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BSI Standards Publication

Tests for mechanical and physical properties of aggregates

Part 9: Determination of the resistance to wear by abrasion from studded tyres — Nordic test

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National foreword

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

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

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Essais pour déterminer les propriétés mécaniques et physiques des granulats - Partie 9: Détermination de la résistance à l'usure par abrasion provoquée par les pneus à crampons - Essai scandinave

Prüfverfahren für mechanische und physikalische Eigenschaften von Gesteinskörnungen - Teil 9: Bestimmung des Widerstandes gegen Verschleiß durch Spikereifen - Nordische Prüfung

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Foreword

This document (EN 1097-9:2014) 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of an identical text or by endorsement, at the latest by July 2014 and conflicting national standards shall be withdrawn at the latest by July 2014.

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 1097-9:1998.

The main technical changes compared to EN 1097-9:1998 are the following:

1) Scope: rewritten to allow the use of other methods under precise conditions;

5) Apparatus: Possibility to use other suitable equipment for drying aggregates than the prescribed ventilated oven. Steel quality has been updated;

6) Preparation of test specimens: rewritten (*Mass of test portion:* Formula revised, *Loading the drum:* Order changed);

8) Calculation and expression of results: the re-testing criteria has been amended and supplemented with Dixon test guidelines;

9) Test report: required and optional data have harmonized according to document CEN/TC 154/SC 6 – N 1120.

The test procedure specified in this European Standard has been developed in Finland, Norway and Sweden where studded tyres are frequently used during cold seasons.

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

EN 932, *Tests for general properties of aggregates*

EN 933, *Tests for geometrical properties of aggregates*

EN 1367, *Tests for thermal and weathering properties of aggregates*

EN 1744, *Tests for chemical properties of aggregates*

EN 13179, *Tests for filler aggregate used in bituminous mixtures*

EN 1097, *Tests for mechanical and physical properties of aggregates,* consists of the following parts:

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

— *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 10: Water suction height*

— *Part 11: Determination of compressibility and confined compressive strength of lightweight aggregates*

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

1 Scope

This European Standard describes the reference method, used for type testing and in case of dispute, for determination of the resistance of coarse aggregate to wear by abrasion from studded tyres. 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 test is applicable to aggregates with a size fraction of 11,2 mm to 16 mm.

NOTE An alternative size fraction 8/11,2 mm for different end uses is given in Annex A.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 932-2:1999, *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, *Tests for geometrical properties of aggregates - Part 1: Determination of particle size distribution - Sieving method*

EN 933-2, *Tests for geometrical properties of aggregates - Part 2: Determination of particle size distribution - Test sieves, nominal size of apertures*

EN 1097-6:2013, *Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption*

EN ISO 4788, *Laboratory glassware - Graduated measuring cylinders (ISO 4788)*

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

ISO 9329-4, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Austenitic stainless steels*

3 Terms and definitions

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

3.1
test specimen
sample used in a single determination when a test method requires more than one determination of a property

3.2
laboratory sample
sample intended for laboratory testing

3.3
constant mass
mass determined after successive weighings at least 1 h apart not differing by more than 0,1 %

Note 1 to entry: In many cases constant mass can be achieved after a test specimen 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

A sample of a single-sized aggregate, 11,2 mm to 16,0 mm, is rotated together with steel balls and water in a steel drum. Three ribs, which are mounted on the interior of the drum, improve the mixing of the aggregate particles and the steel balls. The contents roll within the drum with an abrading action. After the specified number of revolutions, the contents are removed from the drum and the aggregate portion is sieved on the 2 mm sieve to measure the wear as a percentage loss.

5 Apparatus

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

5.1 Standard 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 specimen.

5.1.2 *Set of sieves*, 2,0 mm; 11,2 mm; 14,0 mm; 16,0 mm conforming to EN 933-2.

5.1.3 *Guard sieve*, for protecting the 2 mm sieve.

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

5.1.5 *Means of washing the sieved sample*.

5.1.6 *Equipment for reducing the laboratory samples*, as specified in EN 932-2.

