BRITISH STANDARD

BS EN 12350-7:2000

Testing fresh concrete —

Part 7: Air content — Pressure methods

The European Standard EN 12350-7:2000 has the status of a British Standard

ICS 91.100.30

National foreword

This British Standard is the official English language version of EN 12350-7:2000. It will supersede BS 1881-106:1983 which will be withdrawn in 2003 when the full package of the related concrete package is available.

The UK participation in its preparation was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/1, Production and testing, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 16, an inside back cover and a back cover.

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This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 July 2000

ISBN 0 580 35401 6

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12350-7

April 2000

ICS 91.100.30

English version

Testing fresh concrete – Part 7: Air content – Pressure methods

Essais pour béton frais – Partie 7: Détermination de la teneur en air – Méthode de la compressibilité

Prüfung von Frischbeton – Teil 7: Luftgehalte – Druckverfahren

This European Standard was approved by CEN on 1 November 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 12350-7:2000 E

CONTENTS

Foreword

This European Standard has been prepared by Technical Committee CEN/TC104, Concrete (performance, production, placing and compliance criteria), the Secretariat of which is held by DIN.

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 October 2000, and conflicting national standards shall be withdrawn at the latest by December 2003.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This standard is one of a series concerned with testing fresh concrete.

A draft for this standard was published in 1996 for CEN enquriy as prEN 12395. It was one of a series of individually numbered test methods for fresh or hardened concrete. For convenience it has now been decided to combine these separate draft standards into two new standards with separate parts for each method, as follows:

- Testing fresh concrete (EN 12350);
- Testing hardened concrete (EN 12390);
- Testing concrete in structures (EN 12504).

This series EN 12350 includes the following parts where the brackets give the numbers under which particular test methods were published for CEN enquiry:

EN 12350 Testing fresh concrete

Part 1: Sampling (former prEN 12378:1996);
Part 2: Slump test (former prEN 12382:1996);
Part 3: Vebe test (former prEN 12350:1996);
Part 4: Degree of compactability (former prEN 12357:1996);
Part 5: Flow table test (former prEN 12358:1996);
Part 6: Density (former prEN 12383:1996);
Part 7: Air content - Pressure methods (former prEN 12395:1996).

The standard is based on the draft International Standard ISO 4848, *Concrete – Determination of air content of freshly mixed concrete – Pressure method: First edition – 1980-03-15.* Like the ISO standard it specifies two types of meters for carrying out the test, the water column meter and the pressure gauge meter.

The results of a recent laboratory inter-comparison, in part funded by the EC under Measurement and Testing Programme, Contract MAT1-CT-94-0043 which investigated these two methods of measuring air content, did not find significant difference between them. However, it was found in this programme that the use of an internal vibrator to compact specimens of air entrained fresh concrete should only be done with caution, if loss of entrained air is to be avoided.

The determination of the aggregate correction value for the two methods has been included in normative annexes A and B.

The method of calibrating the two types of apparatus has been included in normative annexes C and D.

> **Caution** When cement is mixed with water, alkali is released. Take precautions to avoid dry cement entering the eyes, mouth and nose whilst mixing concrete. Prevent skin contact with wet cement or concrete by wearing suitable protective clothing. If cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash wet concrete off the skin immediately.

1 Scope

This standard describes two methods for determination of air content of compacted fresh concrete, made with normal weight or relatively dense aggregate of maximum size 63 mm.

NOTE: Neither method is applicable to concretes made with lightweight aggregates, air cooled blast-furnace slag, or aggregates with high porosity, because of the magnitude of the aggregate correction factor, compared with the entrained air content of the concrete.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 12350-1:1999
Testing fresh concrete – Part 1: Sampling.

EN 12350-6:1999
Testing fresh concrete – Part 6: Density.

3 Principles

3.1 General

There are two test methods, both of which use apparatus which employ the principle of Boyle-Mariotte's law. For the purpose of reference, the two methods are referred to as the water column method and the pressure gauge method and the apparatus as a water column meter and a pressure gauge meter.

3.2 Water column method

Water is introduced to a predetermined height above a sample of compacted concrete of known volume in a sealed container and a predetermined air pressure is applied over the water. The reduction in volume of the air in the concrete sample is measured by observing the amount by which the water level is lowered, the water column being calibrated in terms of percentage of air in the concrete sample.

3.3 Pressure gauge method

A known volume of air at a known pressure is merged in a sealed container with the unknown volume of air in the concrete sample. The dial on the pressure gauge is calibrated in terms of percentage of air for the resulting pressure.

