INTERNATIONAL STANDARD

ISO 22282-3

First edition
2012-06-01

Geotechnical investigation and testing — Geohydraulic testing —

Part 3: Water pressure tests in rock

Reconnaissance et essais géotechniques — Essais géohydrauliques — Partie 3: Essais de pression d'eau dans des roches

Reference number
ISO 22282-3:2012(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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 22282-3 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 3:
Water pressure tests in rock

1 Scope

This part of ISO 22282 specifies the requirements for water pressures tests (WPT) carried out in boreholes drilled into rock as part of geotechnical investigation and testing according to EN 1997-1 and EN 1997-2.

The tests are used to investigate the following:

— hydraulic properties of the rock mass, which are mainly governed by discontinuities;

— absorption capacity of the rock mass;

— tightness of the rock mass;

— effectiveness of grouting;

— geomechanical behaviour, e.g. hydrofracturing, hydrojacking.

Many effects of the geohydraulic tests are not only influenced by the ground itself, but stem from the testing procedure. Historically, the water pressure test was evaluated based on the assumption that the stationary behaviour was achieved. Recent advances in geohydraulics have shown that transient phenomena are often present. This part of ISO 22282 attempts to address the limitations of certain testing procedures without restricting the required equipment too stringently.

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

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 of 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 and the following apply.

3.1.1
water flow rate
Q
quantity of water that flows through the test equipment under certain test conditions per time unit

3.1.2
water take
w
water flow Q related to the effective test pressure p_T

3.1.3
single pressure step test
test with only one pressure step

NOTE This test is normally used to check the tightness of the rock or the tightening measures.

3.1.4
multiple pressure step test
test with more than one pressure step

NOTE This test is normally used to investigate the water take and the behaviour of the discontinuities, e.g hydrojacking, hydrofracturing, erosion and clogging.

3.1.5
steady state condition
test phase during which both pressure and flow rate are constant

3.1.6
Lugeon
unit of permeability

NOTE 1 lugeon unit equals 1 litre of water taken per metre of test length, per minute, at 10 bars pressure.

3.1.7
hydrofracturing
formation of new discontinuities by injection

3.1.8
hydrojacking
dilation of discontinuities by injection

3.1.9
flow meter
device used to measure the volume of water usage

3.2 Symbols

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

Table 1 — Symbols

Symbol	Designation	Unit
D	diameter of the test section	m
d	diameter of the pipe	m
g	gravity	m/s^2
h	hydraulic head	m
K	absolute permeability	m^2
k	permeability coefficient	m/s
L	length	m
L_p	length of the packer	m
m	slope	—
N	number of discontinuities	—
p	pressure	MPa
p_A	pressure above packer	MPa
p_B	pressure below packer	MPa
p_M	pressure at the top of the borehole	MPa
p_R	pressure loss	MPa
p_T	effective test pressure	MPa
p_p	pressure at the top of the hole (p_M)	MPa
p_0	press-in pressure	MPa
Δp	pressure loss between the pump and the test section	MPa
Q	flow rate	m^3/s
R	calculated radius of investigation	m
r_0	radius of the borehole	m
S	storage coefficient	—
T	transmissivity	m^2/s
t	time	—
W_m	mean width of joints	m
w	water take	m^3/s
α	shape coefficient of the test section	—
γ	density	kg/m^3
η	dynamic viscosity of the fluid	$N\ s/m^2$
ρ	water density	kg/m^3

4 Equipment

4.1 General

According to Figure 1 water shall be pumped into a test section of a borehole closed by one or more packers to determine the relationship between pressure and water take.

Depending on the type of testing, a single packer or double packer assembly is used (see Figure 1).

The water pressure test can be carried out in a borehole of any orientation and diameter. The test section may be located either below or above the groundwater level.

