hydraulic head and infiltrated volume.



The measurements shall start immediately after the filling of the infiltrometer.

NOTE Because hydraulic head variations are more important during the initial stages of the test, measurements are more frequent at the beginning of testing. Test duration depends on soil permeability.



### 5.4 Decommissioning of the infiltrometer

When the test is finished, the following operations shall be carried out immediately:

— careful extraction of the infiltrometer in such a manner as to avoid damaging the tested soil;

— sampling of soil for characterization of the physical state of the tested material;

— visual observations or photographs.

For interpretation of test results, the depth of the infiltration front, the extension of the saturated zone created during the test, as well as the porosity and the initial and final degree of saturation in the vertical section of soil affected by the test shall be determined by sampling.

## 6 Test results

The test results are:

a) for the constant head procedure: the infiltrated volumes as a function of time;

b) for the variable head procedure: the hydraulic head as a function of time.

Moreover, the recorded volumes shall be plotted on a graph (see also Annex A).

The test results can be used for evaluating:

a) for the constant head procedure:

   — the surface flow rate (or infiltration velocity) for the specified hydraulic head;