5.1.7 *Graduated glass measuring cylinder (or cylinders)*, conforming to EN ISO 4788, or other means of measuring (2,00 ± 0,01) l of water.

5.2 Special apparatus

5.2.1 *Testing machine*, a typical testing machine is detailed in Figure 1 with essential characteristics as specified in 5.2.2 to 5.2.7

5.2.2 *A watertight hollow drum*, closed at one end, having an inside diameter of (206,5 ± 2,0) mm and an internal length measured from the inside of the base to the inside of the lid of (335 ± 1) mm. The drum shall be made of a seamless steel tube conforming to grade TS 5 of ISO 9329-4, with a minimum wall thickness of 6,0 mm.

The drum shall be closed by a flat lid at least 8 mm thick and fitted with watertight and dust seals. The drum shall rotate on a horizontal axis, e.g. placed on 2 shafts as shown in Figure 1.

5.2.3 *Three ribs*, each with a length of (333 ± 1) mm, shall be equally spaced around the internal circumference of the cylinder. The three ribs shall be removable, having an initial profile as shown in Figure 2, and be made of hard and tough steel

NOTE Spring steel conforming to EN 10089 or ISO 683-14 is suitable.

Each rib shall be rigidly secured to the drum with at least three M4 countersunk fixings.

Before first use, the ribs shall be preground in the drum for (24 ± 1) h using an aggregate with a Nordic abrasion value of not more than 6,0 prepared in accordance with Clause 6. Each rib shall be replaced when, or before, its mass is less than 15,0 g less than its mass before it was preground.

5.2.4 *Abrasive charge*, consisting of ball bearings of (15,0 + 0,1/-0,5) mm diameter, as specified in ISO 3290-1. The hardness shall be between HRC 60 and HRC 67.

NOTE 1 The lower limit deviation of the ball diameter is a working tolerance limit.

NOTE 2 The minimum permissible diameter of the balls can be checked quickly by passing them over the gauge (see 5.2.7).

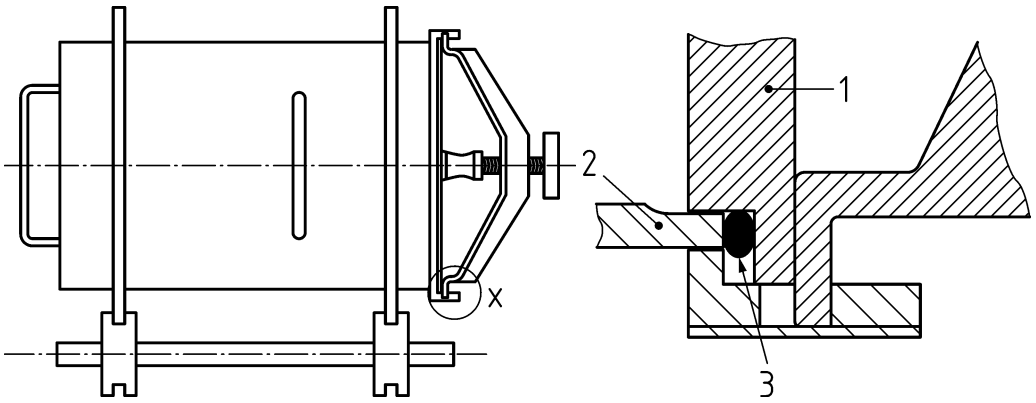
5.2.5 *Motor*, capable of driving the drum at a regular speed of rotation of (90 ± 3) r/min.

5.2.6 *Counter*, or other suitable device which automatically stops the rotation after (5 400 ± 10) revolutions.

5.2.7 *Gauge*, (optional) to control minimum ball size, fitted with slots 14,5 + 0,1/0 mm wide.

5.2.8 *Magnet*, (optional) for removal of the charge from the aggregate test sample after abrasion.

A magnet which is too strong should not be used as the balls can become magnetised.



