

Australian Standard™

Method of testing soils for engineering purposes

Method 3.6.3: Soil classification tests— Determination of the particle size distribution of a soil—Standard method of fine analysis using a hydrometer

AS 1289.3.6.3

1 SCOPE

This Standard sets out a method for the quantitative determination of the particle size distribution in a soil from a coarse sand size down, using a hydrometer for particles finer than the 75 µm sieve (see Note 1). The method as described is not applicable if less than 10% of the material passes the 75 µm sieve as measured in AS 1289.3.6.1. If used in combination with AS 1289.3.6.2 this Method covers the determination of particles finer than the 75 µm sieve.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1152	Specification for test sieves
1289	Methods of testing soils for engineering purposes
1289.0	Part 0: General requirements and list of methods
1289.1	Method 1: Preparation of disturbed soil samples for testing
1289.2.1.1	Method 2.1.1: Soil moisture content tests—Determination of the moisture content of a soil—Oven drying method (standard method)
1289.3.5.1	Method 3.5.1: Soil classification tests—Determination of the soil particle density of a soil—Standard Method
1289.3.6.1	Method 3.6.1: Soil classification tests—Determination of the particle size distribution of a soil—Standard method of analysis by sieving
1289.3.6.2	Method 3.6.2: Soil classification tests—Determination of the particle size distribution of a soil—Analysis by sieving in combination with hydrometer analysis (subsidiary method)
1289.4.1.1	Method 4.1.1: Soil chemical tests—Determination of the organic matter content of a soil—Normal method

2026 Laboratory glassware—Density hydrometers

BS

1377 Methods of test for soils for civil engineering purposes

ASTM

D422 Standard Test Method for Particle-size Analysis of Soils

E100 Standard Specification for ASTM Hydrometers

3 APPARATUS

The following apparatus shall be used:

- (a) A hydrometer complying with the general specifications of AS 2026 and with the following features (see Figure 1):
 - (i) The glass used for the bulb and stem is as free as possible from visible defects.
 - (ii) The stem and bulb are circular in cross-section and symmetrical about the longitudinal axis, with no abrupt changes in cross-section, which may trap air bubbles or hinder cleaning or drying.
 - (iii) The basis of the scale is either density in grams per millilitre (g/mL) at 20°C or grams per litre (g/L) of colloid in suspension at 20°C. The g/mL scale is normally calibrated from 0.995 to 1.038 with graduation lines at every 0.0005 g/mL and a maximum permissible scale error of plus or minus one scale division (0.0005 g/mL). The g/L scale is normally graduated from -2 to +60, with graduation lines at every g/L, and a maximum permissible scale error of plus or minus one scale division (± 1 g/L). The scale is based on a soil particle density of 2.65 g/cm³.
- (b) Two 1 L capacity parallel sided graduated glass-measuring cylinders, about 60 mm internal diameter and 450 mm high, marked at 1 L volume, and graduated in divisions of 10 mL.
- (c) A thermometer covering the range of 0°C to 50°C, graduated to 1°C or less with an uncertainty not exceeding 0.5°C.
- (d) A mechanical dispersion device. The following have all been found to be suitable (see Note 2):
 - (i) A mechanical stirrer, e.g., an electrically driven mixer and a cup to fit, equipped with a wire baffle, the container and baffle being of material resistant to chemical attack from the reagents used. (Many types of paddle or agitator mixers are suitable provided they cause thorough mixing without crushing of particles or splashing. A low peripheral speed of the rotor tips is desirable, provided it is compatible with thorough mixing).
 - (ii) A mortar and suitable rubber pestle.
 - (iii) An air-jet dispersion cup of a type similar to that shown in ASTM D422.
- (e) Sieves, ranging from 2.36 mm to 75 μ m, and a receiver, as specified in AS 1152.
- (f) A balance of about 250 g capacity with a limit of performance not exceeding ± 0.05 g.
- (g) An oven as specified in AS 1289.0.
- (h) A stop-clock or stopwatch.
- (i) A millimetre scale, at least 150 mm in length.
- (j) Four porcelain evaporating dishes—a convenient size is 150 mm diameter.
- (k) A wide-mouth conical flask or conical beaker of 1 L capacity.
- (l) A Buchner funnel and filter flask of about 500 mL capacity with cover glass.
- (m) A 100 mL measuring cylinder.
- (n) A plastics wash bottle containing distilled water.
- (o) Filter papers (Whatman No. 50 or similar grade) to fit the Buchner funnel.
- (p) Litmus paper (blue) or suitable universal pH indicator papers.

