



# Test method T170

Determination of the soil suction –  
Moisture content relationship for soils

OCTOBER 2012



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## Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D.Dash	May 1999
		Date on Test Method Revised to Agree with Date on Revision	D.Dash	Feb 2001
Ed 2/ Rev 0	All	Reformatted RMS template	J Friedrich	July 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T170 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

# Test method T170

## Determination of the soil suction – Moisture content relationship for soils

### 1. Scope

This test method sets out the procedure for determining the soil suction - moisture content relationship for a soil in the range pF 1.0 to pF 4.2.

This test method is derived from American Society for Testing Materials Designation D2325-68.

### 2. Apparatus

- (a) Pressure plate extractors, 5 bar and 15 bar
- (b) Ceramic plates, 1 bar, 3 bar and 15 bar
- (c) A thermostatically controlled oven with good air circulation, capable of maintaining a temperature within the range 105°C to 110°C
- (d) A balance readable and accurate to 0.01 g
- (e) Tins for moisture content determination. A suitable size is approximately 60 mm diameter, 40 mm high with slip-on lid
- (f) Soil retaining rings made of brass, 55 mm dia and 10 mm high
- (g) Steel ram suitable for compacting soil into the above rings
- (h) Filter papers, No 50 soaked in 0.005% HgCl<sub>2</sub> solution and oven dried
- (i) Metal dishes approximately 230 and 100 mm in diameter
- (j) Mixing apparatus such as trowels and spatulas
- (k) 500 mL vacuum flasks
- (l) 250 mL beakers
- (m) 19.0 mm, 9.50 mm, 4.75 mm and 2.36 mm Australian Standard sieves
- (n) 3% copper sulphate solution (CuSO<sub>4</sub>)

### 3. Preparation of Sample

- (a) Dry the sample sufficiently to enable it to be crumbled, if necessary, dry in an oven at a temperature not exceeding 50°C
- (b) Break up any aggregations of particles in such a way as to avoid crushing any discrete particles. All aggregations of particles are to be broken down so that if the sample were sieved on a 4.75 mm A.S. sieve, only discrete uncrushed particles would be retained. A rubber pestle should be used to avoid breaking down sound pieces of mineral matter. Adhering material should be brushed from the coarse pieces. When in doubt as to whether lumps are to be broken place some in water and boil. If slaking occurs, the material should be broken down further with the rubber pestle
- (c) Reduce the sample as necessary, by quartering or riffing to an amount sufficient to yield not less than 3500 g of material passing a 2.36 mm A.S. sieve
- (d) Screen the sample on a 4.75 mm A.S. sieve. To facilitate this operation and to obviate overloading of sieves, screen the sample on 19.0 mm and 9.50 mm sieves prior to separating on the 4.75 mm A.S. sieve
- (e) Mix the material passing 4.75 mm A.S. sieve. Reduce the sample as necessary, by quartering or riffing to obtain a portion of approximately 2500 g. Determine the maximum dry density and optimum moisture content of the portion in accordance with the procedure described in Test Method T110
- (f) Screen the remainder of the sample on a 2.36 mm A.S. sieve and discard the material retained

- (g) Reduce the portion, as necessary, by quartering or riffing, to obtain a test portion of approximately 1000 g
- (h) Dry the test portion to constant mass at a temperature in the range 105°C to 110°C