4 Water column method

4.1 Apparatus

4.1.1 Water column meter, an example of which is shown in Figure 1, consisting of:

a) ***Container,*** a cylindrical vessel of steel or other hard metal, not readily attacked by cement paste, having a nominal capacity of at least 5 l and a ratio of diameter to height of not less than 0,75 nor more than 1,25. The outer rim and upper surface of the flange and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight and in addition it, and the cover assembly, shall be suitable for an operating pressure of approximately 0,1 MPa (N/mm^2) and be sufficiently rigid to limit the pressure expansion constant, *e* (see A.8), to not more than 0,1 % air content;

b) ***Cover assembly,*** a flanged rigid conical cover fitted with a standpipe. The cover shall be of steel or other hard metal not readily attacked by cement paste and shall have interior surfaces inclined at not less than 10° from the surface of the flange. The outer rim and lower surface of the flange and the sloping interior face shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between the flanges of the cover and the container;

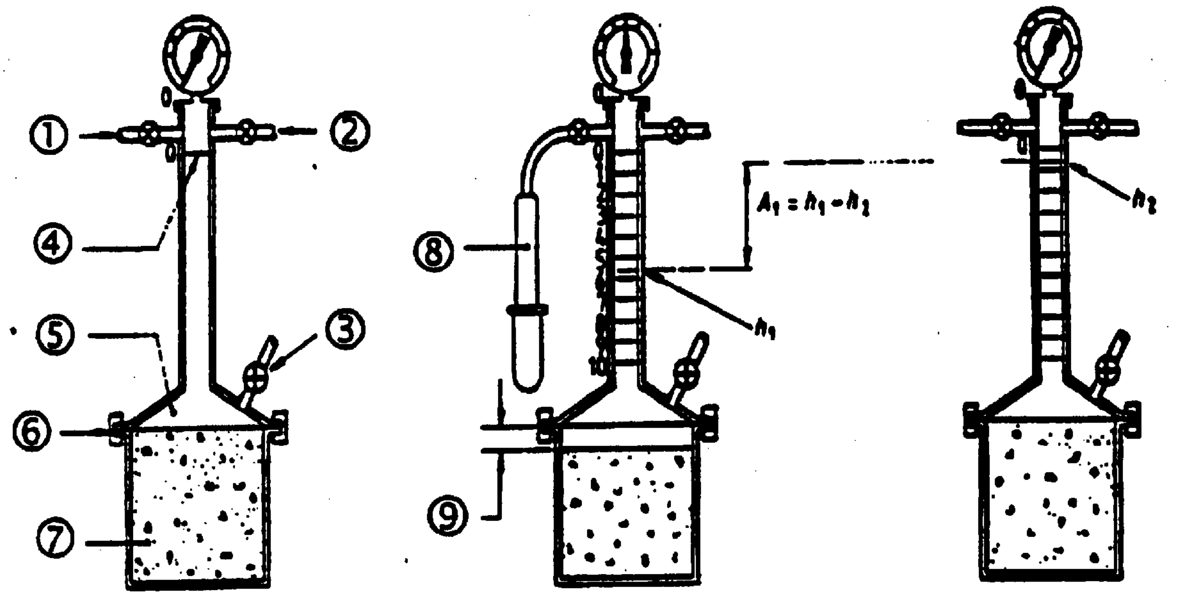
c) ***Standpipe,*** consisting of a graduated glass tube of uniform bore, or a metal tube of uniform bore with a glass gauge attached. The graduated scale shall indicate air content of 0 % to at least 8 % and preferably 10 %. The scale shall be graduated with divisions every 0,1 %, the divisions being not less than 2 mm apart. A scale in which 25 mm represents 1 % of air content is convenient;

d) ***Cover,*** fitted with a suitable device for venting the air chamber, a non-return air inlet valve and a small valve for bleeding off water. The applied pressure shall be indicated by a pressure gauge connected to the air chamber above the water column. The gauge shall be graduated with divisions every 0,005 MPa (N/mm^2), the divisions being not less than 2 mm apart. The gauge shall have a full scale reading of 0,2 MPa (N/mm^2);

e) ***Deflecting plate or spray tube,*** of a thin non-corrodable disc of not less than 100 mm diameter to minimize disturbance of the concrete when water is added to the apparatus. Alternatively a brass spray tube of appropriate diameter which may be an integral part of the cover assembly or provided separately. The spray tube shall be constructed so that when water is added to the container it is sprayed onto the walls of the cover in such a manner as to flow down the sides causing minimum disturbance to the concrete;

f) ***Air pump,*** with a lead facilitating connection to the non-return air inlet valve on the cover assembly.

