SLOVENSKI STANDARD
SIST EN ISO 22476-4:2013

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Geotehnično preiskovanje in preskušanje - Preskušanje na terenu - 4. del: Preskus z Ménardovim presiometrom (ISO 22476-4:2012)

Geotechnical investigation and testing - Field testing - Part 4: Ménard pressuremeter test (ISO 22476-4:2012)

Geotechnische Erkundung und Untersuchung - Felduntersuchungen - Teil 4: Pressiometerversuch nach Ménard (ISO 22476-4:2012)

Reconnaissance et essais géotechniques - Essais en place - Partie 4: Essai au pressiomètre Ménard (ISO 22476-4:2012)

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Geotechnical investigation and testing - Field testing - Part 4: Ménard pressuremeter test (ISO 22476-4:2012)

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Geotechnische Erkundung und Untersuchung - Felduntersuchungen - Teil 4: Pressiometerversuch nach Ménard (ISO 22476-4:2012)

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Foreword

This document (EN ISO 22476-4:2012) has been prepared by Technical Committee CEN/TC 341 “Geotechnical Investigation and Testing”, the secretariat of which is held by ELOT, in collaboration with Technical Committee ISO/TC 182 "Geotechnics".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2013, and conflicting national standards shall be withdrawn at the latest by June 2013.

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INTERNATIONAL STANDARD

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Geotechnical investigation and testing — Field testing —

Part 4: Ménard pressuremeter test

Reconnaissance et essais géotechniques — Essais en place —
Partie 4: Essai au pressiomètre de Ménard

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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.

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ISO 22476-4 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 testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 22476 consists of the following parts, under the general title *Geotechnical investigation and testing — Field testing*:

— *Part 1: Electrical cone and piezocone penetration test*

— *Part 2: Dynamic probing*

— *Part 3: Standard penetration test*

— *Part 4: Ménard pressuremeter test*

— *Part 5: Flexible dilatometer test*

— *Part 7: Borehole jack test*

— *Part 9: Field vane test*

— *Part 10: Weight sounding test* [Technical Specification]

— *Part 11: Flat dilatometer test* [Technical Specification]

— *Part 12: Mechanical cone penetration test (CPTM)*

Geotechnical investigation and testing — Field testing —

Part 4:
Ménard pressuremeter test

1 Scope

This part of ISO 22476 specifies the equipment requirements, execution of and reporting on the Ménard pressuremeter test.

NOTE 1 This part of ISO 22476 fulfils the requirements for the Ménard pressurermeter test, as part of the geotechnical investigation and testing according to EN 1997-1 and EN 1997-2.

This part of ISO 22476 describes the procedure for conducting a Ménard pressuremeter test in natural soils, treated or untreated fills and in weak rocks, either on land or off-shore.

The pressuremeter test results of this part of ISO 22476 are suited to a quantitative determination of ground strength and deformation parameters. They may yield lithological information. They can also be combined with direct investigation (e.g. sampling according to ISO 22475-1) or compared with other *in situ* tests (see EN 1997-2:2007, 2.4.1.4(2) P, 4.1 (1) P and 4.2.3(2) P).

The Ménard pressuremeter test is performed by the radial expansion of a tricell probe placed in the ground (see Figure 1). During the injection of the liquid volume in the probe, the inflation of the three cells first brings the outer cover of the probe into contact with the pocket wall and then presses on them resulting in a soil displacement. Pressure applied to and the associated volume expansion of the probe are measured and recorded so as to obtain the stress-strain relationship of the soil as tested.

Together with results of investigations with ISO 22475-1 being available, or at least with identification and description of the ground according to ISO 14688-1 and ISO 14689-1 obtained during the pressuremeter test operations, the test results of this part of ISO 22476 are suited to the quantitative determination of a ground profile, including

— the Ménard E_{M} modulus,

— the Ménard limit pressure p_{LM} and

— the Ménard creep pressure p_{fM}.

This part of ISO 22476 refers to a probe historically described as the 60 mm G type probe. This part of ISO 22476 applies to test depths limited to 50 m and test pressure limited to 5 MPa.

NOTE 2 Ménard pressuremeter tests are carried out with other probe diameters and pocket dimensions such as shown below.

Probe		**Drilling diameter** (mm)	
Designation	**Diameter** (mm)	**min**	**max**
AX	44	46	52
BX	58	60	66
NX	70/74	74	80

Two alternative methods of measurement are provided as follows.

— Procedure A: data are recorded manually.

— Procedure B: data are recorded automatically.

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

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.

