TECHNICAL SPECIFICATION

ISO/TS 17892-3

First edition
2004-10-15

Geotechnical investigation and testing — Laboratory testing of soil —

Part 3: Determination of particle density — Pycnometer method

Reconnaissance et essais géotechniques — Essais de sol au laboratoire —

Partie 3: Détermination de la masse volumique des grains — Méthode du pycnomètre

Reference number
ISO/TS 17892-3:2004(E)

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Published in Switzerland

Foreword

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ISO/TS 17892-3 was prepared by the European Committee for Standardization (CEN) 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).

Throughout the text of this document, read "...this European pre-Standard..." to mean "...this Technical Specification...".

ISO 17892 consists of the following parts, under the general title *Geotechnical investigation and testing — Laboratory testing of soil*:

— *Part 1: Determination of water content*

— *Part 2: Determination of density of fine-grained soil*

— *Part 3: Determination of particle density — Pycnometer method*

— *Part 4: Determination of particle size distribution*

— *Part 5: Incremental loading oedometer test*

— *Part 6: Fall cone test*

— *Part 7: Unconfined compression test on fine-grained soil*

— *Part 8: Unconsolidated undrained triaxial test*

— *Part 9: Consolidated triaxial compression tests on water-saturated soil*

— *Part 10: Direct shear tests*

— *Part 11: Determination of permeability by constant and falling head*

— *Part 12: Determination of the Atterberg limits*

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Foreword

This document (CEN ISO/TS 17892-3:2004) has been prepared by Technical Committee CEN/TC 341 “Geotechnical investigation and testing”, the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 182 “Geotechnics”.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Introduction

This document covers areas in the international field of geotechnical engineering never previously standardised. It is intended that this document presents broad good practice throughout the world and significant differences with national documents is not anticipated. It is based on international practice (see [1]).

1 Scope

This document describes a test method for determining the particle density by the pycnometer method within the scope of the geotechnical investigations according to prEN 1997-1 and prEN 1997-2.

The pycnometer method is based on the determination of the volume of a known mass of soil by the fluid displacement method. The density of solid particles is calculated from the mass of the soil and the volume. The pycnometer method applies to soil types with particle sizes under 4 mm.

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.

prEN 1997-1, *Eurocode 7 - Geotechnical design — Part 1: General rules.*

prEN 1997-2*, Eurocode 7 - Geotechnical design — Part 2: Ground investigation and testing.*

3 Terms and definitions

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

3.1
density of solid particles
ρ_s
mass of the particles divided by their volume.

NOTE In porous materials which contain enclosed pores, the particles have an apparent density. This is a consequence of the enclosed, air-filled, pores.

4 Equipment

4.1 Balance

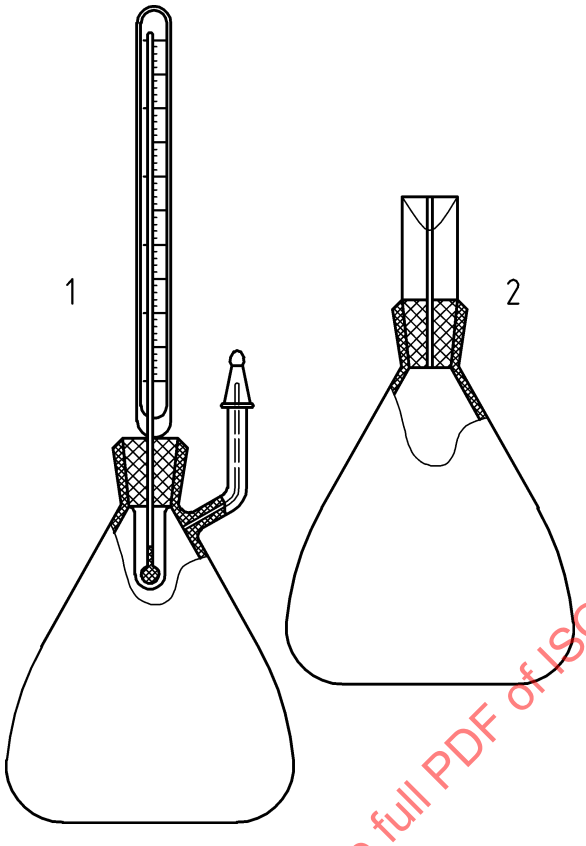
A balance of at least 0,001 g accuracy, and a measuring range of 200 g.

4.2 Pycnometer

A pycnometer with a volume of at least 50 ml, which is provided with a glass stopper which has been ground to fit precisely, and a capillary rising tube (see Figure 1).

4.3 Water bath

Thermosthatically controlled water bath, with temperature variations not exceeding ± 0,5 °C.



Key

1 Pycnometer with capillary and thermometer

2 Pycnometer with capillary

Figure 1 — Examples of pycnometers

4.4 Thermometer

The thermometer shall be readable to 0,1 °C. The thermometer should preferably be included in the glass stopper of the pycnometer. Alternatively, a thermometer may be placed in the water bath, as close to the pycnometer as possible.

4.5 Bell jar

A bell jar with air suction pump.

4.6 Riffle box

A riffle box for obtaining a representative part of the specimen.

Distribution by hand (quartering) is allowed if this results in a representative part of the specimen.