The meter shall be in calibration at the time of the test, using the procedure in annex C. If the meter has been moved to a location which differs in elevation by more than 200 m from the location at which it was last calibrated, it shall be recalibrated.



a) Zero pressure

b) System operating at pressure *P*

c) Zero pressure after release of pressure *P*

Key:

1) Non-return valve
2) Air vent or valve
3) Bleed valve
4) Mark
5) Water
6) Clamp
7) Concrete
8) Air pump
9) Pressure lowered level

h_1 (reading at pressure *P*)
h_2 (reading at zero pressure after release of pressure *P*)

Figure 1: Water column method apparatus

NOTE: $h_1 - h_2 = A_1$ when the container holds concrete as shown in Figure 1.

$h_1 - h_2 = G$ (aggregate correction factor) when the container holds only aggregate and water.

$A_1 - G = A_c$ (air content of concrete).

4.1.2 Means of compacting the concrete, which may be one of the following:

a) ***Internal (poker) vibrator,*** with a minimum frequency of approximately 120 Hz (7 200 cycles per minute), the diameter of the tube not exceeding approximately one-quarter of the smallest dimension of the test specimen;

b) ***Vibrating table,*** with a minimum frequency of approximately 40 Hz (2 400 cycles per minute);

c) ***Compacting rod,*** of circular cross-section, straight, made of steel, having a diameter of approximately 16 mm, length of approximately 600 mm and with rounded ends;

c) ***Compacting bar,*** straight, made of steel having a square cross-section of approximately 25 mm × 25 mm and length of approximately 380 mm.

4.1.3 Scoop, approximately 100 mm width.

4.1.4 Two steel trowels or floats.

4.1.5 Remixing container, flat tray of rigid construction and made from a non-absorbent material not readily attacked by cement paste. It shall be of appropriate dimensions such that the concrete can be thoroughly re-mixed, using the square-mouthed shovel.

4.1.6 Shovel, with square mouth.

NOTE: The square mouth is required to ensure proper mixing of material on the remixing container.

4.1.7 Container with spout, having a capacity of 2 l to 5 l to fill the apparatus with water.

4.1.8 Mallet, soft-faced with a mass of approximately 250 g.

4.2 Procedure

4.2.1 Sampling

Obtain the sample of fresh concrete in accordance with EN 12350-1. Remix the sample before carrying out the test.

4.2.2 Filling the container and compacting the concrete

Using the scoop, place the concrete in the container in such a way as to remove as much entrapped air as possible. Place the concrete in three layers, approximately equal in depth. Compact the concrete immediately after placing it in the container, in such a way as to produce full compaction of the concrete, with neither excessive segregation nor laitance. Compact each layer by using one of the methods described below.

NOTE 1: Full compaction is achieved using mechanical vibration, when there is no further appearance of large air bubbles on the surface of the concrete and the surface becomes relatively smooth with a glazed appearance, without excessive segregation.

NOTE 2: The number of strokes per layer required to produce full compaction by hand will depend upon the consistency of the concrete.

The quantity of material used in the final layer shall be sufficient to fill the container without having to remove excess material. A small quantity of additional concrete may be added if necessary and further compacted in order to fill the container, but the removal of excess material should be avoided.

4.2.3 Mechanical vibration

4.2.3.1 Compacting with internal vibrator

Apply the vibration for the minimum duration necessary to achieve full compaction of the concrete. Avoid over-vibration, which may cause loss of entrained air.

NOTE 1: Care should be taken not to damage the container. The vibrator should be vertical and not allowed to touch the bottom or sides of the container. The use of a filling frame is recommended.

NOTE 2: Laboratory tests have shown that great care is needed if loss of entrained air is to be avoided, when using an internal vibrator.

4.2.3.2 Compacting with vibrating table

Apply the vibration for the minimum duration necessary to achieve full compaction of the concrete. The container should preferably be attached to, or firmly held against, the table. Avoid over-vibration, which may cause loss of entrained air.

4.2.4 Compacting with compacting rod or bar

Distribute the strokes of the compacting rod, or bar, in a uniform manner over the cross-section of the mould. Ensure that the compacting rod, or bar, does not forcibly strike the bottom of the container when compacting the first layer, nor penetrate significantly any previous layer. Subject the concrete to at least 25 strokes per layer. In order to remove pockets of entrapped air but not the entrained air, after compaction of each layer, tap the sides of the container smartly with the mallet until large bubbles of air cease to appear on the surface and depressions left by the compacting rod or bar, are removed.

