



Designation: D 4719 – 00

Standard Test Method for Prebored Pressuremeter Testing in Soils¹

This standard is issued under the fixed designation D 4719; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 This test method covers pressuremeter testing of soils. A pressuremeter test is an in situ stress-strain test performed on the wall of a borehole using a cylindrical probe that is expanded radially. To obtain viable test results, disturbance to the borehole wall must be minimized.

1.2 This test method includes the procedure for drilling the borehole, inserting the probe, and conducting pressuremeter tests in both granular and cohesive soils, but does not include high pressure testing in rock. Knowledge of the type of soil in which each pressuremeter test is to be made is necessary for assessment of (1) the method of boring or probe placement, or both, (2) the interpretation of the test data, and (3) the reasonableness of the test results.

1.3 This test method does not cover the self-boring pressuremeter, for which the hole is drilled by a mechanical or jetting tool inside the hollow core of the probe. This test method is limited to the pressuremeter which is inserted into predrilled boreholes or, under certain circumstances, is inserted by driving.

1.4 Two alternate testing procedures are provided as follows:

1.4.1 *Procedure A*—The Equal Pressure Increment Method.

1.4.2 *Procedure B*—The Equal Volume Increment Method.

NOTE 1—A standard for the self-boring pressuremeter is scheduled to be developed separately. Pressuremeter testing in rock may be standardized as an adjunct to this test method.

NOTE 2—Strain-controlled tests also can be performed, whereby the probe volume is increased at a constant rate and corresponding pressures are measured. This method shall be applied only if special requirements must be met and is not covered by this test method. Strain-controlled tests may yield different results than the procedure described in this test method.

1.5 The values stated in SI units are to be regarded as the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appro-*

priate safety and health practices and determine the applicability of regulatory limitations prior to use. See Note 6.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1587 Practice for Thin-Walled Tube Sampling of Soils²

D 2113 Practice for Diamond Core Drilling for Site Investigation²

3. Terminology

3.1 *Definitions*—For definitions of terms in this test method, refer to Terminology D 653.

3.1.1 *limit pressure*, P_l [FL^{-2}], n —the pressure at which the probe volume reaches twice the original soil cavity volume.

3.1.2 *pressuremeter modulus*, E_p [FL^{-2}], n —the modulus calculated from the slope of the pseudo-elastic portion of the corrected pressure-volume curve experiencing little to no creep.

3.1.3 *unload-reload modulus*, E_R [FL^{-2}], n —the modulus calculated from an unload-reload loop.

3.1.3.1 *Discussion*—The unload-reload modulus varies with stress, or strain level, or both, and thus, the modulus values should be reported with the pressure and volume at the start of the unloading, at the bottom of the loop and at the crossover point.

3.2 *Abbreviations:*

3.2.1 *PBP*—prebored pressuremeter test

4. Summary of Test Method

4.1 A pressuremeter cavity is prepared either by drilling a borehole, or by advancing some type of sampler. Under certain circumstances, the pressuremeter probe is driven into place, usually within a casing. The various tools and methods available to prepare the cavity produce different degrees of disturbance. The recommended methods to be used at a site depend on the soil and the conditions met. The proper choice of tools and methods is covered by this test method.

NOTE 3—It is recommended that several drilling techniques be available on the site to determine which method will provide the most suitable test hole.

¹ This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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² *Annual Book of ASTM Standards*, Vol 04.08.

*A Summary of Changes section appears at the end of this standard.

4.2 The pressuremeter test basically consists of placing an inflatable cylindrical probe in a predrilled hole and expanding this probe while measuring the changes in volume and pressure in the probe. The probe is inflated under equal pressure increments (Procedure A) or equal volume increments (Procedure B) and the test is terminated when yielding in the soil becomes disproportionately large. A conventional limit pressure is estimated from the last few readings of the test and a pressuremeter modulus is calculated from pressure-volume changes read during the test. It is of basic importance that the probe be inserted in a borehole with a diameter close to that of the probe to ensure adequate volume change capability. If this requirement is not met, the test could terminate without reaching sufficient probe expansion in the soil to permit evaluation of the limit pressure. The instrument may be either of the type where the change in volume of the probe is directly measured by an incompressible liquid or the type where feelers are used to determine the change in diameter in the probe. The volume measuring system must be well protected and calibrated against any volume losses throughout the system while the feeler operated probe must be sensitive enough to measure relatively small displacements.

NOTE 4—This test method is based on the type of apparatus where volume changes are recorded during the test. For the system measuring probe diameters, alternate evaluation methods are given in the notes.

5. Significance and Use

5.1 This test method provides a stress-strain response of the soil in situ. A pressuremeter modulus and a limit pressure is obtained for use in geotechnical analysis and foundation design.

