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Soil improvers and growing media — Determination of physical properties — Dry bulk density, air volume, water volume, shrinkage value and total pore space

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Soil improvers and growing media - Determination of physical properties - Dry bulk density, air volume, water volume, shrinkage value and total pore space

Amendements du sol et supports de culture -
Détermination des propriétés physiques - Masse volumique
apparente sèche, volume d'air, volume d'eau, valeur de
rétraction et porosité totale

Bodenverbesserungsmittel und Kultursubstrate -
Bestimmung der physikalischen Eigenschaften - Rohdichte
(trocken), Luftkapazität, Wasserkapazität,
Schrumpfungswert und Gesamtporenvolumen

This European Standard was approved by CEN on 17 September 2011.

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Contents

Page

Foreword.....	3
1 Scope	4
2 Normative references	4
3 Terms and definitions	4
4 Principle.....	5
5 Apparatus	5
5.1 Double rings (see Figure A.1)	5
5.1.1 General.....	5
5.1.2 Lower sample ring	5
5.1.3 Upper ring.....	5
6 Preparation	6
7 Procedure	6
7.1 Moistening, saturating and equilibration at –50 cm water (–5 kPa) pressure head.....	6
7.2 Filling tubes.....	6
7.3 Suction –10 cm water (–1 kPa) pressure head	7
7.4 Separation of rings	7
7.5 Optional suction –50 cm and –100 cm water (–5 kPa and – 10 kPa) pressure head	7
7.6 Drying.....	7
7.7 Organic matter (W_{om}).....	8
7.8 Ash content (W_{ash}).....	8
8 Expression of results	8
8.1 Volume of the sample ring.....	8
8.2 Dry bulk density	8
8.3 Shrinkage value	9
8.4 Particle density	9
8.5 Total pore space	9
8.6 Water volume	10
8.7 Air volume	10
9 Number of replicates	11
10 Precision	11
11 Test report	11
Annex A (normative) Construction of sand suction table	12
Annex B (informative) Results of interlaboratory trial to determine the physical characteristics	16
Bibliography	26

Foreword

This document (EN 13041:2011) has been prepared by Technical Committee CEN/TC 223 “Soil improvers and growing media”, the secretariat of which is held by ASI.

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of an identical text or by endorsement, at the latest by May 2012, and conflicting national standards shall be withdrawn at the latest by May 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13041:1999.

The main change to the previous edition is in the scope of this document.

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1 Scope

This European Standard describes an instrumental method for the routine determination of the physical properties, dry bulk density, water volume, air volume, shrinkage value and total pore space of soil improvers or growing media.

This European Standard is not suitable for those materials which are very coarse, which do not make proper capillary contact or those which are pre-formed and non-particulate and have closed porosity. It is applicable to materials with particles ≤ 25 mm and/or flexible fibres ≤ 80 mm.

This method is not applicable to liming materials and preformed materials such as mineral wool slabs and foam slabs.

NOTE The requirements of the standard may differ from the national legal requirements for the declaration of the products concerned.

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.

EN 12579:1999, *Soil improvers and growing media — Sampling*

EN 13039, *Soil improvers and growing media — Determination of organic matter content and ash*

EN 13040:2007, *Soil improvers and growing media — Sample preparation for chemical and physical tests, determination of dry matter content, moisture content and laboratory compacted bulk density*

3 Terms and definitions

For the purposes of this document the terms and definitions given in EN 12579:1999 and the following apply.

3.1 air volume

that part of the volume of a sample filled by air measured under the conditions specified in this European Standard, in particular at a defined suction (e.g. -10 cm water = -1 kPa suction)

3.2 dry bulk density

ratio of the dry mass and volume of the sample in grams per litre

3.3 total pore space

total volume of voids filled with water and/or air measured under the conditions specified in this European Standard, in particular at a defined suction (e.g. -10 cm water = -1 kPa suction)

3.4 shrinkage value

loss in volume of the sample after drying a moist sample

3.5 water volume

that part of the volume of a sample filled by water measured under the conditions specified in this European Standard, in particular at a defined suction (e.g. -10 cm water = -1 kPa suction)

3.6

particle density

the ratio of the total mass of oven-dry solid particles (minerals, organic matter) to the volume of these particles. The volume of the internal pores of the particles and the pore spaces between particles are excluded

4 Principle

The sample is saturated in water and then equilibrated on a sand box at –50 cm water (–5 kPa) pressure head. The sample is then transferred into double ring sample cylinders, re-wetted and equilibrated at minus 10 cm water (–1 kPa) pressure head. After equilibration the physical properties are calculated from the wet and dry weights of the sample in the lower ring. After –10 cm water pressure head (= –1 kPa) it is optional also to apply –50 cm and –100 cm water (–5 kPa and –10 kPa) pressure head respectively.

5 Apparatus

5.1 Double rings (see Figure A.1)

5.1.1 General

The double rings and fixing collars described in this clause, shall be made from any rigid material that will not deform at a temperature of up to 120 °C.

5.1.2 Lower sample ring

5.1.2.1 Sample ring of internal diameter (D_1) (100 ± 1) mm and height (50 ± 1) mm.

As each ring is individually made it is necessary to determine the volume (V_1), record the mass (m_1) and identify each lower sample ring. The volume shall be determined by measuring the mean height (at least quadruplicate measurements) (h_1) and mean diameter (d_1) of the sample rings with a calliper gauge (At least triplicate measurements; top, middle and bottom).

5.1.2.2 Removable gauze-retaining ring or collar 20 mm high and 7,5 mm to 8,5 mm larger than the outer diameter of the sample ring.

5.1.2.3 Non-biodegradable synthetic gauze with a mesh size of about 0,1 mm.

5.1.3 Upper ring

5.1.3.1 Upper ring having the same internal diameter as the ring prepared in (see 5.1.2.1) and height (53 ± 1) mm.

5.1.3.2 Collar - fixed on the ring permitting the upper cylinder to be secured to the lower cylinder for the duration of the test.

5.2 Plastic tube, of approximately 14 cm diameter and 14 cm high to give a volume of about 2 l. Tightly stretch and secure the gauze (see 5.1.2.3) to one end of the tube by means of an elastic band.

5.3 Water bath, capable of holding at least 4 plastic tubes (see 5.2) standing on a coarse mesh and capable of being filled with water to the top of the plastic tubes.

