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BSI Standards Publication

Tests for mechanical and physical properties of aggregates

Part 1: Determination of the resistance to wear (micro-Deval)

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National foreword

This British Standard is the UK implementation of EN 1097-1:2011. It supersedes BS EN 1097-1:1996 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/502/6, Test methods.

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

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Tests for mechanical and physical properties of aggregates - Part 1: Determination of the resistance to wear (micro-Deval)

Essais pour déterminer les caractéristiques mécaniques et physiques des granulats - Partie 1: Détermination de la résistance à l'usure (micro-Deval)

Prüfverfahren für mechanische und physikalische Eigenschaften von Gesteinskörnungen - Teil 1: Bestimmung des Widerstandes gegen Verschleiß (Micro-Deval)

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Foreword

This document (EN 1097-1:2011) has been prepared by Technical Committee CEN/TC 154 “Aggregates”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by July 2011, and conflicting national standards shall be withdrawn at the latest by July 2011.

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 replaces EN 1097-1:1996.

This standard forms part of a series of tests for mechanical and physical properties of aggregates. Test methods for other properties of aggregates will be covered by the following European Standards:

- EN 932 (all parts), *Tests for general properties of aggregates*;
- EN 933 (all parts), *Tests for geometrical properties of aggregates*;
- EN 1367 (all parts), *Tests for thermal and weathering properties of aggregates*;
- EN 1744 (all parts), *Tests for chemical properties of aggregates*;
- EN 13179 (all parts), *Tests for filler aggregate used in bituminous mixtures*.

The other Parts of EN 1097 will be:

- *Part 2: Methods for the determination of resistance to fragmentation*;
- *Part 3: Determination of loose bulk density and voids*;
- *Part 4: Determination of the voids of dry compacted filler*;
- *Part 5: Determination of the water content by drying in a ventilated oven*;
- *Part 6: Determination of particle density and water absorption*;
- *Part 7: Determination of the particle density of filler — Pyknometer method*;
- *Part 8: Determination of the polished stone value*;
- *Part 9: Determination of the resistance to wear by abrasion from studded tyres — Nordic test*;
- *Part 10: Determination of water suction height*.

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

1 Scope

This European Standard describes the reference method used for type testing and in case of dispute for determining the resistance to wear of coarse aggregates (main text) and aggregates for railway ballast (Annex A). For other purposes, in particular factory production control, other methods may be used provided that an appropriate working relationship with the reference method has been established. The sample is normally tested in a wet condition, but the test may also be carried out in a dry condition. This European Standard applies to natural, manufactured or recycled aggregates used in building or civil engineering.

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 932-2, *Tests for general properties of aggregates — Part 2: Methods for reducing laboratory samples*

EN 932-5, *Tests for general properties of aggregates — Part 5: Common equipment and calibration*

EN 933-1:1997, *Tests for geometrical properties of aggregates — Part 1: Determination of particle size distribution — Sieving method*

EN ISO 4788, *Laboratory glassware — Graduated measuring cylinders (ISO 4788:2005)*

ISO 3290-1, *Rolling bearings — Balls — Part 1: Steel balls*

3 Terms and definitions

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

3.1
test portion
sample used as a whole in a single test

3.2
test specimen
sample used in a single determination when a test method requires more than one determination of a property

3.3
laboratory sample
reduced sample derived from a bulk sample for laboratory testing

3.4
constant mass
mass determined by successive weightings performed at least 1 h apart and not differing by more than 0,1%

NOTE In many cases, constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven at (110 ± 5) °C. Test laboratories can determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

4 Principle

The test determines the micro-Deval coefficient which is the percentage of the original sample reduced to a size smaller than 1,6 mm during rolling.

The test consists of measuring the wear produced by friction between the aggregates and an abrasive charge in a rotating drum under defined conditions.

When rolling is complete, the percentage retained on a 1,6 mm sieve is used to calculate the micro-Deval coefficient.

The test method described in this European Standard is the reference method and is carried out with dry aggregate with the addition of water to give a value of MDE. Annex B gives details of how the test can be performed without the addition of water, to give a value of M_{DS}.

NOTE A lower value of the micro-Deval coefficient indicates a better resistance to wear.

5 Apparatus

Unless otherwise stated, all apparatus shall conform to the general requirements of EN 932-5.

5.1 General apparatus

5.1.1 Balance, capable of weighing both the test specimen and the charge to an accuracy of 0,1 % of the mass of the test portion.

