Designation: D6928 – 17

Standard Test Method for Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus[1]

This standard is issued under the fixed designation D6928; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure for testing coarse aggregate for resistance to abrasion using the Micro-Deval apparatus.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 The text of this method references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the test method.

1.4 *This procedure may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 *Definitions:*

3.1.1 *constant mass, n*—the condition of a test sample dried at a temperature of 110 ± 5 °C such that it will not lose more than 0.1 % moisture after 2 h of drying.

3.1.1.1 *Discussion*—Such a condition of dryness can be verified by determining the mass of the sample before and after successive 2-h drying periods. In lieu of such a determination, samples may be considered to have reached constant mass when they have been dried at a temperature of 110 ± 5 °C for an equal or longer period than that previously found adequate for producing the desired constant mass condition under equal or heavier loading conditions of the oven.

4. Summary of Test Method

4.1 The Micro-Deval test is a measure of abrasion resistance and durability of mineral aggregates resulting from a combination of actions including abrasion and grinding with steel balls in the presence of water. A sample with standard grading is initially soaked in water for not less than 1 h. The sample is then placed in a jar mill with 2.0 L of water and an abrasive charge consisting of 5000 g of 9.5-mm diameter steel balls. The jar, aggregate, water, and charge are revolved at 100 rpm for up to 2 h, depending on the particle size. The sample is then washed and oven dried. The loss is the amount of material passing the 1.18-mm sieve expressed as a percent by mass of the original sample.

5. Significance and Use

5.1 The Micro-Deval abrasion test is a test of coarse aggregate to determine abrasion loss in the presence of water and an abrasive charge. Many aggregates are more susceptible to abrasion when wet than dry, and the use of water in this test incorporates this reduction in resistance to degradation in contrast to some other tests, which are conducted on dry aggregate. The test results are helpful in evaluating the toughness/abrasion resistance of coarse aggregate subject to abrasion when adequate information is not available from service records.

5.2 The Micro-Deval abrasion test is useful for detecting changes in properties of aggregate produced from an aggregate source as part of a quality control or quality assurance process.

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[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.51 on Aggregate Tests.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6. Apparatus

6.1 *Micro-Deval Abrasion Machine,* a jar rolling mill capable of running at 100 ± 5 rpm (Fig. 1).

NOTE 1—Micro-Deval abrasion machine fitted with a counter may be used if the test is conducted on the basis of number of revolutions (see 9.3.2).

6.2 *Containers,* stainless steel Micro-Deval abrasion jars having an apporiximate 5-L capacity, a locking cover and gasket capable of sealing the jar and making it watertight. External diameter of the abrasion jar shall be 194 mm to 202 mm and the internal height shall be 170 mm to 177 mm. The inside and outside surfaces of the jars shall be smooth and have no significant ridges or indentations (Fig. 1).

6.3 *Abrasive Charge*—Magnetic stainless steel balls are required. These shall have a diameter of 9.5 ± 0.5 mm. Each jar requires a charge of 5000 ± 5 g of balls.

6.4 *Sieves,* with square openings, and of the following sizes conforming to Specification E11 specifications: 19.0 mm, 16.0 mm, 12.5 mm, 9.5 mm, 6.7 mm, 6.3 mm, 4.75 mm, and 1.18 mm.

6.5 *Oven,* capable of maintaining a temperature of 110 ± 5 °C.

6.6 *Balance,* or scale accurate to 1.0 g.

7. Supplies

7.1 *Reference Aggregate*—An adequate supply of aggregate, established by the laboratory to use for verification of the consistency of the test method (see 11.1).

8. Test Sample

8.1 The test sample shall be washed and oven dried at 110 ± 5 °C to constant mass, separated into individual size fractions in accordance with Test Method C136, and recombined to meet the grading as shown in 8.2, 8.3, or 8.4. In sections 8.3 and 8.4, the 6.7-mm sieve can be used in place of the 6.3-mm sieve when specified.