5.4 Sand suction table (see Figure A.3)

Prepare the sand suction table for example in accordance with Annex A, using the fine sand to obtain the required suction. The pressure head in the plastic tubes (–50 cm water = –5 kPa) is measured from the

bottom of the tube. The pressure head in the rings (–10 cm, –50 cm and –100 cm water, equivalent to –1 kPa, –5 kPa and –10 kPa, respectively) is measured from the middle of the lower ring (see Figure A.3). The setting of the pressure head can be checked with a tensiometer or pressure transducer.

5.5 Ventilated drying oven set at $(103 \pm 2) ^\circ\text{C}$.

5.6 Analytical balance with a scale interval of 0,1 g.

5.7 Shallow vessel, spoon or scoop approximately 50 ml capacity.

6 Preparation

Prepare the laboratory sample in accordance with 8.4 of EN 13040:2007.

7 Procedure

7.1 Moistening, saturating and equilibration at –50 cm water (–5 kPa) pressure head

7.1.1 Fill at least 2 tubes (see 5.2) with the test portion taking care to prevent artificial air voids. Cover each tube with synthetic gauze (see 5.1.2.3) secured with an elastic band. Place the tube on the grid in a dry water bath (see 5.3).

7.1.2 Slowly, with constant flow, fill the bath with water until the level reaches to within 1 cm below the top of the tube. Filling should take approximately 30 min.

7.1.3 If a tube shows signs of floating, place a weighted disc on the top of the tube allowing air to evacuate and at the same time ensuring that compaction of the sample does not take place, (see Figure A.4).

7.1.4 Allow to stand maintaining a constant water level until the sample is thoroughly wetted (up to 36 h).

7.1.5 Remove the tubes and without delay, transfer the tubes to the sand suction table. The bottom of the tube should be fully in contact with the sand. Apply a –50 cm water (–5 kPa) pressure head, measured from the bottom of the tube, for 48 h.

7.2 Filling tubes

7.2.1 Secure the gauze (see 5.1.2.3) with the collar (see 5.1.2.2) to the base of the lower sample ring (see 5.1.2). Attach and secure the upper sample ring (see 5.1.3) to the lower sample ring.

7.2.2 Empty the tubes containing the equilibrated (–50 cm water, –5 kPa) wet sample from 7.1.5 onto a clean surface and gently mix taking care not to cause any physical damage to the sample.

7.2.3 Transfer using the shallow vessel (see 5.7) approximately 50 ml portions of the mixed sample to the prepared sample rings taking care to avoid compaction or artificial air voids and filling the cylinder and removable ring completely.

7.2.4 Fill at least 4 units with the sample. Place the unit on the grid in a dry water bath. Slowly, with constant flow, fill the bath (see 5.3) with water until the level reaches to within 1 cm below the top of the tube. Filling should take approximately 30 min.

7.2.5 Maintain a constant water level for 24 h (see Figure A.5).

NOTE Two different baths may be used, one for –10 cm water (–1 kPa) and one for –50 cm water (–5 kPa).

7.3 Suction –10 cm water (–1 kPa) pressure head

7.3.1 Carefully remove the units and without delay transfer to the sand bath (see 5.4) making sure there is contact between sand and the lower part of the unit. Cover the sand box and apply a –10 cm (–1 kPa) pressure head, measured from the middle of the lower ring.

7.3.2 It is important to regularly check that no air bubbles are present in the suction level regulator tubes.

Apply the suction until equilibrium is reached. A minimum of 48 h and up to 72 h is required.

7.4 Separation of rings

7.4.1 Remove the double ring sample cylinders from the sand box and place on a flat solid surface. Carefully remove the upper ring in a vertical movement. Use a knife or straight edge to strike off the material level with the top of the sample ring without causing compaction. The levelling of fibrous materials can best be done by cutting off excess matter with a pair of scissors exercising considerable care to avoid other disturbances.

7.4.2 Remove any materials adhering to the outside of the sample ring and record the mass (m_2) taking care not to turn the ring.

7.5 Optional suction –50 cm and –100 cm water (–5 kPa and –10 kPa) pressure head

NOTE After –10 cm water (–1 kPa) pressure head it is possible also to determine the air and water volume at –50 cm and –100 cm water (–5 kPa and –10 kPa) pressure head. The following procedure (see 7.5) can be skipped only if values for water and air volume at –10 cm water (–1 kPa) are necessary.

7.5.1 Carefully place the ring to the sand bath (see 5.4) making sure there is contact between the sand and the lower part of the ring. Cover the sand box and apply a –50 cm water (–5 kPa) pressure head, measured from the middle of the ring.

7.5.2 It is important to regularly check that no air bubbles are present in the suction level regulator tubes.

7.5.3 Apply the suction until equilibrium is reached. A minimum of 48 h and up to 72 h is required.

7.5.4 Record the mass (m_3).

7.5.5 Carefully place the ring to the sand bath (see 5.4) making sure there is contact between the sand and the lower part of the ring. Cover the sand box and apply a –100 cm water (–10 kPa) pressure head, measured from the middle of the ring.

7.5.6 It is important to regularly check that no air bubbles are present in the suction level regulator tubes.

7.5.7 Apply the suction until equilibrium is reached. A minimum of 48 h and up to 72 h is required.

7.5.8 Record the mass (m_4).

7.6 Drying

7.6.1 Place in the drying oven (see 5.5) without altering the structure and dry at $(103 \pm 2) ^\circ\text{C}$ to constant mass (m_5).

7.6.2 Remove the ring and measure with a calliper gauge the mean height (quadruplicate measurements) (h_2) and mean diameter (triplicate measurements; top middle and bottom) (d_2) of the dried samples.

NOTE This procedure cannot be carried out with some granular materials because they do not retain their shape on drying. In these cases, it is recommended to measure the height prior to drying.

7.7 Organic matter (W_{om})

Determine the organic matter content in accordance with EN 13039.

7.8 Ash content (W_{ash})

Determine the mineral matter content in accordance with EN 13039.

8 Expression of results

8.1 Volume of the sample ring

Calculate the volume of the sample ring using the following equation:

$$V_1 = \left\{ \pi \cdot (0,5d_1)^2 \cdot h_1 \right\} \quad (1)$$

where

V_1 is the volume of the ring in cubic centimetres, in cm^3 ;

d_1 is the diameter in centimetres of the sample ring;

h_1 is the height in centimetres of the sample ring.