5.2 The results of this test method are dependent on the degree of disturbance during drilling of the borehole and insertion of the pressuremeter probe. Since disturbance cannot be completely eliminated, the interpretation of the test results should include consideration of conditions during drilling. This disturbance is particularly significant in very soft clays and very loose sands. Disturbance may not be eliminated completely but should be minimized for the prebored pressuremeter design rules to be applicable.

6. Apparatus

6.1 *Hydraulic or Electric Probe*—The apparatus shall consist of a probe to be lowered in the borehole and a measuring or readout device to be located on the ground adjacent to the boring. The probe may be either the hydraulic type or the electric type. The hydraulic probe may be of a single cell or triple cell design. In the latter case, the role of which is to provide effective end restraint and ensure radial expansion of the central cell (Fig. 1a³). The combined height of the measuring and guard cells, if any, shall be at least six diameters. The design of the probe shall be such that the drilling liquid may flow freely past the probe without disturbing the sides of the borehole during insertion or removal. For

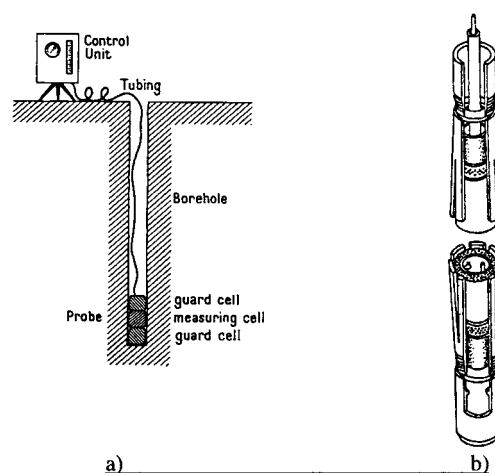


FIG. 1 a) Basic Principles of the Triple Cell Design Pressuremeter (Baguelin, Jézéquel and Shields, 1978,³ b) Slotted Tube with Probe

both systems, the nominal hole diameter shall not be more than 1.2 times the nominal probe diameter. Typical probe dimensions and corresponding borehole diameters are indicated in Table 1.

6.1.1 *Probe Walls*—The flexible walls of the probe may consist of a single rubber membrane (single cell design) or of an inner rubber membrane fitted with an outer flexible sheath or cover (triple cell design) which will take up the shape of the borehole as pressure is applied. In a coarse-grained material like gravel, a steel sheath made of thin overlapping metal strips is often used. The accuracy of the test will be impaired when the probe cannot take up the shape of the borehole accurately.

NOTE 5—Various membrane and sheath, or cover, materials may be used to better accommodate soil types; identify the membrane and sheath, or cover, used in the report.

6.1.2 *Measuring Devices*—Changes in volume of the measuring portion of the probe are measured in the hydraulic apparatus, and alternatively, the probe diameter can be measured by the use of feelers in the electric apparatus. Provisions to measure the diameter in directions at a 120° angle shall be provided with the electric apparatus. The measuring cell shall be prevented from expanding in the vertical direction by guard cells or other effective restraints in the hydraulic apparatus. The accuracy of the readout device shall be such that a change of 0.1 % in the probe diameter is measurable.

6.2 *Lines*—Lines connecting the probe with the readout device consist of plastic tubing in the hydraulic apparatus. To reduce measuring errors, a coaxial tubing is used, whereby the inner tubing is prevented from expanding by a gas pressure at its perimeter. By applying the correct gas pressure, expansion of the inner tubing is reduced to a minimum. Single tubing can

TABLE 1 Typical Probe and Borehole Dimensions

Hole Diameter Designation	Probe Diameter, mm	Borehole Diameter	
		Nominal, mm	Max., mm
Ax	44	45	53
Bx	58	60	70
Nx	74	76	89

³ Baguelin, F., Jézéquel, J.F., and Shields, D.H., "The Pressuremeter and Foundation Engineering," Trans Tech Publications, Series on Rock and Soil Mechanics, Vol 2, No. 4, 1978, p 617.

also be used. In both cases, requirement for volume losses given in 7.3 should apply. Electric lines need special protection against groundwater.

6.3 Readout Device—The readout device includes a mechanism to apply pressure (Procedure A) or volume (Procedure B) in equal increments to the probe and readout of volume change (Procedure A) or pressure change (Procedure B). The equipment using the hydraulic system and guard cells shall also include a regulator whereby the pressure in the gas circuit is kept below the fluid pressure in the measuring cell. The magnitude of pressure difference between gas and fluid must be adjustable to compensate for hydrostatic pressures developing in the probe. In the electrical system the volume readings are substituted by an electrical readout on the diameter of the probe.

6.4 Slotted Tube—A steel tube, (Fig. 1b) that has a series of longitudinal slots (usually six) cut through it to allow for lateral expansion, sometimes is used as a protective housing when the probe is driven, vibrodriven, or pushed into deposits that cannot be prevented from caving by drilling mud alone. The PBP test is performed within the slotted tube.