- (q) A glass rod about 200 mm long and 5 mm diameter.
- (r) A means of obtaining a vacuum, e.g., a filter or vacuum pump.
- (s) A desiccator containing anhydrous silica gel.
- (t) A constant temperature room, bath or cabinet for maintaining the soil suspension at constant temperature during sedimentation. The bath or cabinet must not vibrate the sample.

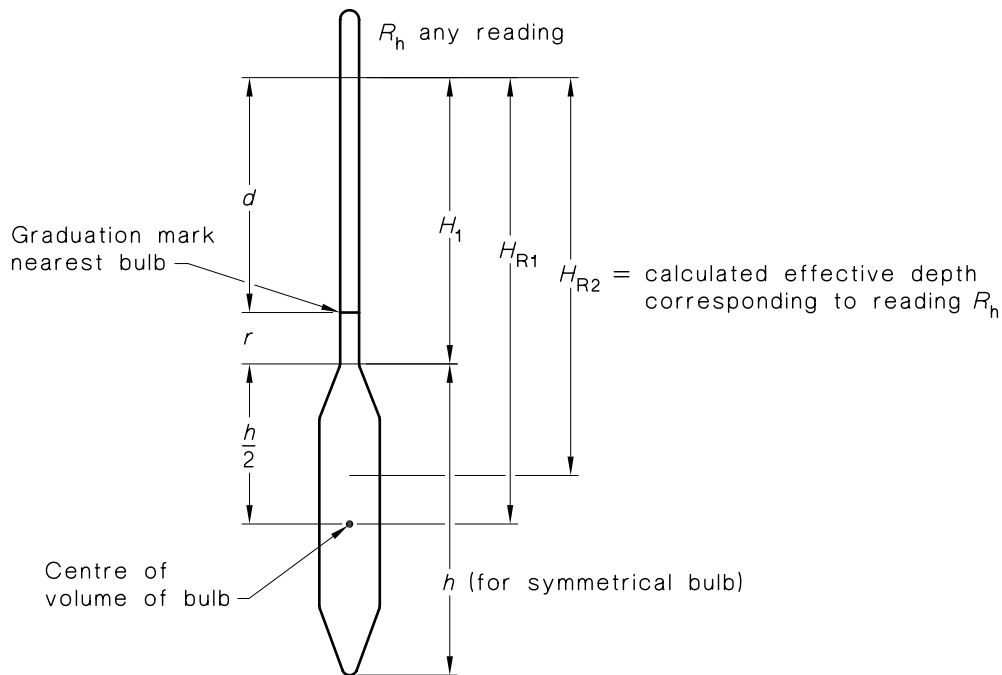


FIGURE 1 HYDROMETER

4 REAGENTS

Use reagents of recognized analytical reagent quality as follows:

- (a) *Hydrogen peroxide* A 20-volume solution.
- (b) *Hydrochloric acid 1M solution* Prepare by diluting 89 mL of concentrated acid ($\rho = 1.18 \text{ g/cm}^3$) with distilled water to make 1 L of solution.
- (c) *Stock dispersing solution* prepared as follows:
 - (i) Dissolve 33 g of sodium hexametaphosphate and either 7 g of anhydrous sodium carbonate (Na_2CO_3) or, alternatively, 18.9 g of hydrated sodium carbonate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) in distilled water to make 1 L of solution.
The decahydrate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) is more readily soluble in water than is anhydrous sodium carbonate (Na_2CO_3) which is only sparingly soluble. The use of warm distilled water will also accelerate the solution of the chemicals.
 - (ii) Store the stock solution in a dark bottle out of sunlight. The date of preparation, or expiry date, shall be recorded on the bottle. The stock solution will be unstable, and shall not be used, if more than one month old.
- (d) *Barium chloride solution* Prepare by dissolving 50 g of barium chloride in 1 L of distilled water.

5 DETERMINATION OF FACTOR F_1

5.1 Volume

Determine the volume of the hydrometer bulb (V_h) by either of the following methods:

- (a) From the volume of water displaced—
- pour approximately 800 mL of water into the graduated 1 L measuring cylinder, read and record the water level;
 - immerse the hydrometer carefully in the water, allow it to float, and again read and record the water level; and
 - record, in millilitres, the difference between the two readings as the volume of the hydrometer bulb plus the submerged part of the stem.
- NOTE: The error due to inclusion of this stem volume is negligible.
- (b) From the mass of the hydrometer—
- Determine the mass of the hydrometer to the nearest 0.1 g; and
 - Record the mass, in grams, as the volume in millilitres of the hydrometer bulb plus the volume of the stem below the 1.0 g/mL or 0 g/L graduation mark.
- NOTE: The error due to inclusion of this stem volume is negligible.