8.2 Dry bulk density

$$D_{BD} = \frac{(m_3 - m_1)}{V_1} \cdot 1000 \quad (2)$$

where

D_{BD} is the dry bulk density in kilograms dry matter per cubic metre, in kg m^{-3} ;

m_1 is the mass in grams of the sample ring;

m_3 is the mass in grams of the dried sample plus sample ring;

V_1 is the volume in cubic centimetres of the sample ring.

8.3 Shrinkage value

Calculate the shrinkage value of the sample after drying using the following equation:

$$S_{\%} = \frac{V_1 - V_m}{V_1} \cdot 100 \quad (3)$$

where

$S_{\%}$ is the shrinkage value of the sample after drying expressed as a percentage by volume;

V_1 is the volume in cubic centimetres of the sample ring (see 8.1);

V_m is the mean volume in cubic centimetres of the dried sample $\{\pi(0,5 \cdot d_2)^2 \cdot h_2\}$.

8.4 Particle density

Calculate the particle density in duplicate using the following equation:

$$P_D = \frac{1}{\{W_{om}/(100 \times 1550)\} + \{W_{ash}/(100 \times 2650)\}} \quad (4)$$

where

P_D is the particle density in kilograms per cubic metre, in $\text{kg} \cdot \text{m}^{-3}$;

W_{om} is the organic matter content expressed as a percentage by mass, in 100 – ash %;

W_{ash} is the ash expressed as a percentage by mass;

1550 is taken as the density in kilograms per cubic metre of organic matter (see Puustjärvi [2], Verdonk [3]);

2650 is taken as the density in kilograms per cubic metre of ash (see Verdonk [3]).

8.5 Total pore space

Calculate the total pore space of the sample after applying –10 cm water (–1 kPa) pressure head using the following equation:

$$P_s = \left[1 - \left(\frac{D_{BD}}{P_D} \right) \right] \cdot 100 \quad (5)$$

where

P_s is the total pore space expressed as a percentage by volume, in % (V/V), wet sample at –10 cm water (–1 kPa) pressure head;

D_{BD} is the dry bulk density in kilograms per cubic metre, in kg m^{-3} ;

P_D is the mean value of the particle density in kilograms per cubic metre, in kg m^{-3} .

8.6 Water volume

Calculate the water volume after applying –10 cm and optional at –50 cm and –100 cm water (–1 kPa, –5 kPa and –10 kPa, respectively) pressure head using the following equations:

$$W_V \text{ at } -10 \text{ cm water } (-1 \text{ kPa}) \text{ pressure head} = \left(\frac{m_2 - m_5}{V_1} \right) \cdot 100 \quad (7)$$

$$W_V \text{ at } -50 \text{ cm water } (-5 \text{ kPa}) \text{ pressure head} = \left(\frac{m_3 - m_5}{V_1} \right) \cdot 100 \quad (8)$$

$$W_V \text{ at } -100 \text{ cm water } (-10 \text{ kPa}) \text{ pressure head} = \left(\frac{m_4 - m_5}{V_1} \right) \cdot 100 \quad (9)$$

where

W_V is the water volume content expressed as a percentage by volume, in % (V/V), wet sample at –10, –50 or –100 cm water (–1 kPa, –5 kPa or –10 kPa) pressure head;

V_1 is the volume in cubic centimetres of the sample ring;

m_2 is the mass in grams of the wet sample plus sample ring at –10 cm water (–1 kPa) pressure head;

m_3 is the mass in grams of the wet sample plus sample ring at –50 cm water (–5 kPa) pressure head;

m_4 is the mass in grams of the wet sample plus sample ring at –100 cm water (–10 kPa) pressure head;

m_5 is the mass in grams of the dried sample plus sample ring.

8.7 Air volume

Calculate the air volume content in the sample after applying –10 cm water (–1 kPa) pressure head and optional at –50 and –100 cm water (–5 kPa and –10 kPa) pressure head using the following equations:

$$A_V \text{ at } -10 \text{ cm water } (-1 \text{ kPa}) \text{ pressure head} = P_s - W_V \text{ at } -10 \text{ cm water } (-1 \text{ kPa}) \text{ pressure head} \quad (10)$$

$$A_V \text{ at } -50 \text{ cm water } (-5 \text{ kPa}) \text{ pressure head} = P_s - W_V \text{ at } -50 \text{ cm water } (-5 \text{ kPa}) \text{ pressure head} \quad (11)$$

$$A_V \text{ at } -100 \text{ cm water } (-10 \text{ kPa}) \text{ pressure head} = P_s - W_V \text{ at } -100 \text{ cm water } (-10 \text{ kPa}) \text{ pressure head} \quad (12)$$

where

A_V is the air volumetric content expressed as a percentage by volume, in % (V/V), wet sample at –10 cm, –50 cm or –100 cm water (–1 kPa, –5 kPa or –10 kPa) pressure head;

P_s is the total pore space expressed as a percentage by volume, in % (V/V), wet sample at –10 cm water (–1 kPa) pressure head (as defined in 8.5);

W_V is the water volume content expressed as a percentage by volume, in % (V/V), wet sample at –10 cm, –50 cm or –100 cm water pressure (–1 kPa, –5 kPa or –10 kPa) (as defined in 8.6).

9 Number of replicates

Determinations shall be carried out on the basis of four replicates.

The calculation of the particle density shall be carried out on the basis of two replicates on both results to be reported.

10 Precision

The repeatability and reproducibility of the physical characteristics of the sample measured in four separately prepared samples should be in accordance with Tables B.1 to B.6.

A summary of the results of an interlaboratory trial to determine the precision of the method in accordance with ISO 5725 is given in Annex B.

NOTE The values derived from the interlaboratory trial may not be applicable to concentrations and matrices other than those given.

11 Test report

The test report shall contain the following information:

- a) a reference to this European Standard;
- b) all information necessary for complete identification of the sample;
- c) the results of the determination in whole numbers;
- d) details of any operations not specified in the European Standard or regarded as optional, as well as any factor which may have affected the results.