8.2 Aggregate for the test sample shall consist of material passing the 19.0-mm sieve, retained on the 9.5-mm sieve. An oven-dried sample of 1500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
19.0-mm	16.0-mm	375 g
16.0-mm	12.5-mm	375 g
12.5-mm	9.5-mm	750 g

8.3 In a case where the maximum nominal size of the coarse aggregate is 12.5 mm, a sample of 1500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
12.5-mm	9.5-mm	750 g
9.5-mm	6.3-mm	375 g
6.3-mm	4.75-mm	375 g

8.4 In a case where the maximum nominal size of the coarse aggregate is 9.5 mm or less, a sample 1500 ± 5 g shall be prepared as follows:

Passing	Retained	Mass
9.5-mm	6.3-mm	750 g
6.3-mm	4.75-mm	750 g

9. Test Procedure

9.1 Prepare a representative 1500 ± 5-g test sample. Weigh the sample and record the mass, *A*, to the nearest 1.0 g.

9.2 Immerse the test sample in 2.0 ± 0.05 L of tap water at a temperature of 20 ± 5 °C for a minimum of 1 h either in the Micro-Deval container or some other suitable container.

9.3 Place the test sample in the Micro-Deval abrasion container with 5000 ± 5 g steel balls and the water used in 9.2 to immerse the sample. Install the cover and place the Micro-Deval container on the machine.

9.3.1 Run the machine at 100 ± 5 rpm for 2 h ± 1 min for the grading shown in 8.2. For the grading shown in 8.3, run the machine for 105 ± 1 min. For the grading shown in 8.4, run the machine for 95 ± 1 min.

9.3.2 If a revolution counter is available, run the machine for 12 000 ± 100 revolutions for the grading shown in 8.2. For the grading shown in 8.3, run the machine for 10 500 ± 100 revolutions. For the grading shown in 8.4, run the machine for 9500 ± 100 revolutions.

9.4 Carefully pour the test sample and the steel balls over a 4.75-mm sieve superimposed on a 1.18-mm sieve. Take care to remove the entire test sample from the stainless steel jar. Wash and manipulate the retained material on the sieve with water using a hand-held water hose and the hand until the washings are clear and material smaller than 1.18 mm passes that sieve. Discard material smaller than 1.18 mm. Remove the stainless steel balls as described in 9.5.

9.5 Remove the steel balls using one of the following options:

9.5.1 *Option 1, Wet Method for Removing Steel Balls from Sample*—Remove the stainless steel balls from the sample immediately after washing using a magnet or other suitable means, being careful not to lose any material. Combine the material retained on the 4.75-mm and 1.18-mm sieves. Oven-dry the test sample to a constant mass at 110 ± 5 ºC.

9.5.2 *Option 2, Dry Method for Removing Steel Balls from Sample*—Combine the material retained on the 4.75-mm and 1.18-mm sieves and steel balls, being careful not to lose any material. Oven dry the test sample and steel balls to a constant mass at 110 ± 5 ºC. Remove the steel balls from the dry sample using a magnet or other suitable means.