5.2 Hydrometer scale

The hydrometer scale shall be determined as follows:

- Determine the sectional area of the 1 L cylinder to be used in the test by measuring the distance between two graduations (e.g., 100 mL to 900 mL). Divide the volume in millilitres included between the graduations, by the measured distance in millimetres, and multiply by 1000 to obtain the sectional area (A) in square millimetres.
- Measure and record the distance (d), in millimetres, from the graduation mark nearest to the neck on the stem of the hydrometer to each of the other major graduation marks (R_h).
- Measure and record the distance (r), in millimetres, from the neck of the bulb to the nearest graduation mark.
- Calculate $H_1 = d + r$, in millimetres, corresponding to each graduation mark (see Figure 1).
- Measure the height of the bulb (h), in millimetres, from the neck to the bottom of the bulb. If the bulb is symmetrical record this distance as equal to twice the length from the neck of the bulb to its centre of volume. If the bulb is not symmetrical estimate the position of its centre of volume by any suitable means (see Note 3) and record twice the distance from the neck to the centre of volume as an equivalent h .
- Calculate the effective depth (H_R), in millimetres (see Note 4) corresponding to each major graduation mark from the equations:
 - $H_{R1} = H_1 + 0.5h$ for use when the hydrometer remains in the suspension from the start of the test;
 - $H_{R2} = H_1 + 0.5\left(h - \frac{1000V_h}{A}\right)$ for use when the hydrometer is inserted to take a single reading;

where

h = twice the distance from the neck of the bulb to its centre of volume, in millimetres

V_h = volume of hydrometer bulb, in millilitres

A = area of measuring cylinder, in square millimetres

- (g) Calculate a factor $F_1 = \sqrt{\frac{H_R}{10}}$ (see Note 5) and plot curves of F_1 , for both H_{R1} and H_{R2} against hydrometer reading R_h (corrected for meniscus only) (see Note 6).

6 PROCEDURE

6.1 Pretreatment of soil

The pretreatment of soil shall be as follows (see Note 7):

- (a) Obtain a sample that has been prepared in accordance with the procedure prescribed in AS 1289.1 and then take the following steps:

(i) Sieve sufficient representative material on the 2.36 mm sieve to provide, after riffing or quartering, two subsamples each about 50 g to 100 g of material passing the sieve and another subsample of about 200 g for determination of soil particle density. The mass of the smaller subsamples required will vary according to the type of soil, e.g., 50 g with a clayey soil and 100 g with a sandy soil (see Notes 8 and 9).

(ii) Determine the total mass (m_1) of all material passing the 2.36 mm sieve. Dry the material retained on the 2.36 mm sieve in the oven at 105°C to 110°C, allow to cool, and determine the dry mass (m_2).

(iii) Obtain the two subsamples of the air-dry material, passing the 2.36 mm sieve, by riffing or quartering, and determine the moisture content (w) of one subsample in accordance with AS 1289.2.1.1, and the mass of the other subsample (m_3) accurately to the nearest 0.01 g. Place the subsample (m_3) in the wide-mouth conical flask.

(iv) Calculate the oven-dry mass of the subsample (m_4) from—

$$m_4 = \frac{m_3 \times 100}{100 + w}; \text{ or}$$

(v) Alternatively, obtain the sample for the hydrometer analysis during the performance of a sieve analysis as described in AS 1289.3.6.2 by collecting the sieve washings instead of letting them run to waste. (The dry mass of this subsample (m_4) as defined in this method was calculated in AS 1289.3.6.2, as m_{10} of that test.) Evaporate any excess water.

- (b) For soils not containing calcium compounds or soluble salts and having an organic matter content less than 2% (as measured by AS 1289.4.1.1 (see Note 10)), the procedure described in Steps (d), (e) and (f) may be omitted (see Notes 10, 11 and 12) and the sample described in Step (a) used for the preparation of the suspension (see Note 11).

- (c) For samples obtained during the sieve analysis detailed in AS 1289.3.6.2, where pretreatment is required, filter the washings on the Buchner funnel and transfer all the soil on the filter paper to the wide mouth conical flask, using the minimum quantity of distilled water.

- (d) To remove organic matter, add 150 mL of hydrogen peroxide to the sample in the flask and stir the mixture gently with a glass rod for a few minutes. Cover the flask with a cover glass and leave it to stand overnight (about 12 h).

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