Detail X – Typical lid edge

Key

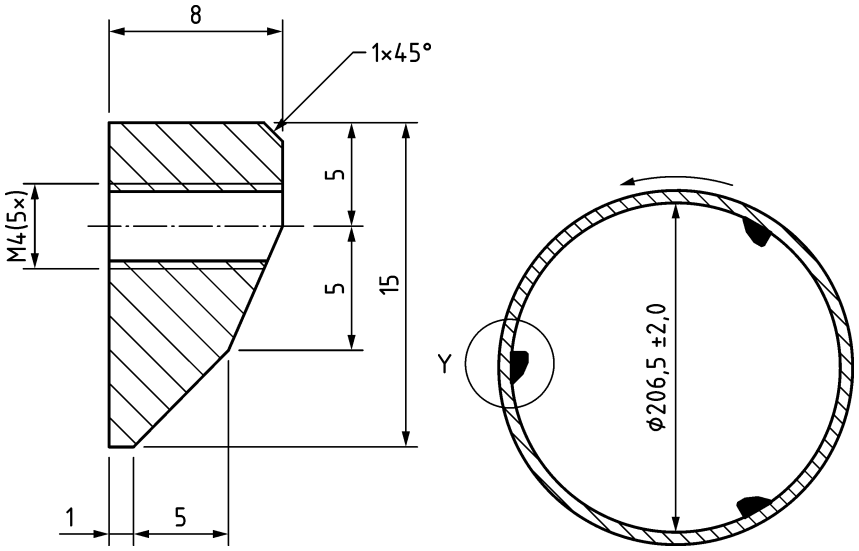
1 lid

2 cylinder

3 rubber packing

Figure 1 — Typical testing machine

Dimensions in millimetres



Detail Y, Rib detail before pregrinding

Section of the drum with the three ribs

With a tolerance of ± 0,5 mm

Figure 2 — The three ribs

6 Preparation of test specimens

The mass of the laboratory sample shall be large enough for the preparation of four test specimens.

The grading of the test specimen shall have (65 ± 1) % passing the 14,0 mm sieve, i.e. (35 ± 1) % of the test specimen shall consist of particles in the 14,0 to 16,0 mm size range.

Each test specimen shall have an initial dry mass, M_1, in grams, defined in accordance with the following formula:

$$M_1 = \frac{1000\,\rho_p}{2{,}65} \pm 5$$

where

M_1 is the initial dry mass of the test specimen (in grams);

ρ_p is the pre-dried particle density determined in accordance with EN 1097-6:2013, Annex A, in megagrams per cubic metre.

Wash the laboratory sample on the 2 mm sieve and dry it to constant mass in the oven at (110 ± 5) °C.

Allow the washed and dried sample to cool to ambient temperature. Sieve the sample according to EN 933-1 to provide a sufficient amount for the preparation of at least two test specimens. Use the 11,2 mm, 14,0 mm and 16,0 mm sieves to give two separate particle size fractions 11,2/14 mm and 14/16 mm.

Reduce the size fractions in accordance with EN 932-2:1999, Clause 11, in order to get a test specimen of the specified composition.

NOTE It is also acceptable to compose a sufficient amount of the test sample 11,2/16 mm and then reduce this amount to the required mass of the test specimens.

7 Procedure

Place the charge of (7000 ± 10) g into the drum. Add then the test specimen and finally (2,00 ± 0,01) l of water.

Fit the lid to the drum. Rotate the drum at a speed of (90 ± 3) r/min for (5400 ± 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 onto the 2,0 mm sieve, protected by an appropriate guard sieve (5.1.3). Wash the material in a stream of clean water.

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

Place the aggregate particles retained on the guard sieve and the 2,0 mm sieve onto a tray.

Dry the tray and its contents in the oven at (110 ± 5) °C to constant mass. Determine the mass of aggregate particles greater than 2 mm by dry sieving according to EN 933-1. Record the mass, M_2, to the nearest gram.

Repeat the above procedure on a second test specimen.

8 Calculation and expression of results

For each test specimen calculate the Nordic abrasion value, A_N, to the nearest single decimal place as follows:

$$A_N = 100\ (M_1 - M_2)/\ M_1$$

where

M_1 is the initial dry mass of the test specimen, in grams;

M_2 is the dry mass of aggregate particles greater than 2 mm, obtained after abrasion, in grams.