5.1.2 Test sieves: 1,6 mm, 8 mm, 10 mm, 11,2 mm (or 12,5 mm) and 14 mm.

5.1.3 Ventilated oven, controlled to maintain a temperature of (110 ± 5) °C.

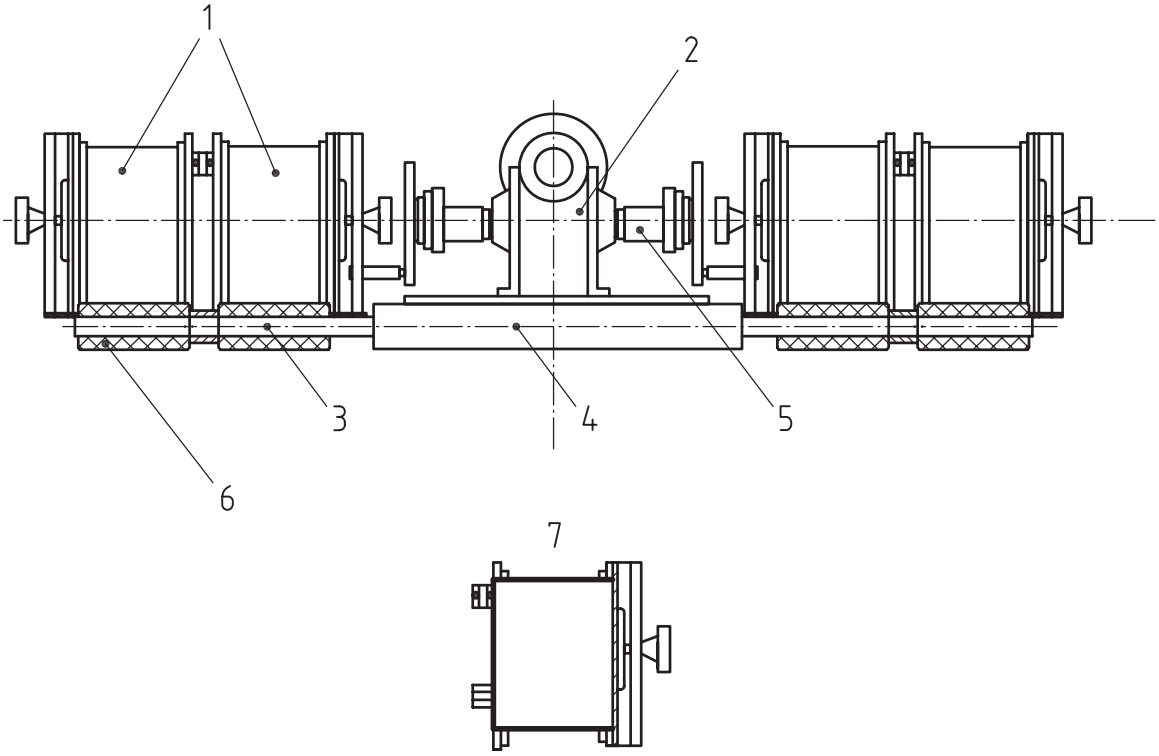
5.1.4 Means of washing the sieved sample.

5.1.5 Equipment for reducing the laboratory samples to a test portion, as described in EN 932-2.

5.1.6 Graduated glass measuring cylinder (or cylinders), conforming to EN ISO 4788, or other means of measuring (2,5 ± 0,05) l of water.

5.2 Additional apparatus required for the determination of the micro-Deval coefficient of aggregate

5.2.1 A typical micro-Deval apparatus as shown in Figure 1. A micro-Deval apparatus shall have the following essential characteristics as specified in 5.2.2, 5.2.3, 5.2.4, 5.2.5 and 5.2.6.



Key

1 drums
2 electric motor and reduction gearing
3 fixed shaft
4 frame
5 flexible coupling
6 drive wheel
7 cross section of a drum

Figure 1 — Diagram of typical apparatus

5.2.2 It shall consist of one of four hollow drums, closed at one end, having an inside diameter of (200 ± 1) mm and an internal length measured from the base to the inside of the lid of (154 ± 1) mm. The drums shall be made of stainless steel at least 3 mm thick which are placed on two shafts which rotate on a horizontal axis.

5.2.3 The insides of drums shall be free of protrusions resulting from welding or the method of attachment. The drums shall be closed by flat lids at least 8 mm thick and fitted with watertight and dust tight seals.

5.2.4 The abrasive charge shall consist of steel balls complying with ISO 3290-1 (10 ± 0,5) mm in diameter.

NOTE The diameter of the balls can be checked quickly by passing them over parallel bars 9,5 mm apart.

5.2.5 A suitable motor (a capacity of about 1 kW is typical) to drive the drums at a regular speed of rotation of (100 ± r/min).