4.2.5 Measuring air content

Thoroughly clean the flanges of the container and cover assembly. In the absence of the spray tube, place the deflecting plate centrally on the concrete and press it into contact. Clamp the cover assembly in place. Ensure that there is a good pressure seal between the cover and the container. Fill the apparatus with water and tap lightly with the mallet to remove air adhering to the interior surfaces of the cover. Bring the level of water in the standpipe to zero by bleeding through the small valve with the air vent open. Close the air vent and apply the operating pressure, P, by means of the air pump. Record the reading on the gauge tube, h_1, and release the pressure. Read the gauge tube again and if the reading, h_2, is 0,2 % air content or less record the value $(h_1 - h_2)$ as the apparent air content, A_1, to the nearest 0,1 % air content. If h_2 is greater than 0,2 % air content apply the operating pressure, P, again, giving a gauge tube reading h_3 and a final reading h_4 after release of the pressure. If $(h_4 - h_2)$ is 0,1 % air content or less record the value $(h_3 - h_4)$ as the apparent air content. If $(h_4 - h_2)$ is greater than 0,1 % air content, it is probable that leakage is occurring and the test shall be disregarded.

5 Pressure gauge method

5.1 Apparatus

5.1.1 Pressure gauge meter, an example of which is shown in Figure 2, consisting of:

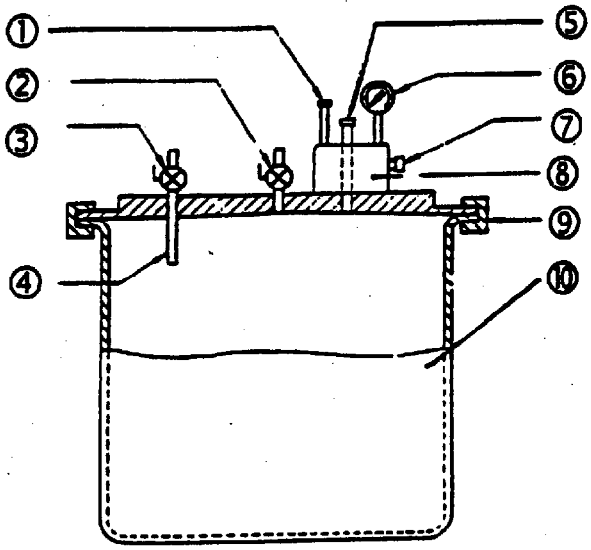
a) ***Container,*** a flanged cylindrical vessel of steel or other hard metal, not readily attacked by cement paste, having a nominal capacity of at least 5 l and a ratio of diameter to height of not less than 0.75 or more than 1.25. The outer rim and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight and in addition it and the cover assembly shall be suitable for an operating pressure of approximately 0,2 Mpa;

b) ***Cover assembly,*** a flanged rigid cover of steel or other hard metal not readily attacked by cement paste. The outer rim and lower surface of the flange as well as the interior surfaces shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between flanges of the cover and the container;

c) ***Pressure gauge,*** fitted to the cover assembly, calibrated to indicate air content from 0 % to at least 8 % and preferably 10 %. The graduations for different ranges of the scale should be 0,1 % for the range 0 to 3 %, 0,2 % for the range 3 to 6 % and 0.5 % for the range 6 to 10 %;

d) ***Air pump,*** built into the cover assembly.

The meter shall be in calibration at the time of the test, using the procedure in annex D.



Key:

1) Pump
2) Valve B
3) Valve A
4) Extension tubing for calibration checks
5) Main air valve
6) Pressure gauge
7) Air bleeder valve
8) Air chamber
9) Clamping device
10) Container

Figure 2: Pressure gauge method apparatus

5.1.2 Means of compacting the concrete, which may be one of the following:

a) ***Internal (poker) vibrator,*** with a minimum frequency of approximately 120 Hz (7 200 cycles per minute), the diameter of the tube not exceeding approximately one-quarter of the smallest dimension of the test specimen;

b) ***Vibrating table,*** with a minimum frequency of approximately 40 Hz (2 400 cycles per minute);

c) ***Compacting rod,*** of circular cross-section, straight, made of steel, with a diameter of approximately 16 mm length of approximately 600 mm and with rounded ends;

d) ***Compacting bar,*** straight, made of steel having a square cross-section of approximately 25 mm × 25 mm and length of approximately 380 mm.

5.1.3 Scoop, approximately 100 mm in width.

5.1.4 Two steel trowels or floats.

5.1.5 Remixing container, flat tray of rigid construction and made from a non-absorbent material not readily attacked by cement paste. It shall be of appropriate dimensions such that the concrete can be thoroughly re-mixed, using the square-mouthed shovel.

5.1.6 Shovel, with square mouth.

NOTE: The square mouth is required to ensure proper mixing of material on the remixing container.

5.1.7 Syringe, rubber, suitable for injecting water into the container, either through valve A or valve B.

5.1.8 Mallet, soft-faced with a mass of approximately 250 g.

5.1.9 Timer, capable of measuring to 0,5 s.

5.2 Procedure

5.2.1 Sampling

Obtain the sample of fresh concrete in accordance with EN 12350-1. Remix the sample before carrying out the test.