Calculate the mean of the two values. If the difference between the values for the two test specimens is smaller than or equal to 10 % of the mean value, record the mean value to the nearest single decimal place. If the difference is greater, test two further test specimens.

If the results of the first two test specimens are below 5,0, further testing may be omitted.

If further test specimens are tested, calculate the standard deviation of the four A_N values. If the standard deviation is greater than 9 % of the mean of the four values, examine if any suspect extreme value shall be discarded in accordance with the following procedure:

Arrange the four results in order of magnitude, denoted A_{N1}, A_{N2}, A_{N3} and A_{N4}. Calculate the following two quotients Q_1 and Q_2:

$$Q_1 = (A_{N2} - A_{N1})/(A_{N4} - A_{N1})$$

$Q_2 = (A_{N4} - A_{N3})/(A_{N4} - A_{N1})$

If Q_1 or Q_2 > 0,829, discard the suspect extreme value. Calculate the mean of all accepted values.

NOTE The critical value 0,829 is valid according to Dixon's test at the 5 % level (ISO 5725-1:1994).

Report the mean value to the nearest single decimal place.

9 Test report

9.1 Required data

The test report shall include the following information:

a) reference to this European Standard;

b) identification of the test sample, including identification of the source and date of sampling;

c) sample reception date if different from sampling date;

d) identification of the laboratory;

e) particle size fraction tested;

f) Nordic abrasion values to the nearest single decimal place (mean value and each accepted individual value);

g) deviations from the reference method – if any.

9.2 Optional data

The test report can include the following information:

a) date of test;

b) reference to the chosen sampling procedure;

c) reference to the chosen sample reduction procedure;

d) mass of test portion;

e) individual test results with significant digits;

f) other influencing parameters.

10 Precision

The repeatability (r) and reproducibility (R) have been determined on the basis of inter-laboratory studies in 1994 in the Nordic countries (eleven laboratories, eight levels and two test specimens at each level). Interpretation of the test results has been made in accordance with ISO 5725-1:1994.

For Nordic abrasion values (A_N) from 5 to 16, the precision was as follows:

$r = 0{,}13\ A_N - 0{,}17$

$R = 0{,}14\ A_N + 0{,}27$

Annex A
(informative)

Alternative 8/11,2 mm size fraction for the Nordic test

The following variation to the reference test (see Clause 6) given in Table A.1 may provide additional information for certain end uses.

The test parameters for the testing of the alternative 8/11,2 mm size fraction involve adjustments to the abrasive charge intended to produce test results close to those from the reference 11,2/16 mm size fraction. However, the relationship is not the same for all aggregates and the results for the alternative size fraction should not be expected to be identical to those from the reference size fraction.

Table A.1 — Changes of testing conditions for the alternative 8/11,2 mm size fraction

Clause	Item	Size fraction 8/11,2 mm	Size fraction 11,2/16 mm (reference)
5	Apparatus	2–8–10–11,2	2–11,2–14–16
5.1.2	Set of sieves, (mm)		
5.2.4	Abrasive charge, (mm diameter)	11,1+0,1/-0,5	15,0+0,1/-0,5
5.2.7	Gauge to control ball size		
	Distance between two parallel bars (mm)	10,7 ± 0,1	14,6 ± 0,1
	Preparation of test specimens		
6	Intermediate sieve, (mm)	10,0	14,0
	Percentage passing intermediate sieve, (%)	(65 ± 1)	(65 ± 1)

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[1] Schouenborg, B., Viman, L.: *Studded Tyre Test- Precision Trials*, SP Swedish National Testing and Research Institute, SP REPORT 1994:21

[2] EN 10089, *Hot-rolled steels for quenched and tempered springs - Technical delivery conditions*

[3] ISO 683-14, *Heat-treatable steels, alloy steels and free-cutting steels — Part 14: Hot-rolled steels for quenched and tempered springs*

[4] ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

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