5.2.6 A counter or other device shall be fitted, which automatically stops the motor after the specified number of revolutions.

6 Preparation of the test specimens

The mass of the sample sent to the laboratory shall have at least 2 kg of particles in the 10 mm to 14 mm size range.

NOTE Alternative size fractions for different end uses are given in Annex C. Testing other size fractions may produce results different from those obtained using the 10/14 mm size fraction and the size fraction used should be given in the test report.

The test shall be carried out on aggregate passing the 14 mm sieve and retained on the 10 mm sieve. In addition, the grading of the test portion shall comply with at least one of the following requirements:

a) between 30 % and 40 % passing a 11,2 mm sieve; or

b) between 60 % and 70 % passing a 12,5 mm sieve.

Sieve the laboratory sample using the 10 mm, 11,2 mm (or 12,5 mm) and 14 mm sieves to give separate fractions in the range 10 mm to 11,2 mm (or 12,5 mm) and 11,2 mm (or 12,5 mm) to 14 mm. Wash each fraction separately, in accordance with 7.1 of EN 933-1:1997, and dry them in the oven at (110 ± 5) °C to constant mass.

Allow the fractions to cool to ambient temperature. Mix the two fractions to provide a modified 10 mm to 14 mm laboratory sample which complies with the appropriate additional grading requirements given in paragraph 2 of this clause.

Reduce the modified laboratory sample prepared from the mixed fractions to test portion size in accordance with the requirements of EN 932-2. The test portion shall consist of two test specimens, each having a mass of (500 ± 2) g.

7 Test procedure

Place each test specimen into a separate drum. Add (5 000 ± 5) g of steel balls to each drum.

NOTE When testing alternative size fractions according to Annex C, the mass of ball load in Table C.1 should be used.

Add (2,5 ± 0,05) l of water to each drum.

Fit a lid to each drum, and place each drum on the two shafts.

Rotate the drums at a speed of (100 ± 5) min–1 for (12 000 ± 10) revolutions.

After the test, collect the aggregate and the steel balls in a pan, taking care to avoid the loss of any aggregate. Using a washing bottle, carefully wash the inside of the drum and the lid, and retain the washings.

Empty the material and all the washings on to the 1,6 mm sieve protected by an 8 mm guard sieve. Wash the materials in a stream of clean water.

Carefully separate the aggregate particles retained on the 8 mm guard sieve from the steel balls, taking care not to lose any aggregate particles. The aggregate particles may be picked out by hand, or the balls may be removed from the sieve using a magnet.

Place the aggregate particles retained on the 8 mm guard sieve onto a tray. Add the material retained on the 1,6 mm sieve to the same tray.

Dry the tray and its contents in the oven at (110 ± 5) °C. Complete the determination of the mass retained on the 1,6 mm sieve in accordance with EN 933-1.

Record the mass (m) retained on the 1,6 mm sieve to the nearest gram.

8 Calculation and expression of results

For each test specimen calculate the micro-Deval coefficient, MDE, to the nearest 0,1 units using the following equation:

$$M_{DE} = \frac{500 - m}{5}$$

where:

M_{DE} is the micro-Deval coefficient (in the wet condition);

m is the mass of the oversize fraction retained on a 1,6 mm sieve, in grams.

Using the values obtained for the two test specimens, calculate the mean value of micro-Deval coefficient.

Report the mean value as the micro-Deval coefficient for the sample submitted to the laboratory. Express the mean value to the nearest whole number.

NOTE A statement on the precision of the micro-Deval test is given in Annex D.

9 Test report

The test report shall affirm that the micro-Deval value was determined in accordance with this European Standard.

The test report shall contain at least the following information:

a) Name and source of sample;

b) Grading class of the sample submitted for testing;

c) The type of test (wet or dry);

d) Test result(s) for the test, including the value for each test specimen and the mean value;

e) Date of test.

Annex A
(normative)

Determination of the resistance to wear (micro-Deval) of railway ballast

NOTE The following clause numbers refer to the corresponding clauses in the main document. These clauses express additions or modifications to main text clauses.

5 Apparatus

5.1 General apparatus

5.1.2 Test sieves

10 mm, 11,2 mm (or 12,5 mm) and 14 mm sieve sizes shall be replaced by 31,5 mm, 40 mm and 50 mm sieve sizes.

5.2.2 The internal length of each **hollow** drum shall be (400 ± 2) mm.

5.2.4 The abrasive charge is not required.

6 Preparation of the test specimens

The mass of the sample sent to the laboratory shall have at least 25 kg of particles in the 31,5 mm to 50 mm size fraction. The test portion shall consist of two test specimens.