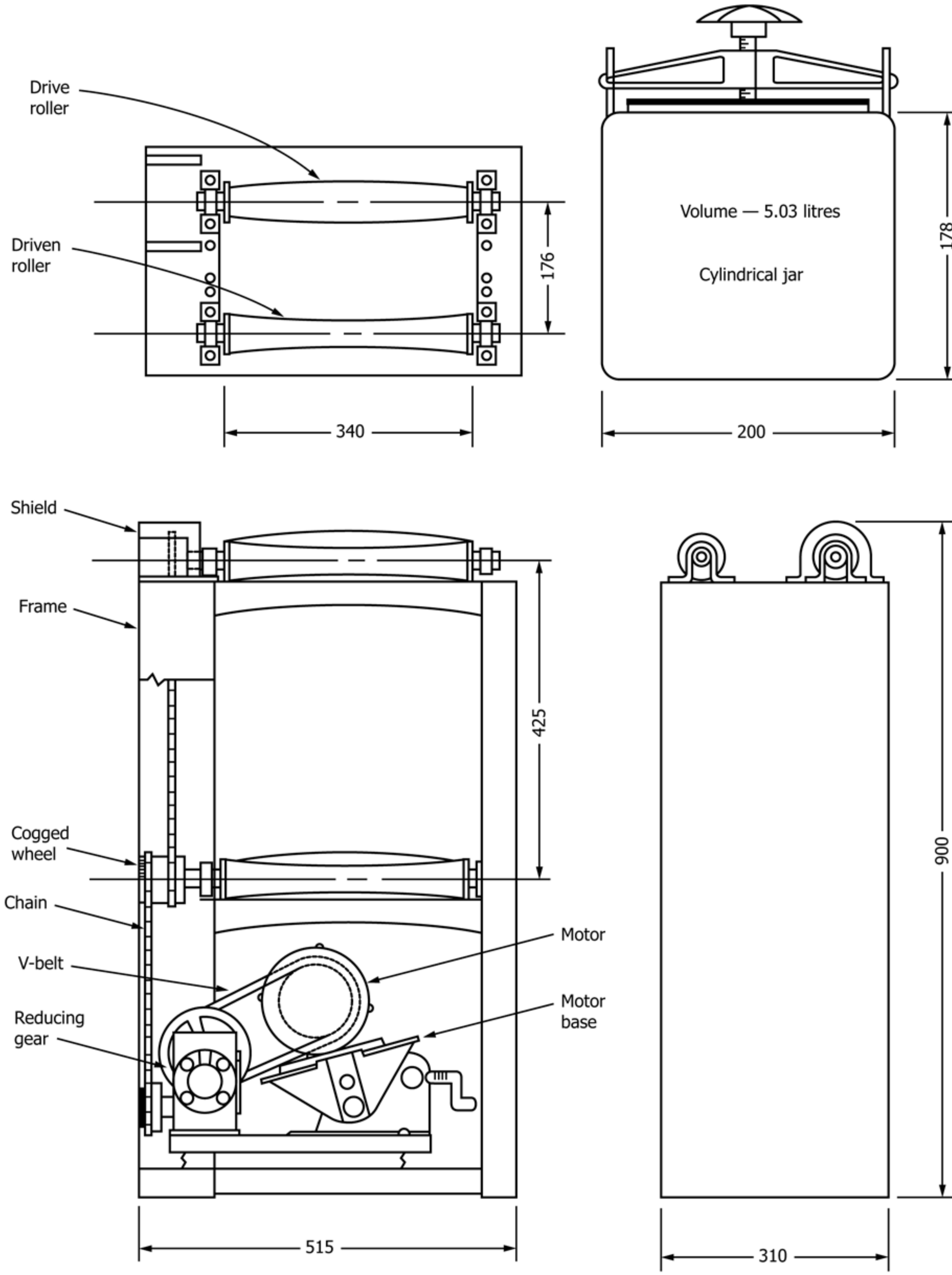
NOTE 2—Extreme care must be taken if using the wet method for removing the steel balls. The surface tension of the water may cause small pieces of the aggregate to adhere to the balls. The wet method for removal is allowed to expedite additional testing for laboratories with a limited supply of balls. Otherwise, the dry method may be used to eliminate this potential source of error. However, care should still be taken when removing the balls to avoid loss of aggregate.

9.6 Oven dry the test sample to constant mass at 110 ± 5 °C.

9.7 Weigh the test sample to the nearest 1.0 g. Record the mass, *B*.

10. Calculation

10.1 Calculate the Micro-Deval abrasion loss, as follows, to the nearest 0.1 %.



NOTE 1—Dimensions are in millimeters.

