INTERNATIONAL STANDARD

ISO 22476-8

First edition
2018-09

Geotechnical investigation and testing — Field testing —

Part 8: Full displacement pressuremeter test

Reconnaissance et essais géotechniques — Essais en place —

Partie 8: Essai au pressiomètre refoulant

Reference number
ISO 22476-8:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 22476 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Geotechnical investigation and testing — Field testing —

Part 8:
Full displacement pressuremeter test

1 Scope

This document specifies the equipment requirements, execution of and reporting on full displacement pressuremeter (FDP) tests.

NOTE This document fulfils the requirements for full displacement pressurementer test as part of the geotechnical investigation services according to EN 1997-1 and EN 1997-2.

Tests with the full displacement pressuremeter cover the measurement in situ of the deformation of soils and weak rocks by the expansion/contraction of a cylindrical flexible membrane under pressure.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 22476-1, *Geotechnical investigation and testing — Field testing — Part 1: Electrical cone and piezocone penetration test*

ISO 22476-4:2012, *Geotechnical investigation and testing — Field testing — Part 4: Ménard pressuremeter test*

ISO 10012, *Measurement management systems — Requirements for measurement processes and measuring equipment*

ENV 13005:1999; *Guide to the expression of uncertainty in measurement*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

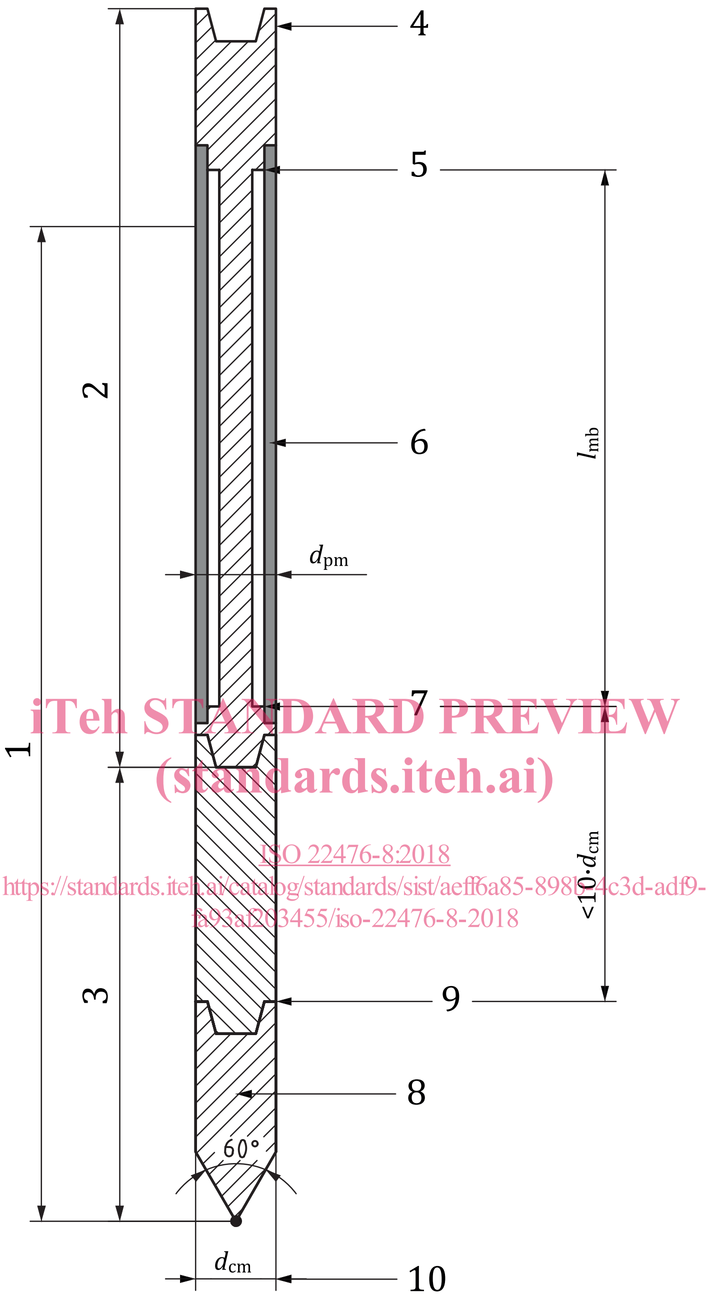
— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
full displacement pressuremeter
FDP
assembly containing a *pressuremeter module* (3.1.2) and a *cone module* (3.1.3)

Note 1 to entry: The FDP is jacked or driven directly into undisturbed ground with an integral cone at its lower end thereby creating its own test hole. No preparation of the cavity is permitted either by pre-boring, pre-pushing or any other means.