Sieve the laboratory sample using the 31,5 mm, 40 mm and 50 mm to give the separate size fractions in the ranges 31,5 mm to 40 mm and 40 mm to 50 mm. Wash each fraction separately, in accordance with EN 933-1 and dry it in the oven at (110 ± 5) °C to constant mass. Allow the fractions to cool to ambient temperature.

Divide and reduce the mass of the 31,5 mm to 40 mm size fraction as specified in EN 932-2, so as to create two size fractions, each with a mass of (5 000 ± 50) g. Repeat for the 40 mm to 50 mm size fraction.

Combine one 31,5 mm to 40 mm size fraction with one 40 mm to 50 mm size fraction to produce a test specimen with a total dry mass of (10 000 ± 100) g. Repeat for the second two size fractions.

7 Test procedure

Do not use steel balls. Add (2,0 ± 0,05) l of water to each drum and rotate the drums for (14 000 ± 10) revolutions.

8 Calculation and expression of results

Calculate the Micro-Deval coefficient $M_{DE,RB}$ from the following equation:

$$M_{DE,RB} = \frac{10\,000 - m}{100}$$

9 Test report

The test report shall mention that the Micro-Deval test was carried out in accordance with Annex A of this standard. It shall include the following information:

a) Micro-Deval coefficient $M_{DE,RB}$

Annex B
(informative)

Determination of micro-Deval coefficient in the dry condition

B.1 Introduction

This annex describes a variation of the method given in this standard, which is carried out without the addition of water to each drum, to give a value of M_{DS}. This method can provide additional information about the characteristics of the test specimen, but should not be used in place of the reference method.

NOTE The determination of micro-Deval coefficient in the dry condition can be carried out at the same time as the reference method, if the shafts described in 5.2.2 are long enough to hold four drums.

B.2 Apparatus

The apparatus described in Clause 5 should be used, except that the means of measuring the volume of added water (see 5.1.6) is not required.

B.3 Preparation of sample for testing

Two oven dry test specimens should be prepared, each having a mass of (500 ± 2) g, as described in Clause 6.

B.4 Test procedure

The test as described in Clause 7 should be carried out, except that water is not added to the test portion in each drum.

B.5 Calculation and expression of results

The micro-Deval coefficient as described in Clause 8 should be calculated, except replace M_{DE} with M_{DS}, the micro-Deval coefficient for aggregate in a dry condition.

B.6 Report

The test report should be in accordance with Clause 9, and should state that the test was carried out with the aggregate in a dry condition.

Annex C
(informative)

Alternative narrow range classification for the micro-Deval test

The following variations to the reference test (see Clause 6) may provide additional information for certain end uses.

The alternative narrow range classifications for the Micro-Deval test stated in Table C.1 provide a methodology for testing size fractions other than the standard 10/14 mm size fraction in the reference test. Different masses of ball loads are given for each range classification. These have been selected in order to produce results from the non-standard fractions close to those from the standard 10/14 mm fraction, although the mass of ball load may be amended to suit the type of aggregate tested.

NOTE The relationship is not the same for all aggregates and the alternative size fractions should not be expected to give results identical to those from the 10/14 mm reference method.

Test sieves of the appropriate size, instead of those specified in Clause 6, should be used to match the range classification. An appropriate size for the guard sieve specified in Clause 7 should also be used.

Table C.1 — Alternative narrow range classifications to the 10/14 mm size fraction

Range classification mm	**Intermediate sieve size** mm	**Percentage passing intermediate sieve** %	**Mass of ball load** g
4 to 6,3	5	30 to 40	2 000 ± 5
4 to 8	6,3	60 to 70	2 800 ± 5
6,3 to 10	8	30 to 40	4 000 ± 5
8 to 11,2	10	60 to 70	4 400 ± 5
11,2 to 16	14	60 to 70	5 400 ± 5

9 Test report

The test report shall mention that the Micro-Deval test was carried out in accordance with Annex C of this standard. It shall include the following information:

a) Micro-Deval coefficient M_{DE};

b) Range classification and mass of ball load;

c) Date of test.

Annex D
(informative)

Precision

The repeatability r and reproducibility R have been determined on the basis of two repetitions of tests on each of the three materials tested by 20 laboratories from 11 European countries.

The results established using the 10/14 mm size fraction for levels 5 to 25 are as follows (wet conditions):

— Repeatability r = 0,893 + 0,003 x

— Reproducibility R = 0,260 + 0,137 x

where:

x is the level of the value.

The results were interpreted in accordance with ISO 5725-2:1994.

Bibliography

[1] ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

[2] NF P18-572:1990, *Granulats — Essai d'usure micro-Deval*

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