4.7 Drying oven

A drying oven capable of maintaining a temperature of 105 °C ± 5 °C.

4.8 Control liquid

4.8.1 A control liquid from de-aerated distilled, demineralized or deionized water.

4.8.2 In order to promote and accelerate complete saturation and deposition, a liquid with a lower surface tension than that of water may be used. Speed is particularly important for fine particles. Examples of such lower surface tension liquids are ethanol, trichloroethylene, methylenechloride, decahydronaphtalene and kerosene.

4.8.3 When working with soil which mainly consists of organic material, the liquids kerosene, toluene or hexane may be used. Hexane is less harmful to health than toluene and is therefore preferable.

WARNING —Use of other liquids than water can cause health or safety hazards, or contravene national laws.

5 Test procedure

5.1 Calibration

5.1.1 Pycnometer dry mass

The dry mass m_0 of the clean and dry pycnometer shall be determined to the nearest 0,001 g.

5.1.2 Pycnometer with control liquid

5.1.2.1 The pycnometer shall be filled with the control liquid. No air shall be left in the pycnometer or capillary tube.

5.1.2.2 The pycnometer shall be placed in the water bath. Only the neck, the stopper and the capillary rising tube of the pycnometer should emerge above the water surface of the water bath. This immersion shall be continued until the temperature of the liquid in the pycnometer has become equal to that of the water basin.

5.1.2.3 The level of the liquid in the pycnometer shall be verified. Liquid shall be added or removed when necessary. Depending on the type of pycnometer, the level of the liquid should be at the calibration mark, or at the top of the capillary.

5.1.2.4 After taking the pycnometer out of the water basin the pycnometer shall be dried immediately.

5.1.2.5 The total mass shall be determined immediately, to the nearest 0,001 g (m_1). But quickly drying and then immediately determining the mass of the pycnometer thermal expansion, which may result in a significant loss of liquid, is prevented.

5.2 Specimen requirements

5.2.1 The specimen may be oven-dried, or soil taken from soil in its natural condition.

5.2.2 The selected specimen shall be representative for the soil, and have a dry mass of at least 10 g. If the soil contains predominantly organic material, the selected specimen shall have a volume of at least 75 ml. In such case, a pycnometer with a volume of at least 100 ml shall be used. The specimen should not consist of one piece but of a quantity of granular material or fibre fragments.

5.2.3 Dry specimens shall be dried in an oven at 105 °C ± 5 °C until the mass of the soil specimen is constant. The time required to obtain constant mass will vary depending on the type of soil, size of specimen, oven type and capacity, and other factors. The influence of these factors generally can be established by good judgement, and

experience with the soil being tested and the apparatus being used. In most cases, drying a test specimen for 16 h to 24 h is sufficient. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the mass after two successive periods (greater than 1 h) of drying indicate an insignificant change (less than about 0,1 % of the specimen mass). Specimens of sand may often be dried to constant mass in a period of about 4 h, when a forced-draft oven is used.

5.2.4 If the density of the solid particles is to be determined without any pores, the porous material shall first be finely ground so that no enclosed pores are left.

5.3 Test execution

5.3.1 Method A: Oven-dried specimens

5.3.1.1 The pycnometer shall be cleaned and dried. The specimen shall be transfered to the pycnometer, and immediately the total mass shall be determined to the nearest 0,001 g (m_2):

5.3.1.2 The pycnometer which contains the specimen shall be filled with control liquid, until the liquid reaches to 10 mm to 20 mm above the soil.

5.3.1.3 Any enclosed air shall be removed by one of the following methods:

— The specimen shall be boiled gently for at least 10 min while agitating the pycnometer occasionally to assist in the removal of air. Then the heated specimen shall cool to room temperature.

— The contents shall be subjected to a vacuum for at least 30 min either by connecting the pycnometer directly to an aspirator or vacuum pump or by use of a bell jar. While the vacuum is being applied, the pycnometer shall be periodically agitated gently to assist the removal of the air.

— By using deaired water and removal of enclosed air from the soil by holding the pycnometer at an oblique angle, it shall be turned around its longitudinal axis and knocked gently.

5.3.1.4 The pycnometer shall be adjusted to constant temperature according to 5.1.2. The mass of the pycnometer completely filled with the saturated specimen and control liquid (m_3) shall be determined to the nearest 0,001 g.

5.3.2 Method B: Moist specimens

5.3.2.1 The specimen shall be transfered to the calibrated pycnometer. Specimens of clayey soils shall be dispersed in distilled water before transfering to the pycnometer.

5.3.2.2 The mass of the pycnometer with the test specimen (m_3) shall be determined in accordance with 5.3.1.2 to 5.3.1.4.

5.3.2.3 The specimen shall be removed from the pycnometer, and dried to a constant mass in a drying oven at 105°C ± 5°C.

5.3.2.4 The mass of the dry specimen shall be determined to the nearest 0,001 g (m_4).

5.3.2.5 The dry mass of the pycnometer shall be added to the dry mass of the specimen to obtain m_2.

6 Test results

6.1 Dry mass of specimen

For test method A, the dry mass of the specimen shall be determined by equation (1):

$$m_4 = m_2 - m_0 \quad (1)$$