7. Calibration

7.1 The instrument shall be calibrated before each use to compensate for pressure losses (P_c) and volume losses (V_c).

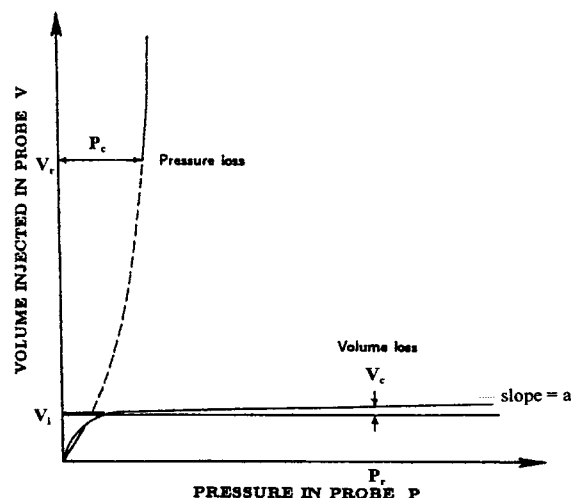
7.2 Pressure Losses—Pressure losses (P_c) occur due to the rigidity of the probe walls. The pressure readings obtained during the test on the readout device include the pressure required to expand the probe walls; this membrane resistance must be deducted to obtain the actual pressure applied to the soil. Calibrations for membrane resistance shall be performed by inflating the probe, completely exposed to the atmosphere, with the probe placed at the level of the pressure gauge.

NOTE 6—Warning: The performance of the pressuremeter test, and particularly the calibration procedures, may present a safety hazard to the operator and persons assisting in the test. The blowout of the probe if on the ground or at shallow depth in the hole may cause injuries from flying debris. Wearing protective devices over the eyes and face or other measures such as putting the probe in a protective cylinder during calibration are recommended.

7.2.1 Apply pressures in 10-kPa increments for Procedure A and hold for 1 min. Make volume readings after 1-min elapsed time. When Procedure B is used, increase the volume of the probe in increments equal to 5% of the nominal volume of the measuring portion of the uninflated probe (V_0). Apply the volume increase in about 10 s and hold constant for 1 min. Continue steps in both procedures until the maximum probe volume is reached. Plot results using a pressure versus volume plot. The obtained curve is the pressure calibration curve. The pressure correction (P_c) is the pressure loss obtained from the calibration for the volume reading (V_r) (Fig. 2).

7.2.2 The pressure correction (P_c) must be deducted from the pressure readings obtained during the test. The maximum value of P_c should be less than 50 % of the limit pressure as defined in 10.6.

7.3 Volume Losses—Volume losses (V_c) occur due to expansion of tubing and compressibility of any part of the testing equipment, including the probe and the liquid. Calibration is made by pressurizing the equipment with the probe in heavy



NOTE 1—The schematic graphs are not to scale; each calibration requires different volumes and pressures.

FIG. 2 Calibration for Volume and Pressure Losses

duty steel casing or pipe. A suggested procedure is to increase the pressure in steps of 100 kPa or 500 kPa depending if the probe is designed for a maximum expansion pressure of 2.5 MPa or 5.0 MPa, respectively. Each pressure increment should be reached within 20 s and once in contact with the steel tube, held constant for 1 minute. The resulting graph of injected volume (V_r) at the end of each pressure increment (P_r) is the volume calibration curve. The zero volume calibration is obtained by first fitting a straight line extension of the curve to zero pressure, as shown in Fig. 2. The resulting intercept V_i can be used to estimate the deflated volume of the probe measuring cell (V_0) as follows:

$$V_0 = (\pi/4) LD_i^2 - V_i \quad (1)$$

where:

D_i = inside diameter of the heavy duty steel casing or pipe, and

L = length of the measuring cell.

The volume loss (V_c) of the instrument for a particular pressure is obtained by using the factor a corresponding to the slope of the volume versus pressure calibration plot (Fig. 2) as follows:

$$V_c = V_r - aP_r \quad (2)$$

This volume loss correction (V_c) must be deducted from the measured volumes during the test. This correction is relatively small in soils and can be neglected if the correction is less than 0.1 % of the nominal volume of the measuring portion of the uninflated probe (V_0) per 100 kPa (1 tsf) of pressure. In very hard soils or rock, the correction is significant and must be applied. In no case should this correction exceed 0.5 % of the nominal volume of the measuring portion of the deflated probe (V_0) per 100 kPa (1 tsf) of pressure.

7.4 Corrections for temperature changes and head losses due to circulating liquid are usually small and may be disregarded in routine tests for soils. For tests at depths greater than 50 m (150 ft), special procedures are required to account for head losses.