The basic equipment consists of the following parts (see also the example in Figure 1):

— pump, including water supply;

— pipes;

— single or double packer;

— shut-off valve in the pipe above the test section;

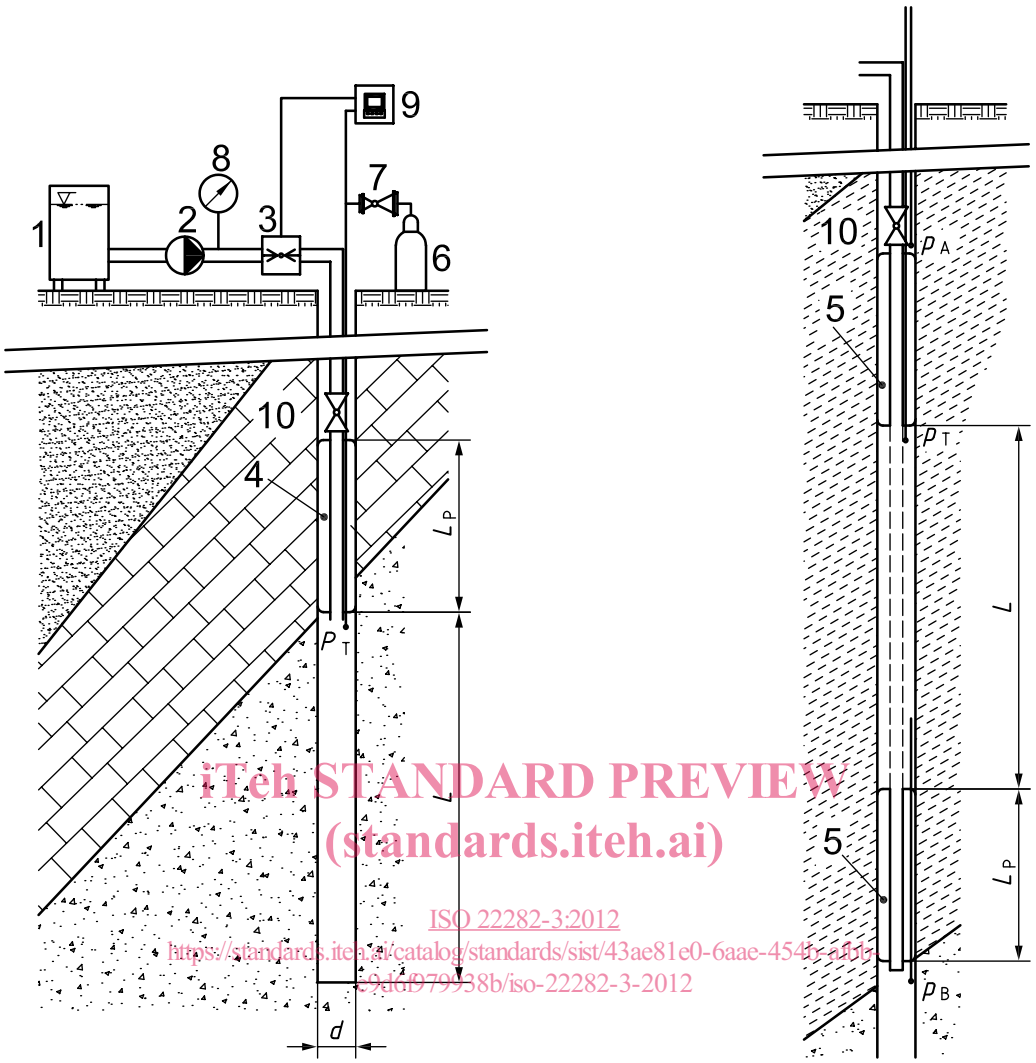
— pressure measuring device;

— measurements in test section with pressure transducer;

— control measurements at the surface with manometer;

— flow meter;

— data recording system.



a) With single packer **b) With double packer**

Key

1 reservoir
2 pump
3 flow meter
4 single packer, inflatable
5 double packer, inflatable
6 compressed gas bottle
7 controller to regulate pressure inflating packers
8 manometer
9 data recording unit
10 shut-in valve
L length of test section
L_p length of packer
p_T effective test pressure
p_A pressure in borehole above packer (optional)
p_B pressure below double packer in borehole (optional)

Figure 1 — Example of equipment and set-up of water pressure test using single packer and double packer

The function of manometers and flow meters used shall be verified before each test. In cases of manual recording, two manometers and two flow meters of different ranges shall be installed. In cases of automatic recording, a visual control shall be available.