5.2.2 Filling the container and compacting the concrete

Using the scoop, place the concrete in the container in such a way as to remove as much entrapped air as possible. Place the concrete in three layers, approximately equal in depth. Compact the concrete immediately after placing it in the container, in such a way as to produce full compaction of the concrete, with neither excessive segregation nor laitance. Compact each layer by using one of the methods described below.

NOTE 1: Full compaction is achieved using mechanical vibration when there is no further appearance of large air bubbles on the surface of the concrete and the surface becomes relatively smooth with a glazed appearance, without excessive segregation.

NOTE 2: The number of strokes per layer required to produce full compaction by hand will depend upon the consistency of the concrete.

NOTE 3: The quantity of material used in the final layer shall be sufficient to fill the container without having to remove excess material. A small quantity of additional concrete may be added if necessary and further compacted in order to fill the container, but the removal of excess material should be avoided.

5.2.3 Mechanical vibration

5.2.3.1 Compacting with internal vibrator

Apply the vibration for the minimum duration necessary to achieve full compaction of the concrete. Avoid over-vibration, which may cause loss of entrained air.

NOTE 1: Care should be taken not to damage the container. The vibrator should be vertical and not allowed to touch the bottom or sides of the container. The use of a filling frame is recommended.

NOTE 2: Laboratory tests have shown that great care is needed if loss of entrained air is to be avoided when using an internal vibrator.

5.2.3.2 Compacting with vibrating table

Apply the vibration for the minimum duration necessary to achieve full compaction of the concrete. The container should preferably be attached to, or firmly held against, the table. Avoid over-vibration, which may cause loss of entrained air.

5.2.4 Compacting with compacting rod or bar

Distribute the strokes of the compacting rod, or bar, in a uniform manner over the cross section of the mould. Ensure that the compacting rod, or bar, does not forcibly strike the bottom of the container when compacting the first layer, nor penetrate significantly any previous layer. Subject the concrete to at least 25 strokes per layer. In order to remove pockets of entrapped air but not the entrained air, after compaction of each layer, tap the sides of the container smartly with the mallet until large bubbles of air cease to appear on the surface and depressions left by the compacting rod or bar are removed.

5.2.5 Measuring air content

Thoroughly clean the flanges of the container and cover assembly. Clamp the cover assembly in place. Ensure that there is a good seal between the cover and the container. Close the main air valve and open valve A and valve B. Using a syringe, inject water through either valve A or B until water emerges from the other valve. Lightly tap the apparatus with the mallet until all entrapped air is expelled. Close the air bleeder valve on the air chamber and pump air into the air chamber until the hand on the pressure gauge is on the initial pressure line. After allowing a few seconds for the compressed air to cool to ambient temperature stabilize the hand on the pressure gauge at the initial pressure line by further pumping in or bleeding off air as necessary. During this process lightly tap the gauge. Close both valve A and valve B and then open the main air valve. Tap the sides of the container sharply. Whilst lightly tapping the pressure gauge, read the indicated value, which is the apparent percentage of air, A_1. Open valves A and B in order to release the pressure before the cover assembly is removed.

6 Calculation and expression of results

Air content of the sample tested.

Calculate the air content of the concrete in the container, A_c, from the formula:

$$A_c = A_1 - G$$

where

A_1 is the apparent air content of the sample tested;

G is the aggregate correction factor.

Express the air content as a percentage to the nearest 0,1 %.

NOTE: The methods of determining the aggregate correction value are set out in annexes A and B.

7 Test report

The report shall include:

a) identification of the test sample;

b) location of performance of test;

c) date and time of performance of test;

d) measurement of consistency of the sample;

e) method of compaction;

f) aggregate correction (where appropriate);

g) test method and procedure used (water column or pressure gauge);

h) information relevant to the specific test, e.g. altitude;

i) measured air content;

j) any deviation from standard test method (where appropriate);

k) a declaration by the person carrying out the test that it was carried out in accordance with this standard, except as noted in item j).

The report may include:

l) temperature of the re-mixed sample;

m) observations on condition of test sample.

8 Precision

8.1 Water column method

Precision data are given in Table 1. These apply to air content measurements made by the water column method on concrete taken from the same sample and compacted by hand when each test result is obtained from a single air content determination.

Table 1 - Precision data for air content measurements

Level	**Repeatability conditions**		**Reproducibility conditions**	
	s_r	r	s_R	R
% 5,6	% 0,16	% 0,4	% 0,45	% 1,3

NOTE 1: The precision data were determined as part of an experiment carried out in the UK in 1987 in which precision data were obtained for several of the tests then described in BS 1881. The experiment involved 16 operators. The concretes were made using an ordinary Portland cement, Thames Valley sand, and Thames Valley 10 mm and 20 mm coarse aggregates.