#### 4. Procedure

- (a) Compaction of the specimens
  - (i) Calculate the amount of the test portion of the soil and water necessary to fill one of the brass retaining rings at maximum density and optimum moisture content as determined in *Preparation of Sample (e)*. Weigh out sufficient of the dry test portion (usually 1000 g) to fill twenty retaining rings
  - (ii) Add water to bring the 1000 g portion to the optimum moisture content. Place the soil in a sealed tin or plastic bag. Weigh out the quantity of wet soil sufficient to fill one ring as each sample is prepared
  - (iii) Compact each of the twenty soil portions into brass rings using a steel ram until the top of the compacted material is level with the top of the ring
  - (iv) Place ten of the compacted samples on filter papers in water approximately 10 mm deep for 24 hours
  - (v) Place the remaining ten compacted samples on filter papers and dry at a temperature in the range 105°C to 110°C for 24 hours
- (b) Preparation of Ceramic Plates
  - (i) Soak three 1 bar, one 3 bar and one 15 bar ceramic plates for 24 hours in water containing 3% CuSO<sub>4</sub>
  - (ii) Connect plastic tubes individually to two of the 1 bar plates and connect to separate vacuum flasks. Bleed out all the air from the ceramic plates by repeating syphoning. Set the head of water on the ceramic plates at zero
  - (iii) Place the remaining 1 bar ceramic plate, the 3 bar and the 15 bar plates in the two 5 bar and 15 bar pressure extractors respectively. Place the tubes connecting the ceramic plates to the atmosphere in beakers containing about 100mL of water
- (c) Divide the samples from *Procedure (a)* into five pairs of saturated samples and five pairs of oven dried samples. Subdivide the ten pairs of samples into five sets of samples; each set containing one pair of saturated samples and one pair of oven dried samples
- (d) Place one set of samples, still on their filter papers, on each of the five prepared ceramic plates. Place a weighed control sample of oven dried filter paper on each ceramic plate
- (e) Adjustment of ceramic plates and pressure plate extractors
  - (i) Adjust the head of water on the two 1 bar ceramic plates connected to the vacuum flasks to - 100 mm (pF 1.0) and - 630 mm (pF 1.8) respectively and enclose the individual ceramic plates and samples in plastic bags to minimise evaporation and thermal gradients
  - (ii) For the 1 bar ceramic plate in the 5 bar pressure extractor, secure the lid and raise the pressure to 30.3 kPa (pF 2.5)
  - (iii) For the 3 bar ceramic plate in the 5 bar pressure extractor, secure the lid and raise the pressure to 202.7 kPa (pF 3.3)
  - (iv) For the 15 bar ceramic plate in the 15 bar pressure extractor, secure the lid and raise the pressure to 1551 kPa (pF 4.2)
- (f) Leave the samples until equilibrium is reached (usually 7 to 10 days). Weigh the samples daily until constant mass is attained. Before removing the samples from the pressure extractors, and before the pressure is released, clamp the external tube. For weighing, place the samples plus filter papers in pre-weighed air tight containers and record the mass to the nearest 0.01 g

- (g) After constant mass has been attained and the mass recorded place the samples plus filter papers in the oven and dry to a constant mass at a temperature in the range 105°C to 110°C. Record the mass to the nearest 0.01 g.

## 5. Calculations

- (a) Calculate the moisture content for each sample as follows:-

$$\text{Moisture Content} = \frac{C - (A + B)}{A - D} \times \frac{100}{1} \%$$

Where

A = Mass of tin + dry sample + ring + dry filter paper (g)

B = Mass of water in control filter paper (g).

= Mass of wet filter paper - mass of dry filter paper (g)

C = Mass of tin + wet sample + ring + wet filter paper.

D = Mass of tin + ring + dry filter paper.

- (b) Calculated the moisture content separately for each suction value. Separate values are also to be obtained depending on whether the material was wetting up or drying out

## 6. Reporting

- (a) Report the moisture contents for each sample at each suction value to the nearest 0.1% and the average for the two samples reported to the nearest 0.1% for both the desorption and absorption curve
- (b) The moisture contents should be plotted against the pF values and a smooth curve drawn through the points

## 7. Techniques

- (a) Care must be taken to ensure all air is bled from the tubes connecting the 1 bar ceramic plate to the vacuum flasks. Any air bubbles in the system will significantly alter the result
- (b) The tubes leading from the pressure plate extractors must be under water at all times
- (c) The time taken for individual samples to reach equilibrium usually increases with increasing pF and may be longer for samples that are wetting up than for those that are drying out at any given pF value. Also fine grained soils generally take longer to reach equilibrium than sandy soils