Annex A (normative)

Construction of sand suction table

Construct a flushable drain system from semi-rigid tubing, e.g. as shown in Figure A.2 to fit the floor of the container, allowing a 2 cm margin from the walls. Cement all joints with waterproof adhesive. Cut slits 1 cm long in the underside of the tubing at 1 cm to 2 cm spacing. Wrap the tubes in 3 layers of nylon voile. Fit PVC tubing through the bung to the drain system and cement the bung into the sink outlet. Ensure that the drain system slopes upwards to a point above the outlet. Assemble glassware and external tubing as in Figures A.3 and A.4. Close the tap. Flush the drain system to remove the air. Fill all tubes with deaerated water and half fill the container. Connect a 5 l aspirator bottle and vacuum pump at point B. Pour sufficient clean coarse sand into the sink to cover the drain system to about 1 cm, ensuring that the slope towards the outlet is retained within the sand. Add about 3 cm of saturated fine sand. Open the tap A, turn on the vacuum to draw off water, but continue to maintain the water level well above the sand surface. When no air bubbles are visible in the tube below the sink outlet, close tap A and add a second layer of saturated fine sand. Repeatedly add fine sand and draw off included air until the sand surface is about 7 cm from the top of the sink, ensuring that at all times the surface is submerged under water. De-airing should continue at intervals for a few days after filling is completed, until there is no evidence of air in the system. Finally, remove the vacuum system from B, set the desired pressure by adjusting the height of the outflow of the levelling bottle, open the tap A and drain off surplus water. The desired pressure is $-(h)$ cm of water. Place a sheet of nylon voile on the sand surface while it is still wet.

To test that the sand has an air-entry value in excess of the desired pressure, leave the levelling bottle at this height for 2 d; raise the level at 10 min intervals by 20 cm until the surface is flooded, reconnect the vacuum source and check that no air appears at the outlet tube. During the later stages of filling the container, fine material may accumulate on the surface or in suspension, allow this to settle overnight and scrape off before recommencing filling.

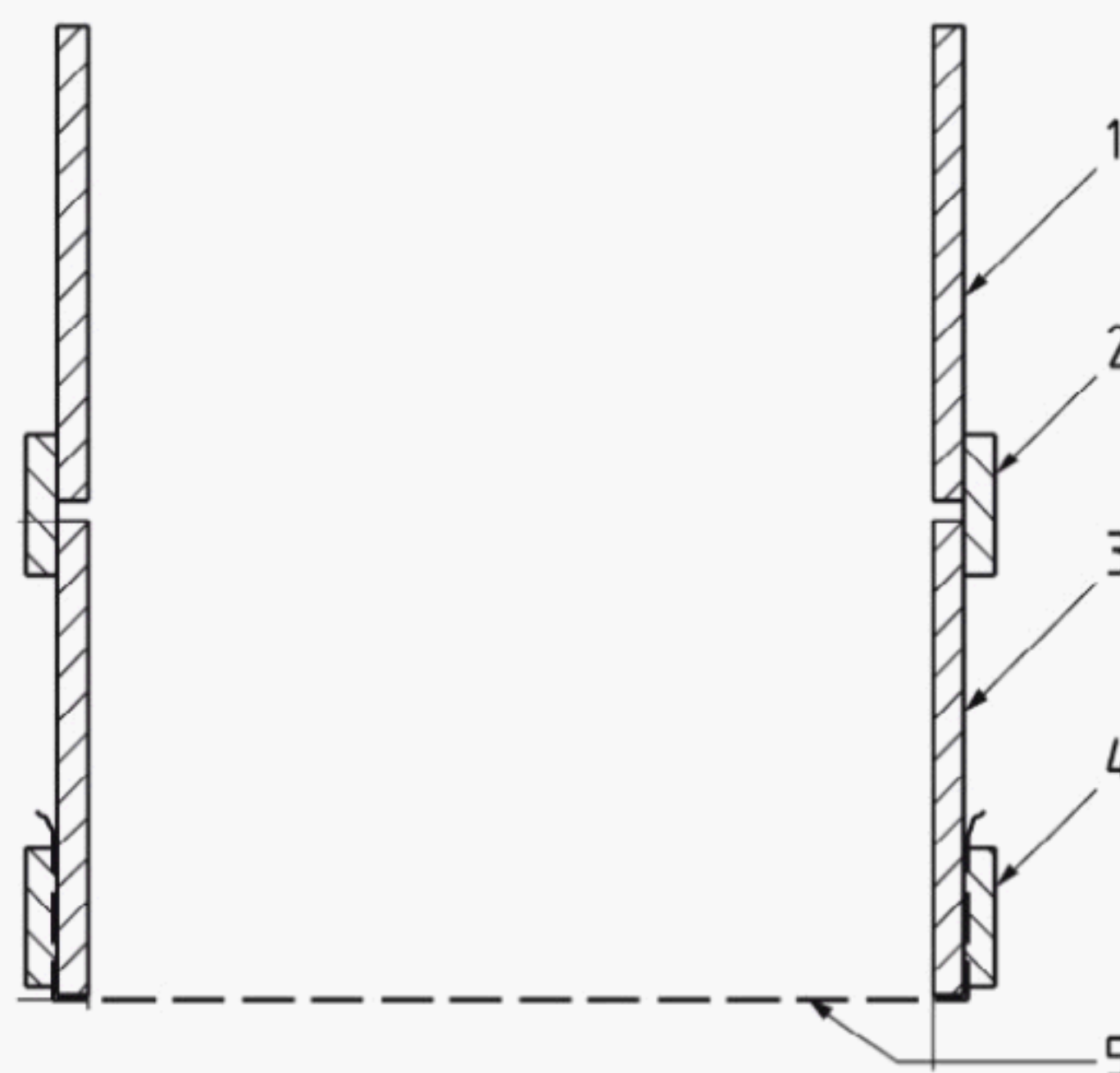
Should air entry occur at any time, reflood the sand table with de-aired water and allow to drain to the pre-set suction. In case the sand table becomes airlocked, apply a vacuum suction at point B as before, but only if the surface is water covered, otherwise air will be drawn into the system.

For construction of suction table commercially, available graded and washed industrial sands with a narrow particle size distribution are most suitable. The particle size distributions of some suitable grades and the approximate suctions they can attain are given in Table A.1. It is permissible to use other packing materials such as fine glass beads or aluminium oxide powder if they can attain the required air entry values.

NOTE The design of the suction table is given as an example.