NOTE 2: The difference between two tests results from the same sample by one operator using the same apparatus within the shortest feasible time interval will exceed the repeatability value r on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 3: Test results on the same sample obtained within the shortest feasible time interval by two operators each using their own apparatus will differ by the reproducibility value R on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 4: For further information on precision, and for definitions of the statistical terms used in connection with precision, see ISO 5725.

8.2 Pressure gauge method

No data are available on the precision of the pressure gauge method.

ANNEX A (normative) Aggregate correction factor - water column method

A.1 General

The aggregate correction factor will vary with different aggregates ,and although it remains reasonably constant for a particular aggregate, an occasional check shall be carried out. The aggregate correction factor can be determined only by test as it is not directly related to the water absorption of the particles.

A.2 Aggregate sample size

Determine the aggregate correction factor by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate proportions and moisture conditions that exist in the concrete sample. Obtain the sample of aggregates either by washing the cement from the concrete sample tested for air content, through a 150 μm sieve, or by using a combined sample of fine and coarse aggregate similar to that used in the concrete. In the latter case calculate the masses of fine and coarse aggregates to be used, m_f and m_c, respectively as follows:

$$m_f = V_o D p_f$$

$$m_c = V_o D p_c$$

where:

p_f and p_c	are the proportions of fine and coarse aggregates, respectively, expressed as fractions by mass of the total concrete mix (aggregates, cement and water);
V_o	is the capacity of the container (in cubic metres) (see C.3 of annex C);
D	is the density of the concrete to be tested (in kilograms per cubic metre), determined in accordance with EN 12350-6 or calculated from the known proportions and densities of the materials and the nominal air content.

A.3 Filling the container

Partially fill the container of the apparatus with water then introduce the combined sample of aggregate in small scoopfuls. This shall be done in such a manner as to entrap as little air as possible. If necessary add additional water to inundate all of the aggregate. After the addition of each scoopful remove any foam promptly then stir the aggregate with the compacting bar and tap the container with the mallet to release any entrapped air.

A.4 Determination of aggregate correction factor

When all the aggregate has been placed in the container wipe clean the flanges of the container and clamp the cover in position. Fill the apparatus with water and tap lightly with the mallet to remove air adhering to the interior surfaces of the apparatus. Bring the level of the water in the standpipe to zero by bleeding through the small valve with the air vent open. Close the air vent and apply the operating pressure, P, by means of the air pump.

Record the reading of the gauge tube as h_1, release the pressure and take a further reading, h_2. Repeat the entire procedure once, obtaining a second pair of readings, h_3 and h_4.Take the average value of $(h_1 - h_2)$ and $(h_3 - h_4)$ as the aggregate correction factor, G, unless the two values of $(h_1 - h_2)$ and $(h_3 - h_4)$ differ by more than 0,1 % air content, in which case carry out further determinations until consistent results are obtained.

ANNEX B (normative)
Aggregate correction factor - pressure gauge method

B.1 General

The aggregate correction factor will vary with different aggregates, and although ordinarily it remains reasonably constant for a particular aggregate, occasional checks shall be carried out. The aggregate correction factor can be determined only by test as it is not directly related to the water absorption of the particles.

B.2 Aggregate sample size

Determine the aggregate correction factor by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate amounts, proportions and moisture conditions that exist in the concrete sample. Obtain the sample of aggregates either by washing the cement through a 150 μm sieve from the concrete sample tested for air content or by using a combined sample of fine and coarse aggregate similar to that used in the concrete. In the latter case calculate the masses of fine and coarse aggregates to be used, m_f and m_c respectively, as follows:

$$m_f = V_o D_{pf}$$

$$m_c = V_o D p_c$$

where

p_f and p_c are the proportions of fine and coarse aggregates, respectively, expressed as fractions by mass of the total concrete mix (aggregates, cement and water);

V_o is the capacity of the container (in cubic metres) determined as described in D.3 of annex D;

D is the density of the concrete to be tested (in kilograms per cubic metre), determined in accordance with EN 12350-6 or calculated from the known properties and densities of the materials and the nominal air content.

B.3 Filling the container

Partially fill the container of the apparatus with water then introduce the combined sample of aggregate in small scoopfuls in such a manner as to entrap as little air as possible.

If necessary add additional water to inundate all of the aggregate. After the addition of each scoopful remove any foam promptly and stir the aggregate with the compacting bar and tap the container with the mallet to release any entrapped air.