3.1.1
pressuremeter
whole equipment which is used to carry out a Ménard pressuremeter test, excluding the means necessary to place the pressuremeter probe into the ground

NOTE 1 A pressuremeter includes a pressuremeter probe, a pressure and volume control unit, called CU, lines to connect the probe to the CU and, in the case of procedure B, a data logger which is either built into the CU or linked to it.

NOTE 2 See Figure 2.

3.1.2
pressuremeter test pocket
circular cylindrical cavity formed in the ground to receive a pressuremeter probe

3.1.3
pressuremeter borehole
borehole in which pressuremeter pockets with circular cross sections are made in the ground, and into which the pressuremeter probe is to be placed

3.1.4
pressuremeter test
process during which a pressuremeter probe is inflated in the ground and the resulting pocket expansion is measured by volume as a function of time and pressure increments according to a defined programme

NOTE See Figure 4 and F.1.

3.1.5
pressuremeter sounding
whole series of sequential operations necessary to perform Ménard pressuremeter testing at a given location, i.e. forming pressuremeter test pockets and performing pressuremeter tests in them

NOTE See F.2.

3.1.6
pressuremeter pressure reading, p_r
pressure p_r as read at the CU elevation in the liquid circuit supplying the central measuring cell

3.1.7
pressure loss
difference between the pressure inside the probe and the pressure applied to the pocket wall

3.1.8
volume loss
difference between the volume actually injected into the probe and the volume read on the measuring device

3.1.9
raw pressuremeter curve
graphical plot of the injected volumes recorded at time 60 s, V_{60}, versus the applied pressure at each pressure hold, p_r

3.1.10
corrected pressuremeter curve
graphical plot of the corrected volume V versus the corrected pressure p

NOTE See Figure 5.

3.1.11
Ménard creep
difference in volumes recorded at 60 s and at 30 s at each pressure hold: $V_{60} - V_{30} = \Delta V_{60/30}$

3.1.12
corrected Ménard creep curve
graphical plot of the corrected Ménard creep versus the corrected applied pressure at each pressure hold

NOTE See Figure 5.

3.1.13
pressuremeter log
graphical report of the results of the pressuremeter tests performed in pockets at a succession of depths in the same pressuremeter borehole, together with all the information gathered during the drilling

NOTE See Annex F.

3.1.14
Ménard pressuremeter modulus, E_M
E-modulus obtained from the section between (p_1, V_1) and (p_2, V_2) of the pressuremeter curve

NOTE See Figure 5 and Annex D.

3.1.15
Ménard pressuremeter limit pressure, p_{LM}
pressure at which the volume of the test pocket at the depth of the measuring cell has doubled its original volume

NOTE See Annex D.

3.1.16
pressuremeter creep pressure, p_{fM}
pressure derived from the creep curve

NOTE See Annex D.

3.1.17
operator
qualified person who carries out the test

3.1.18
casing
lengths of tubing inserted into a borehole to prevent the hole caving in or to prevent the loss of flushing medium to the surrounding formation, above pocket location

3.2 Symbols

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

Table 1 — Symbols

Symbol	Description	Unit
a	Apparatus volume loss coefficient	cm³/MPa
d_{ci}	Outside diameter of the inner part of the probe with slotted tube	mm
d_{i}	Inside diameter of the calibration cylinder used for the volume loss calibration	mm
d_{c}	Outside diameter of the central measuring cell, including any additional protection such as a slotted tube	mm
d_{t}	Drilling tool diameter	mm
e	Wall thickness of the calibration cylinder used for the volume loss calibration	mm
l_{p}	Length of the calibration cylinder used for the volume loss calibration	mm
l_{g}	Length of each guard cell	mm
l_{gs}	Length of each guard cell for a short central measuring cell pressuremeter probe	mm
l_{gl}	Length of each guard cell for a long central measuring cell pressuremeter probe	mm
l_{m}	Length along the tube axis of the slotted section of the slotted tube	mm
l_{c}	Length of the central measuring cell of the probe, measured after fitting the membrane	mm
l_{cs}	Length of the short central measuring cell after fitting the membrane	mm
l_{cl}	Length of the long central measuring cell after fitting the membrane	mm
m_{E}	Minimum value, strictly positive, of the m_i slopes	cm³/MPa
m_i	Slope of the corrected pressuremeter curve between the two points with coordinates ($p_{i\text{-}1}$, $V_{i\text{-}1}$) and (p_i, V_i).	cm³/MPa
p	Pressure applied by the probe to the ground after correction	MPa
p_{e}	Correction for membrane stiffness usually called pressure loss of the probe	MPa
p_{E}	Pressure at the origin of the segment exhibiting the slope m_{E}	MPa
p_{el}	Ultimate pressure loss of the probe	MPa
p_{fM}	Pressuremeter creep pressure	MPa
p_{g}	Gas pressure applied by the control unit indicator to the guard cells of the pressuremeter probe	MPa
p_{h}	Hydrostatic pressure between the control unit indicator and the central measuring cell of the pressuremeter probe	MPa
p_{k}	Gas pressure in the guard cells	MPa
p_{LM}	Ménard pressuremeter limit pressure of the ground	MPa
$p_{\mathrm{LM}}{}^*$	Ménard net pressuremeter limit pressure of the ground	MPa
p_{LMH}	Ménard pressuremeter limit pressure as extrapolated by the hyperbolic best fit method	MPa
p_{LMDH}	Ménard pressuremeter limit pressure as extrapolated by the double hyperbolic method	MPa
p_{LMR}	Ménard pressuremeter limit pressure as extrapolated by the reciprocal curve method	MPa
p_{m}	Pressure loss of the central measuring cell membrane for a specific expansion	MPa
p_{r}	Pressure reading at the CU transducer elevation in the central measuring cell liquid circuit	MPa
p_{c}	Liquid pressure in the central measuring cell of the pressuremeter probe	MPa
p_{t}	Target pressure for each pressure hold according to loading programme	MPa
p_1	Corrected pressure at the origin of the pressuremeter modulus pressure range	MPa
p_2	Corrected pressure at the end of the pressuremeter modulus pressure range	MPa
t	Time	s
t_{i}	Time required for incrementing to the next pressure hold	s
t_{h}	Time the loading pressure level is held	s