Table A.1 — Permissible content of sands and silica flour for suction tables

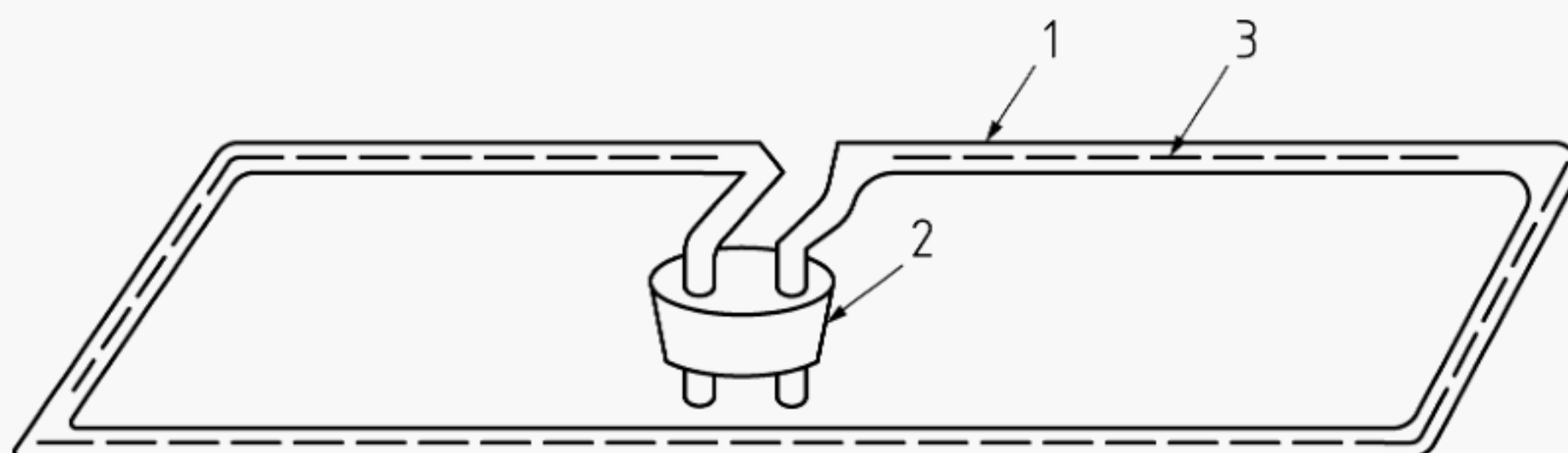
Typical particle size distribution	Permissible content % (V/V)		
	Coarse sand ^a	Medium sand ^b	Fine sand ^c
> 600 µm	1	1	1
> 200 µm to 600 µm	61	8	1
> 100 µm to 200 µm	36	68	11
> 63 µm to 100 µm	1	20	30
20 µm to 63 µm	1	3	52
< 20 µm	0	0	5
^a For base of suction tables. ^b For surface of suction tables at 5 kPa suction (5 kPa ≈ 50 cm). ^c For surface of suction tables at 11 kPa suction (11 kPa ≈ 110 cm).			
NOTE Pascal is the standard unit of pressure but many other units are still in use. Table A.1 of ISO 11274:1998 provides conversions for most units.			



Key

- 1 upper ring
- 2 fixed collar
- 3 lower sample ring
- 4 loose collar
- 5 synthetic gauze

Figure A.1 — Double ring

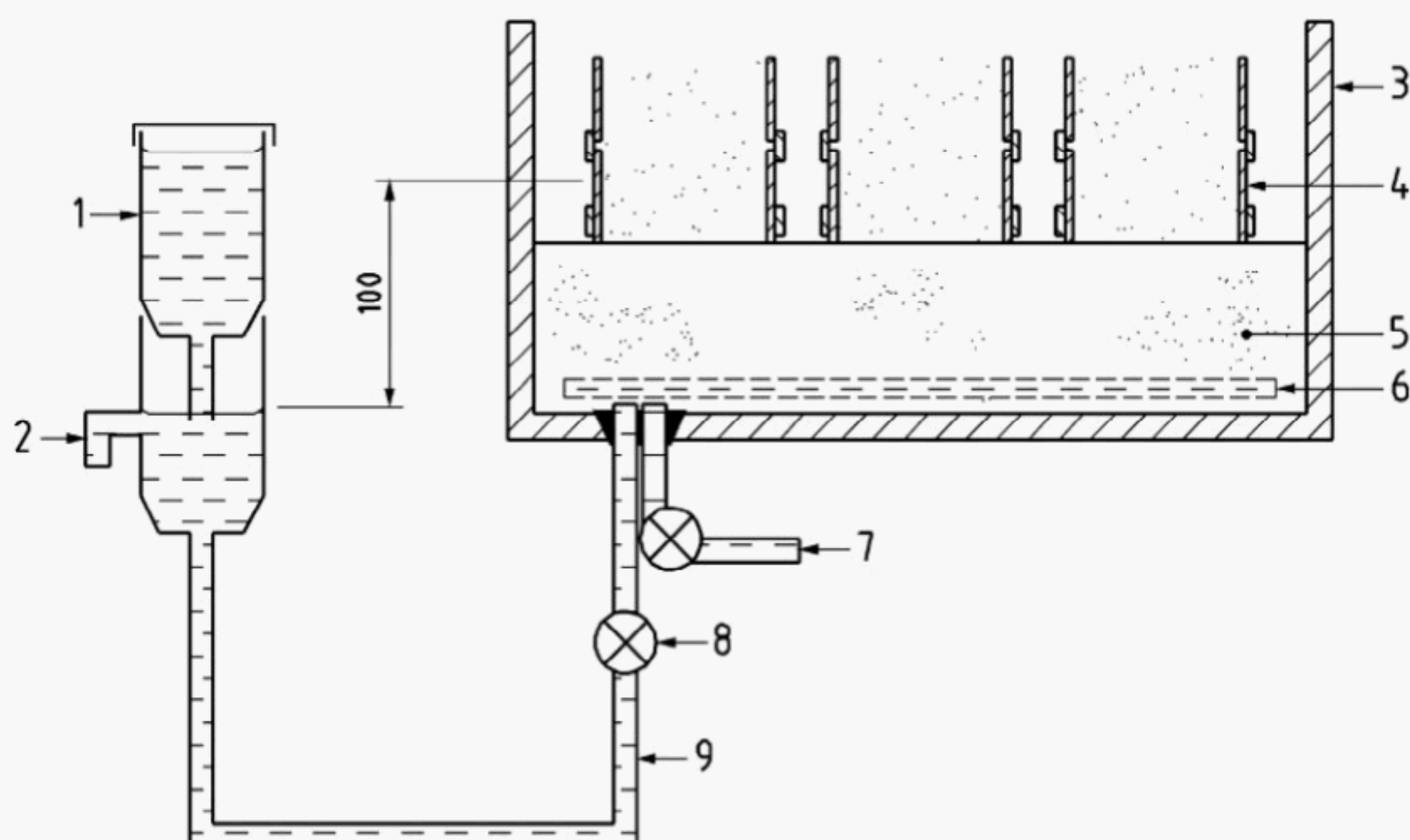


Key

- 1 nylon voile
- 2 bung
- 3 slotted underside

Figure A.2 — Drain system (sand box)