B.4 Determination of aggregate correction factor

When all the aggregate has been placed in the container wipe clean the flanges of the container and the cover assembly thoroughly and clamp the cover assembly into position so that a pressure-tight seal is obtained. Close the main valve and open valves A and B. Using the rubber syringe, inject water through either valve A or valve B until water emerges from the other valve. Tap the apparatus lightly with the mallet until all entrapped air is expelled from this same valve. Remove a volume of water from the container approximately equivalent to the volume of air that would be contained in a typical concrete sample of a size equal to the volume of the container. Remove the water in the apparatus in the manner described in D.4 for the calibration test. Complete the test using the procedure described in 5.2.5.

The aggregate correction factor, G, is equal to the reading on the air content scale minus the volume of water removed from the container expressed as a percentage of the capacity of the container.

ANNEX C (normative)
Calibration of apparatus - water column method

C.1 General

C.1.1 The calibration tests described in C.3, C.4, C.5 and C.6 shall be made at the time of the initial calibration of the apparatus and at any time when it is necessary to check whether the capacity of the calibration cylinder or container may have changed. The calibration test described in C.7 and C.8 shall be made as frequently as necessary to check the pressure gauge in order to ensure that the proper gauge pressure, *P*, is being used. Recalibration of the apparatus will also be required when the location at which it is to be used varies in elevation by more than 200 m from that at which it was last calibrated.

C.2 Apparatus

C.2.1 Calibration cylinder, of brass or other strong non-corrodable metal, having a capacity of approximately 0,3 l. The rim of the cylinder shall be machined to a smooth plane surface at right angles to the axis of the cylinder.

C.2.2 Support, for the calibration cylinder made of non-corrodable material and which allows free flow of water into and out of the cylinder in the inverted position.

C.2.3 Spring, or equivalent made from non-corrodable material for retaining the calibration cylinder in place.

C.2.4 Transparent plates, one suitable for use as a closure for the calibration cylinder and one as a closure for the container.

C.2.5 Balances, a calibrated balance capable of weighing up to 1 kg to an accuracy of ±0,5 g over the range used in the test and a calibrated balance capable of weighing up to 20 kg to an accuracy of ±5 g over the range used in the test.

C.3 Capacity of the calibration cylinder

Using the 1 kg balance, determine the capacity of the calibration cylinder by measuring the mass of water required to fill it. For this purpose, fill the weighed cylinder with water at ambient temperature (15 °C to 25 °C) and carefully cover it with the previously weighed transparent plate, ensuring that no air bubbles are trapped under the plate and that surplus water is wiped away before weighing the assembly. By repeating this procedure, make a total of three weighings of the covered cylinder filled with water. Calculate the average mass of water, m_1, contained in the full cylinder and record it to the nearest 0,5 g.

C.4 Capacity of the container

Using the 20 kg balance, determine the capacity of the container by measuring the mass of water required to fill it. For this purpose, smear a thin film of grease on the flange of the container, and, after weighing empty, fill with water at ambient temperature (15 °C to 25 °C). Make a watertight joint by sliding the weighed transparent plate over the top of the container, ensuring that no air bubbles are trapped under the plate and that surplus water is wiped away before weighing the assembly. By repeating this procedure, make a total of three weighings of the covered container filled with water. Calculate the average mass of water, m_2, contained in the full container and record it to the nearest 5 g.

C.5 Pressure expansion constant, *e*

Determine the pressure expansion constant by filling the apparatus with water, making sure that all entrapped air has been removed and the water level is exactly on the zero mark, and applying an air pressure of 100 kPa. The reading of water column (in percent air content) will be the pressure expansion constant, *e*, for the apparatus.

NOTE: Strictly speaking, the air pressure applied during this procedure should be the required operating pressure *P* determined as in C.8. However, as the value of *e* is needed to determine *P* by way of the calibration constant *K* a logically closed cycle of operations exists. In practice, the change in *e*, due to a change in *P*, is small enough to be ignored. As *P* is commonly about 100 kPa, this value is prescribed to overcome the problem. Its use will lead to a value of *e* that is sufficiently accurate for the test.

C.6 Calibration constant, *K*

The calibration constant is the reading needed on the air content scale during the routine calibration procedure to obtain the gauge pressure required to make the graduations on the air content scale correspond directly to the percentage of air introduced into the container by the calibration cylinder when the container is full of water.

The constant, *K*, is generally calculated using the formula:

$$K = 0{,}98\,R + e$$

where

e is the pressure expansion constant (see C.5);

R is the capacity of the calibration cylinder expressed relative to the capacity of the container and is calculated using the formula:

$$R = \frac{m_1}{m_2} \times 100\,\%$$

NOTE: The factor 0.98 is used to correct for the reduction in the volume of air in the calibration vessel when it is compressed by a depth of water equal to the depth of the container. This factor is approximately 0,98 for a 200 mm deep container at sea level. Its value decreases to approximately 0,975 at 1 500 m above sea level and 0,970 at 4 000 m above sea level. The value of the constant will decrease by approximately 0,01 for each 100 mm increase in bowl depth. Hence the term 0,98*R* represents the effective volume of the calibration vessel expressed as a percentage of the container under normal operating conditions.