Note 2 to entry: The applied pressure and associated expansion of the probe are measured and recorded so as to obtain the stress-displacement relationship for the soil as tested (see Figure 1).



Key

1 full displacement pressuremeter
2 pressuremeter module
3 cone module
4 push rod connector
5 upper fixed membrane point
6 membrane
7 lower fixed membrane point
8 cone
9 cone tip
10 25 mm to 50 mm (according to ISO 22476-1)

NOTE The example is not to scale.

Figure 1 — Cross section of a full displacement pressuremeter

3.1.2
pressuremeter module
cylindrical device designed to apply a uniform pressure to the walls of a cavity by means of an expandable flexible single-cell membrane

3.1.3
cone module
cylindrical device with a conical shaped lower end and a connection to which the *pressuremeter module* (3.1.2) can be attached

Note 1 to entry: The cone module can be instrumented with cone, friction sleeve and pore pressure sensors according to ISO 22476-1.

3.1.4
membrane
part of the *pressuremeter module* (3.1.2) that is expanded and thereby transmits pressure to the cavity wall

Note 1 to entry: The membrane is fitted on a mandrel. It may be externally or internally reinforced or protected. The reinforcement or protection is deemed to be part of the membrane.

3.1.5
membrane length
l_{mb}
distance between the upper and lower fixed points of the *membrane* (3.1.4)

Note 1 to entry: See Figure 1.

3.1.6
pressuremeter system
pressuremeter module (3.1.2), *cone module* (3.1.3), controlling devices and measuring system in combination with any lines connecting them together

3.1.7
volume-displacement type pressuremeter
pressuremeter module (3.1.2) fitted with a sensor to measure the change in the volume of the expanding cavity

3.1.8
radial-displacement type pressuremeter
pressuremeter module (3.1.2) fitted with sensors to measure the change in the radius or diameter of the expanding cavity

3.1.9
membrane pressure loss
pressure in the *pressuremeter module* (3.1.2) required to expand the *membrane* (3.1.4) in air, expressed as a funtion of the expansion

3.1.10
membrane compressibility
change in thickness of the *membrane* (3.1.4) as related to the change in internal pressure in the *pressuremeter module* (3.1.2)

3.1.11
system compliance
volume change in a *pressuremeter system* (3.1.6) in response to the internal pressure variation in a situation where the expansion of the *membrane* (3.1.4) is restricted

Note 1 to entry: The system compliance takes into account both the deformation of the *pressuremeter system* (3.1.6) and the *membrane compressibility* (3.1.10) and includes time effects.

3.1.12
applied pressure
pressure applied by the external surface of the *membrane* (3.1.4) to the walls of the cavity in the soil or weak rock

3.1.13
calibration cylinder
cylindrical tube of known elastic properties used for the restriction of the membrane expansion and hence for the determination of system compliance

3.1.14
reference reading
reading of a sensor just before the *membrane* (3.1.4) touches the wall of the *calibration cylinder* (3.1.13) when expanding

3.1.15
cavity volume
V
volume of the cavity in the ground between the upper and lower fixed points of the *membrane* (3.1.4)

3.1.16
initial cavity volume
V_0
theoretical *cavity volume* (3.1.15), calculated as:

$$V_0 = l_{mb} \cdot ¼\, \pi\, (d_{cm})^2$$

where

l_{mb} is the membrane length;

d_{cm} is the maximum diameter of the cone module

3.1.17
volumetric strain
ε_v
change in the volume of the cavity with respect to the *initial cavity volume* (3.1.16)

$$\varepsilon_v = \frac{V - V_0}{V_0}$$

where

V is the cavity volume;

V_0 is the initial cavity volume

Note 1 to entry: Conversions between the volumetric strain and the radial strain are given in Annex E.

3.1.18
initial cavity radius
r_0
theoretical radius of the cavity, calculated as follows:

$$r_0 = 0{,}5\, d_{cm}$$

where d_{cm} is the maximum cone module diameter

3.1.19
radial strain
ε_r
change in the radius of the cavity with respect to the *initial cavity radius* (3.1.18):

$$\varepsilon_r = \frac{r - r_0}{r_0}$$

where

r is the cavity radius;

r_0 is the initial cavity radius

3.1.20
rate of volumetric strain change
$\dot{\varepsilon}_V$
change of the *volumetric strain* (3.1.17) with time:

$$\dot{\varepsilon}_V = \frac{\Delta V}{V_0} \cdot \frac{1}{\Delta t}$$

where

ΔV is the volume change over a selected period Δt;

V_0 is the initial cavity volume;

Δt is the time increment over which the volume change took place

3.1.21
rate of radial strain change
$\dot{\varepsilon}_r$
change of the *radial strain* (3.1.19) with time:

$$\dot{\varepsilon}_r = \frac{\Delta r}{r_0} \cdot \frac{1}{\Delta t}$$

where

Δr is the radius change over a selected period Δt;

r_0 is the initial cavity radius;