Dimensions in millimetres

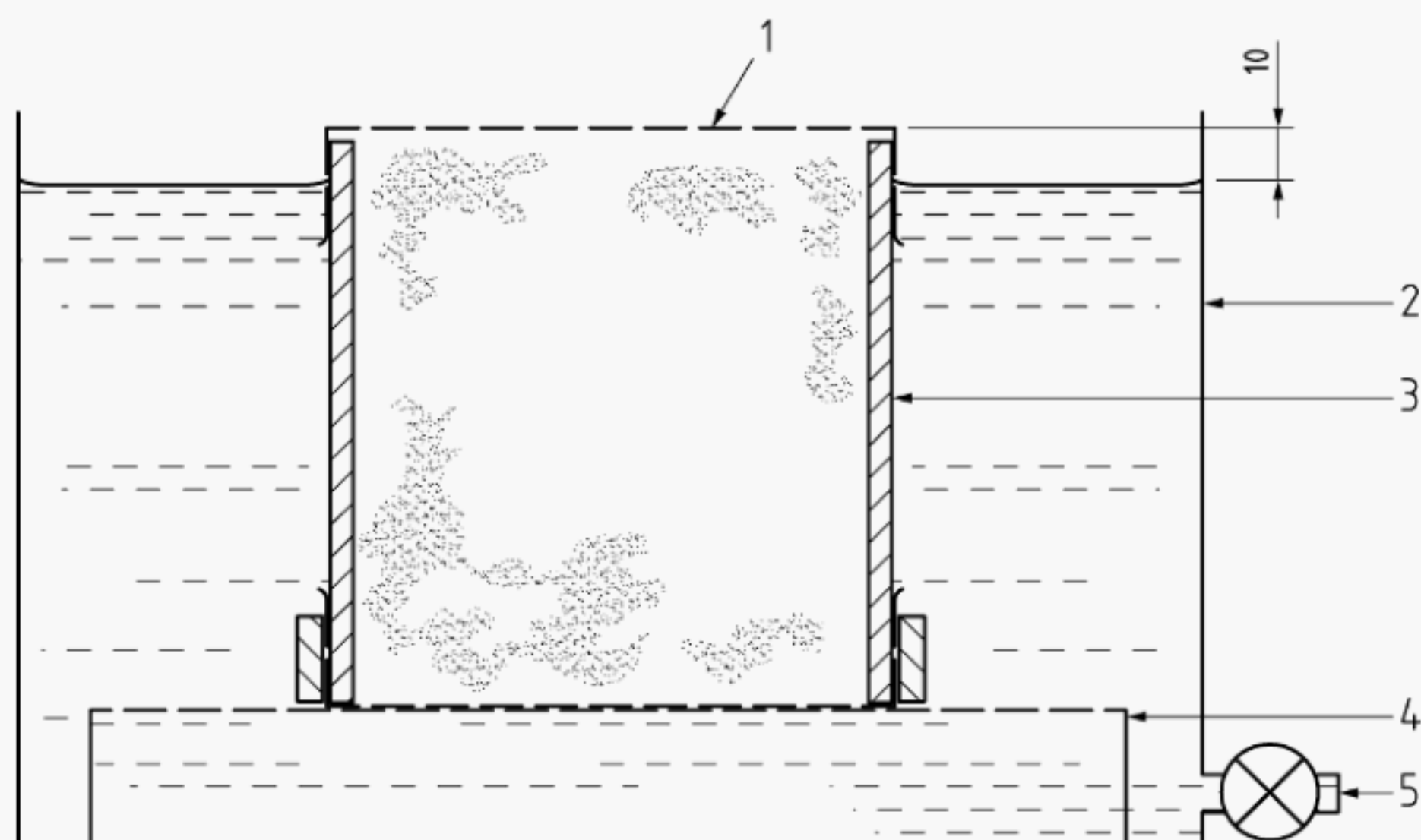


Key

- | | |
|---------------------------|----------------------------|
| 1 water reservoir | 6 drain system |
| 2 suction level regulator | 7 outlet and tap (point B) |
| 3 sand suction table | 8 tap A |
| 4 double ring unit | 9 flexible nylon tubing |
| 5 calibrated sand | |