C.7 Required operating pressure

Place the calibration cylinder support centrally on the bottom of the clean container and place the cylinder on the support with its open end downward. Place the coil spring on the cylinder and clamp the cover assembly carefully in place.

Fill the apparatus with water at ambient temperature to a level above the zero mark on the air content scale. Close the air vent and pump air into the apparatus approximately to the operating pressure (about 100 kPa). Lightly tap the sides and cover with the mallet to remove as much entrapped air as possible adhering to the interior surfaces of the apparatus and gradually reduce the pressure by opening the vent. Bring the water level exactly to the zero mark by bleeding water through the small valve in the conical cover and close the air vent. Apply pressure by means of the pump until the reading of the water level equals the calibration constant, *K* (see C.6). Record the pressure, *P*, indicated on the pressure gauge. Gradually release the pressure by opening the vent until zero pressure is indicated. If the water level returns to a reading less than 0,05 % air content, take the pressure, *P*, as the operating pressure. If the water level fails to return to a reading below 0,05 % air content, check the apparatus for leakage and repeat the procedure.

C.8 Alternative operating pressure

The range of air contents which can be measured with a particular apparatus can be extended by determining an appropriate alternative operating pressure, e.g: if the range is to be doubled the alternative operating pressure, P_1, is that for which the apparatus indicates half of the calibration reading, *K* (see C.6).

Exact calibration will require the determination of the pressure expansion constant, *e* (see C.5), for the reduced operating pressure but, since the change in the pressure expansion constant can normally be disregarded, the alternative operating pressure can be determined during the determination of the normal operating pressure (see C.7).

ANNEX D (normative)
Calibration of apparatus - pressure gauge method

D.1 General

The calibration test detailed below shall be made as frequently as necessary to check the accuracy of the graduations indicating air content on the dial of the pressure gauge.

NOTE: Recalibration of the apparatus is not required with changes in elevation at which it is used or with changes in atmospheric pressure.

D.2 Apparatus

D.2.1 Calibration cylinder, of brass or other non-corrodable metal having a capacity of approximately 0,3 l, which may be integral with the cover assembly.

D.2.2 Transparent plate, suitable for use as a closure for the container.

D.2.3 Balance, calibrated and capable of weighing up to 1 kg to an accuracy of ±0,5 g over the range used in the test and a calibrated balance capable of weighing up to 20 kg to an accuracy of ±5 g over the range used in the test.

D.3 Checking the capacity of the container

The capacity of the container is found by determining the mass of water, m_2, required to fill it.

Smear a thin film of grease on the flange of the container to make a water tight joint between the transparent plate and the top of the container. Fill the container with water at ambient temperature and place the transparent plate over it to eliminate any convex meniscus. Wipe away surplus water and determine the mass of the container filled with water by weighing on the balance.

D.4 Checking air content graduations on the pressure gauge

Screw the extension tubing (see Figure 2) into the threaded hole beneath valve A on the underside of the cover assembly and clamp the cover assembly into place, taking care to ensure that there is a good pressure seal between cover and container. Close main air valve and open valves A and B. Add water through valve A until all trapped air has been expelled through valve B. Pump air into the air chamber until the pressure reaches the indicated initial pressure line. After allowing a few seconds for the compressed air to cool to ambient temperature, stabilize the hand on the pressure gauge at the initial pressure line by further pumping in or bleeding off air as necessary. During this process lightly tap the gauge and close valve B.

Remove water from the apparatus to the calibration cylinder in sufficient quantity to fill it completely, or up to a predetermined line marked on it, then determine the mass of water displaced, m_3, by weighing on the balance.

Depending upon the particular apparatus design, control the flow of water either by opening valve A and using the main air valve to control flow, or by opening the main air valve and using valve A to control flow. Release the pressure in the container by opening valve B. (If the apparatus employs an auxiliary tube for filling the calibration cylinder, open valve A so that the tube is drained back into the container, or alternatively if the calibration is an integral part of the cover assembly close valve A immediately after filling the calibration vessel and leave it closed until the test has been completed.) The volume of air in the container is now equal to the volume of the displaced water; close all valves, pump air into the air chamber until the pressure reaches the initial pressure line, and then open the main air valve. The air content indicated by the pressure gauge corresponds to the percentage of air, A_1, determined to be in the container, where $A_1 = m_3/m_2 \times 100$ %. If two or more determinations show the same variation from the correct air content, reset the hand on the pressure gauge to the correct air content and repeat the test until the gauge reading corresponds to the calibrated air content within 0.1 % air content.

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