Table 1 *(continued)*

Symbol	Description	Unit
u_s	Pore water pressure in the ground at the depth of the test	MPa
z	Elevation, positively counted above datum	m
z_c	Elevation of the pressure measuring device for the liquid injected in the measuring cell	m
z_{cg}	Elevation of the pressure measuring device for the gas injected in the guard cells of the pressuremeter probe	m
z_N	Elevation of the ground surface at the location of the pressuremeter sounding	m
z_p	Elevation of the measuring cell centre during testing	m
z_w	Elevation of the ground water table (or free water surface in a marine or river environment)	m
CU	Pressure and volume control unit	—
E	Type of pressuremeter probe where the three cells are formed by three separate membranes in line	—
E_M	Ménard pressuremeter modulus	MPa
G	Type of pressuremeter probe where the central measuring cell is formed by a dedicated membrane over which an external membrane is fitted to form the guard cells (see Figure 2)	—
K_o	Coefficient of earth pressure at rest at the test depth	—
V	Value, after zeroing and data correction, of the volume injected in the central measuring cell and measured 60 s after starting a pressure hold	cm^3
V_c	Original volume of the central measuring cell, including the slotted tube, if applicable	cm^3
V_m	The average corrected volume between V_1 and V_2	cm^3
V_p	Volume obtained in the volume loss calibration test (see Figure B.2)	cm^3
V_E	Value, after data correction, of the volume injected in the central measuring cell for pressure p_E	cm^3
V_L	Value, after data correction, of the volume injected in the central measuring cell when the original volume of the pressuremeter cavity has doubled	cm^3
V_r	Volume injected in the probe as read on the CU, before data correction	cm^3
V_t	Volume of the central measuring cell possibly including the slotted tube	cm^3
V_1	Corrected volume at the origin of the pressuremeter modulus pressure range (see Figure 5)	cm^3
V_2	Corrected volume at the end of the pressuremeter modulus pressure range	cm^3
V_{30}	Volume injected in the central measuring cell as read 30 s after the beginning of the pressure hold	cm^3
V_{60}	Volume injected in the central measuring cell as read 60 s after the beginning of the pressure hold	cm^3
β	Coefficient used to determine the pressuremeter modulus pressure range	—
γ	Unit weight of soil at the time of testing	KN/m^3
γ_l	Unit weight of the liquid injected in the central measuring cell	KN/m^3
γ_w	Unit weight of water	KN/m^3
λ_g	Rate of change of pressure head of gas at p_k per metre depth	m^{-1}
ν	Poisson's ratio	—
σ_{vs}	Total vertical stress in the ground at test depth	kPa
σ_{hs}	Total horizontal stress in the ground at test elevation	kPa
Δp	Loading pressure increment	MPa
Δp_1	Initial pressure increment	MPa
$\Delta V_{60/30}$	Injected volume change from 30 s to 60 s after reaching the pressure hold − the Ménard creep	cm^3
$\Delta V_{60/60}$	60 s injected volume change between successive pressure holds	cm^3