All devices shall be calibrated in accordance with ISO 22282-1. The pressure loss of the system shall be assessed.

4.2 Pump and supply

A pressure controlled pump shall be suitable to produce the pressure required by the local conditions.

NOTE A controlled pump typically has an output capacity of up to 150 l/min. A pump of 1,5 MPa is usually suitable.

In order to provide an oscillation-free water flow and pressure, a pump with an oscillation pressure of maximum ± 3 % or a pressure damper that is constant within ± 3 % shall be used.

The water shall be pumped through a flexible pressure hose or a pipe system to the test section.

4.3 Flow meter

The measuring range of the flow meters used shall be adapted to the quantity of water (water flow) Q expected to be absorbed. It may be necessary to install two flow meters covering different measuring ranges:

— if Q_{max} reaches the order of 100 l/min, a flow of 2 l/min shall be identifiable;

— if Q_{max} reaches the order of 10 l/min, a flow of 0,5 l/min shall be identifiable.

The accuracy of the flow meter shall be better than 3 % of the measuring range.

4.4 Packers

The effective length of the packer sleeve shall be at least 10 times the diameter of the borehole and at least 0,5 m. The pressure to expand the packer shall be at least 30 % higher than the maximum test pressure expected.

5 Test procedure

5.1 Test preparation

Before the water pressure test is carried out, the basic requirements according to ISO 22282-1 shall be considered.

In addition to the requirements in ISO 22282-1, the following test requirements shall be given:

— purpose of the test (e.g. estimation of permeability or groutablity);

— depth and sequence of test section;

— length of test section;

— application of testing pressure;

— number and duration of pressure stages, as ascending and descending pressure steps;

— maximum pressure allowable during the test.

After drilling, the borehole shall be cleaned by flushing prior to the execution of the test.

NOTE Drilling and flushing for cleaning of the borehole influences the groundwater in the rock mass.

The pressure in the test section shall be measured and recorded before starting the test while the packer is set and the water supply pipe is closed.

5.2 Test execution

During the test, readings shall be taken and recorded of the pressure p and the quantity of water (water flow) Q flowing through the flow meter over a certain time (Figure 2).

Pressure and flow rate shall be simultaneously adapted to the value of the pressure step.

A substantial increase of the flow rate compared to the pressure may be an indication of hydrofracturing or hydrojacking. A reduced increase of the flow rate compared to the pressure may indicate turbulent flow in the rock surrounding the boring.

The data shall be taken during each pressure step until the steady state condition is reached for both the pressure p and the water flow Q, i.e. the pressure and the water flow remain constant. Each step shall last at least 10 min. Where steady state conditions are not reached within 10 min, the measurements may be stopped when the variation is less than 5 % per minute or after 30 min.

The reading and recording of the data can be done either manually or automatically.

If automatic recording is used, the data shall be recorded at least every 5 s. If manual recording is used, the data shall be recorded at least every minute.

Manual readings generally require steady state conditions which can be reached after 10 min of water flow per pressure step.

For manual readings at the surface the length of the pipe shall be less than 30 m below the manometer in order to make a reasonable correction of the pressure loss in the pipe system.

If pressure transducers are used, an additional manometer at the surface should be used for checking.

Direct measurements in the test section should be done to avoid additional corrections.