Figure A.3 — Sand suction table

Dimensions in millimetres

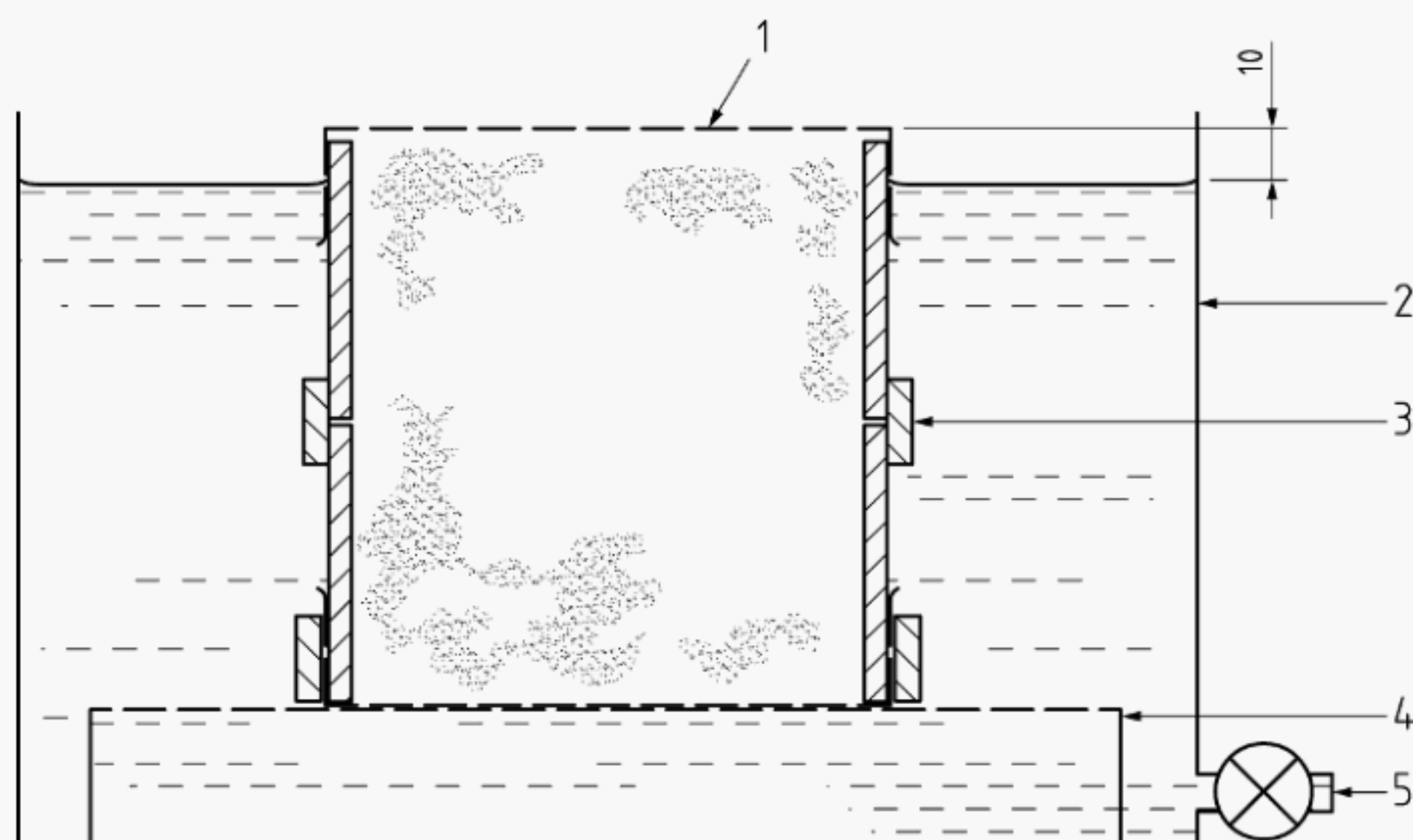


Key

- 1 nylon gauze
- 2 water bath
- 3 plastic tube
- 4 grid
- 5 outlet with tap

Figure A.4 — Moistening equipment

Dimensions in millimetres



Key

- | | |
|---------------|-------------------|
| 1 nylon gauze | 4 grid |
| 2 water bath | 5 outlet with tap |
| 3 double ring | |

Figure A.5 — Saturation equipment

Annex B
(informative)

Results of interlaboratory trial to determine the physical characteristics

Two interlaboratory trials were organized, one in 1995 and one in 2004, under the auspices of the European Committee for Standardization, to test the procedure specified in this European Standard.

In both trials the number of laboratories given in Tables B.1 to B.10 determined the physical characteristics in three different types of samples. Unfertilized peat/perlite, Composted coarse bark and composted straw and domestic sewage were analysed in 1995. Fertilized peat/ vermiculite growing medium, coarse coir dust and composted green waste were analysed in 2004 [4]. The samples were tested as received.

Table B.1 — Summary of the results of two interlaboratory trials for the determination of dry bulk density

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/ vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers	10	11	12	15	16	15
Number of outliers (laboratories)	1	0	0	1	0	1
Mean value (kg · m ⁻³)	102,5	190,6	322,3	174,8	72,2	281,7
Repeatability standard deviation, <i>s_r</i> (kg · m ⁻³)	1,73	4,19	5,35	4,75	2,41	6,11
Repeatability relative standard deviation (%)	1,67	2,20	1,66	2,72	3,33	2,17
Repeatability limit, <i>r</i> = 2,8 <i>s_r</i> (kg · m ⁻³)	4,84	11,73	14,98	13,31	6,74	17,10
Reproducibility standard deviation, <i>s_R</i> (kg · m ⁻³)	2,55	8,24	14,28	12,21	8,38	16,97
Reproducibility relative standard deviation (%)	2,49	4,33	4,43	6,98	11,61	6,02
Reproducibility limit, <i>r</i> = 2,8 <i>s_R</i> (kg · m ⁻³)	7,15	23,08	39,97	34,18	23,47	47,51

Table B.2 — Summary of the results of two interlaboratory trials for the determination of shrinkage

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers	9	9	10	14	12	13
Number of outliers (laboratories)	0	0	0	0	2	1
Mean value (% V/V)	25,9	21,6	27,8	33,8	16,4	15,4
Repeatability standard deviation, s_r (% V/V)	0,58	1,05	1,02	1,82	1,93	1,70
Repeatability relative standard deviation (%)	2,25	4,85	3,67	5,38	11,78	11,05
Repeatability limit, $r = 2,8 s_r$ (% V/V)	1,63	2,93	2,85	5,10	5,42	4,76
Reproducibility standard deviation, s_R (% V/V)	5,48	3,24	2,45	5,40	7,32	4,46
Reproducibility relative standard deviation (%)	21,18	15,03	8,81	15,95	44,60	29,00
Reproducibility limit, $r = 2,8 s_R$ (% V/V)	15,33	9,08	6,85	15,12	20,50	12,49

Table B.3 — Summary of the results of two interlaboratory trials for the determination particle density