Δt is the time increment over which the radial displacement took place

3.1.22
rate of pressure application
$\dot{p}$
rate of change of the applied pressure with time.

$$\dot{p} = \frac{\Delta p}{\Delta t}$$

where

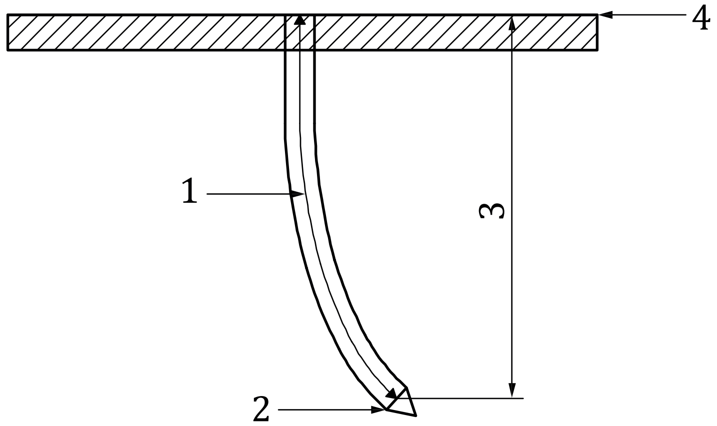
Δp is the pressure change over a selected period Δt;

Δt time increment over which the pressure took place

3.1.23
thrust machine
equipment that pushes the *FDP* (3.1.1) and *rods* (3.1.24) into the ground at a constant rate of penetration

3.1.24
push rods
string of rods for the transfer of forces to the *FDP* (3.1.1)

Note 1 to entry: The fixed horizontal plane (Figure 2) usually corresponds to the level of the ground surface (on shore or off shore). This may be different from the starting point of the test.



Key

1 penetration length

2 base of the conical part of the cone module

3 penetration depth

4 fixed horizontal plane

Figure 2 — Penetration length and penetration depth

3.1.25
penetration depth
z
depth to the base of the cone, relative to the fixed horizontal plane

3.1.26
penetration length
sum of the length of the *push rods* (3.1.24) and of the *FDP* (3.1.1), reduced by the height of the conical part, relative to the fixed horizontal plane

Note 1 to entry: See Figure 2.

3.1.27
test depth
depth where a pressuremeter test is performed, measured at membrane mid-height and relative to the fixed horizontal plane

3.1.28
measuring system
all sensors, ancillary parts and software used to transfer and to store the measurements made during the full displacement pressuremeter test

3.1.29
unload-reload cycle
controlled decrease in the pressure and volume or radius, after which the expansion is resumed

3.1.30
reload-unload cycle
controlled increase in the pressure and volume or radius during the final contraction phase of the test after which the contraction is resumed

3.1.31
zero load reading
stable output of a measuring system if there is zero load on the sensors, i.e. the parameter to be measured has a value of zero while any auxiliary power supply required to operate the measuring system is switched on

3.1.32
drift
absolute difference of the zero load readings or reference readings of the measuring system before and after the execution of the full displacement pressuremeter test

3.1.33
uncertainty
expanded uncertainty with a coverage factor 2

Note 1 to entry: Coverage factors are defined in ENV 13005.

3.2 Symbols

Symbol	Description	Unit
A_c	cross-sectional projected area of the cone	mm^2
d_{cm}	maximum diameter of the cone module	mm
d_{pm}	maximum diameter of the pressuremeter module	mm
d_t	internal diameter of the calibration cylinder	mm
h_c	height of the conical part of the cone module	mm
l_{mb}	membrane length	mm
M_s	system stiffness	kPa/mm^3
P	pressure	kPa
p_h	pressure difference between the pressure sensor and the pressure at the midheight of the membrane	kPa
p_r	pressure reading in the pressuremeter module	kPa
p_m	pressure loss pressure to overcome the membrane resistance	kPa
p_{offset}	offset of the pressure	kPa
p_{rm}	pressure reading corrected for the membrane resistance	kPa
p_{ref}	pressure at reference volume V_{ref}	kPa
p_0	pressure at initial cavity volume V_0	kPa
$\dot{p}$	rate of pressure change	kPa/s
r	cavity radius	mm
r_{offset}	offset of the real radius with the sensor reading of the radius	mm
r_0	initial cavity radius	mm
t	time	s
V	cavity volume	mm^3
V_{offset}	offset of the real volume with the sensor reading of the volume	mm^3
V_{ref}	reference volume	mm^3
V_0	initial cavity volume	mm^3
z	penetration depth	m