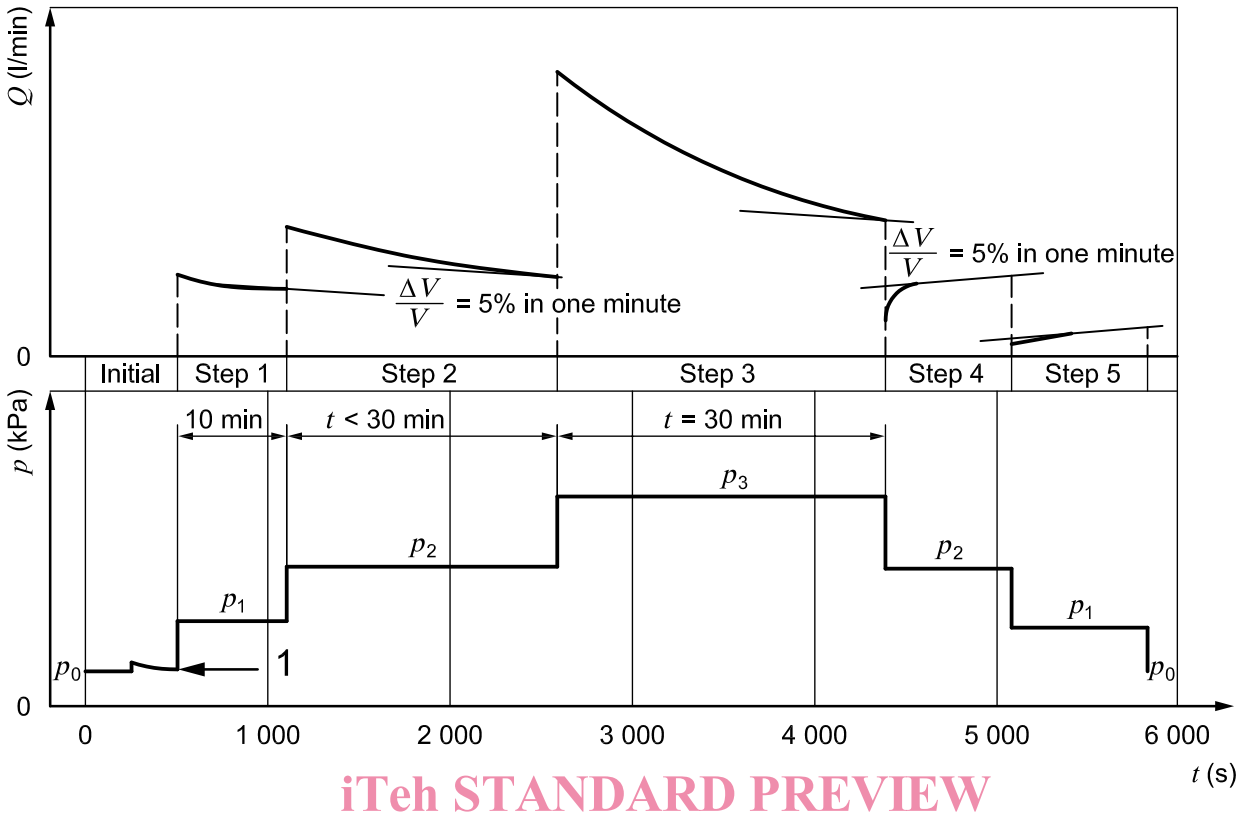
Leakages around and/or along the packer(s) can be detected by installation of pressure transducers above the upper packer (and below the lower packer). Changes in water pressure may indicate leakages.

Leakages around and/or along the packer shall be minimized. Examples of actions that can be taken are:

— applying a drilling technique producing a smooth and uniform surface of the borehole wall and constant borehole diameter;

— using a suitable flexible material for the packer sleeve allowing a tight contact with the borehole wall;

— using longer packer sleeves depending on the local conditions in case of a tight net of open joints.



Key

1 pressure in ground

Figure 2 — Example of a record of pressure and flow rate of a multi-stage water pressure test

The results of a water pressure test are the recorded pressure p and the water flow Q as a function of time.

Moreover, the recorded pressure p and the water flow Q shall be plotted on a graph (see Annex B).

The test results can be used for evaluating the permeability and groutability with steady state conditions (see Annex C) and transient conditions (see Annex D).

6 Reports

6.1 Field report

6.1.1 General

At the project site, a field report shall be completed. This field report shall consist of the following, if applicable:

a) summary log according to ISO 22475-1;

b) drilling record according to ISO 22475-1;

c) sampling record according to ISO 22475-1;

d) record of identification and description of rock according to ISO 14689-1;

e) installation record according to 6.1.2;

f) calibration record according to ISO 22282-1;

g) record of measured values and test results according to 6.1.3.