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers	9	10	11	8	9	10
Number of outliers (laboratories)	2	1	1	6	5	4
Mean value ($\text{kg} \cdot \text{m}^{-3}$)	1691	1728	2005	1898	1579	2056
Repeatability standard deviation, s_r ($\text{kg} \cdot \text{m}^{-3}$)	9,51	12,60	11,86	2,41	0,64	23,70
Repeatability relative standard deviation (%)	0,56	0,73	0,59	0,13	0,04	1,15
Repeatability limit, $r = 2,8 s_r$ ($\text{kg} \cdot \text{m}^{-3}$)	26,6	35,3	33,2	6,75	1,80	66,35
Reproducibility standard deviation, s_R ($\text{kg} \cdot \text{m}^{-3}$)	11,93	32,43	28,75	9,63	13,55	30,51
Reproducibility relative standard deviation (%)	0,71	1,89	1,43	0,51	0,86	1,48
Reproducibility limit, $r = 2,8 s_R$ ($\text{kg} \cdot \text{m}^{-3}$)	33,4	90,8	80,5	26,97	37,94	85,44

Table B.4 — Summary of the results of two interlaboratory trials for the determination of the total pore space

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers	11	11	12	14	16	15
Number of outliers (laboratories)	0	0	0	2	0	1
Mean value (% V/V wet sample)	94,0	88,9	83,9	90,8	95,5	86,2
Repeatability standard deviation, s_r (% V/V wet sample)	0,08	0,31	0,28	0,24	0,13	0,32
Repeatability relative standard deviation (%)	0,08	0,35	0,33	0,27	0,14	0,37
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)	0,22	0,86	0,79	0,68	0,37	0,90
Reproducibility standard deviation, s_R (% V/V wet sample)	0,23	0,53	0,66	0,71	0,64	1,22
Reproducibility relative standard deviation (%)	0,24	0,60	0,78	0,78	0,67	1,41
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)	0,63	1,48	1,84	1,98	1,80	3,41

Table B.5 — Summary of the results of two interlaboratory trials for the determination water volume content at –10 cm water pressure (–1 kPa)

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers	11	11	12	15	16	15
Number of outliers (laboratories)	0	0	0	1	0	1
Mean value (% V/V wet sample)	77,9	62,7	52,0	82,3	37,8	44,9
Repeatability standard deviation, s_r (% V/V wet sample)	0,60	1,73	0,63	1,21	1,45	1,37
Repeatability relative standard deviation (%)	0,76	2,76	1,21	1,47	3,85	3,04
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)	1,69	4,85	1,77	3,40	4,07	3,82
Reproducibility standard deviation, s_R (% V/V wet sample)	3,26	3,81	3,78	3,35	3,26	3,55
Reproducibility relative standard deviation (%)	4,18	6,09	7,27	4,06	8,62	7,89
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)	9,12	10,68	10,59	9,37	9,13	9,93

Table B.6 — Summary of the results of two interlaboratory trials for the determination the air volume content at –10 cm water pressure (–1 kPa)

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers	11	11	12	15	16	15
Number of outliers (laboratories)	0	0	0	1	0	1
Mean value (% V/V wet sample)	16,0	26,2	31,9	8,3	57,7	40,8
Repeatability standard deviation, s_r (% V/V wet sample)	0,57	1,83	0,78	1,37	1,61	1,68
Repeatability relative standard deviation (%)	3,56	6,97	2,45	16,48	2,79	4,12
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)	1,58	5,12	2,19	3,85	4,51	4,70
Reproducibility standard deviation, s_R (% V/V wet sample)	3,33	4,13	4,26	3,71	3,56	3,77
Reproducibility relative standard deviation (%)	20,73	15,74	13,36	44,52	6,18	9,25
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)	9,31	11,56	11,94	10,39	9,97	10,57

Table B.7 — Summary of the results of two interlaboratory trials for the determination water volume content at –50 cm water pressure (–5 kPa)

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers				12	13	14
Number of outliers (laboratories)				2	2	1
Mean value (% V/V wet sample)				56,4	32,0	35,0
Repeatability standard deviation, s_r (% V/V wet sample)				0,89	1,23	1,04
Repeatability relative standard deviation (%)				1,57	3,86	2,96
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)				2,49	3,46	2,90
Reproducibility standard deviation, s_R (% V/V wet sample)				5,52	3,17	3,18
Reproducibility relative standard deviation (%)				9,78	9,93	9,10
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)				15,46	8,89	8,91

Table B.8 — Summary of the results of two interlaboratory trials for the determination the air volume content at –50 cm water pressure (–5 kPa)

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers				12	13	13
Number of outliers (laboratories)				2	2	2
Mean value (% V/V wet sample)				34,3	63,5	50,7
Repeatability standard deviation, s_r (% V/V wet sample)				0,99	1,32	1,14
Repeatability relative standard deviation (%)				2,90	2,08	2,25
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)				2,78	3,69	3,19
Reproducibility standard deviation, s_R (% V/V wet sample)				5,85	3,53	2,86
Reproducibility relative standard deviation (%)				17,06	5,56	5,64
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)				16,38	9,87	8,00

Table B.9 — Summary of the results of two interlaboratory trials for the determination water volume content at –100 cm water pressure (–10 kPa)

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers				11	11	11
Number of outliers (laboratories)				0	0	0
Mean value (% V/V wet sample)				50,7	31,1	33,6
Repeatability standard deviation, s_r (% V/V wet sample)				2,01	1,17	1,25
Repeatability relative standard deviation (%)				3,96	3,76	3,71
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)				5,62	3,27	3,50
Reproducibility standard deviation, s_R (% V/V wet sample)				6,42	3,28	3,60
Reproducibility relative standard deviation (%)				12,66	10,56	10,70
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)				17,97	9,19	10,08

Table B.10 — Summary of the results of two interlaboratory trials for the determination the air volume content at –100 cm water pressure (–10 kPa)

Sample	Unfertilized peat/perlite	Composted coarse bark	Composted straw and domestic sewage	Fertilized peat/vermiculite growing medium	Coarse coir dust	Composted green waste
Number of laboratories retained after eliminating outliers				11	11	11
Number of outliers (laboratories)				0	0	0
Mean value (% V/V wet sample)				40,1	64,3	52,6
Repeatability standard deviation, s_r (% V/V wet sample)				2,08	1,26	1,41
Repeatability relative standard deviation (%)				5,17	1,95	2,68
Repeatability limit, $r = 2,8 s_r$ (% V/V wet sample)				5,81	3,51	3,95
Reproducibility standard deviation, s_R (% V/V wet sample)				6,51	3,54	4,23
Reproducibility relative standard deviation (%)				16,24	5,50	8,05
Reproducibility limit, $r = 2,8 s_R$ (% V/V wet sample)				18,24	9,91	11,86

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