FIG. 1 Micro-Deval Abrasion Machine and Container

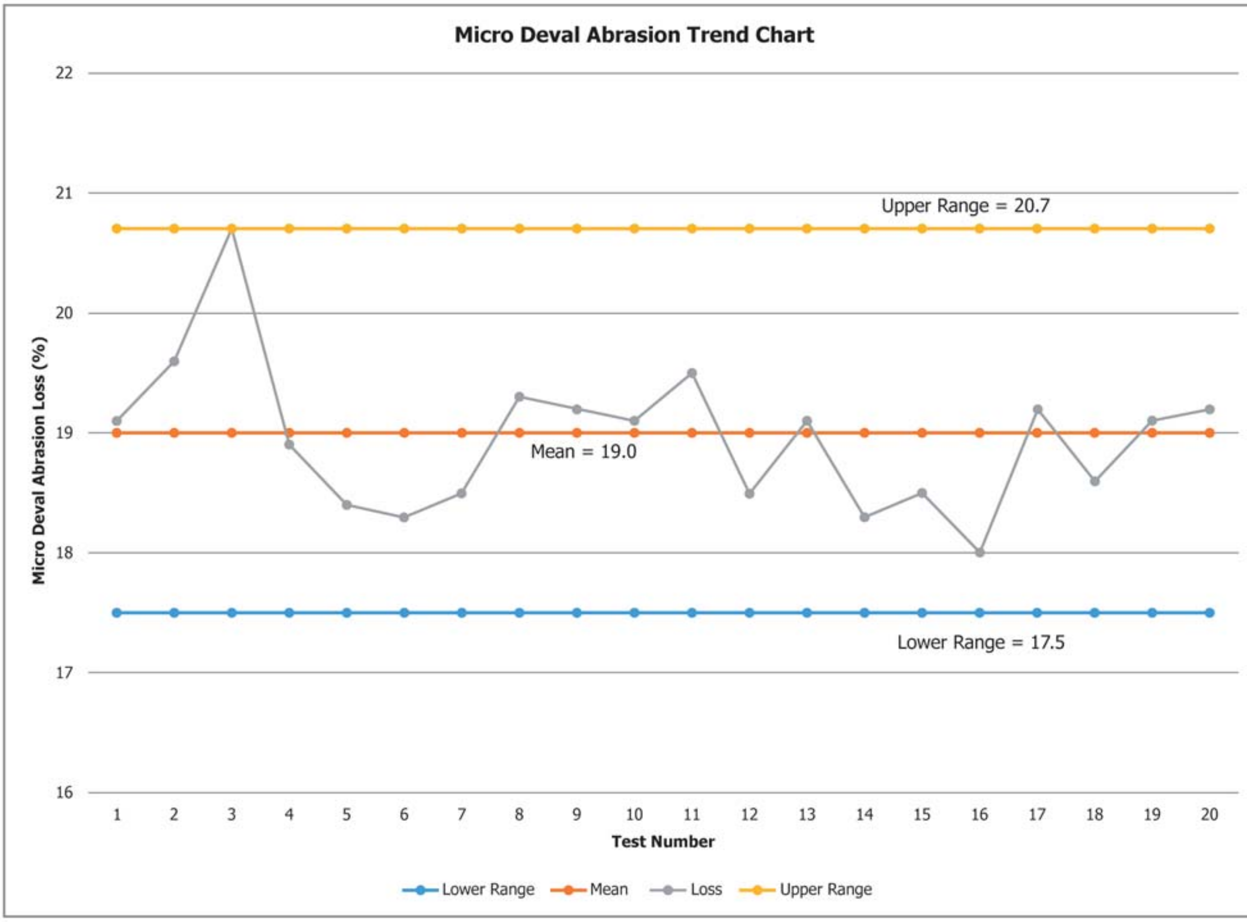


FIG. 2 Micro-Deval Abrasion Trend Chart for Reference Aggregate

$$\text{Percent Loss} = (A - B)/A \times 100 \quad (1)$$

11. Use of the Reference Aggregate

11.1 *Reference Aggregate*—The laboratory will establish an adequate supply of material to use for verification of the consistency of the test method. A suitable material with a loss of between 10 and 25 % shall be established. From this material ten samples shall be taken randomly and tested. At any time a new supply of the reference aggregate (7.1) is required, this procedure shall be conducted.

11.1.1 The mean value and range (±2 standard deviations) obtained from the supply of the reference aggregate shall be determined from the ten samples.

11.1.2 When test data of the reference aggregate is outside the range, an investigation as to the probable cause shall be conducted. The equipment shall be re-calibrated and the testing technique re-examined to detect nonconformance with the test procedure.

11.2 Every ten samples, but at least every week in which a sample is tested, a sample of the reference aggregate shall also be tested. The material shall be taken from a stock supply and prepared according to 8.2. When 20 samples of calibration material have been tested, and the results show satisfactory variation, the frequency of testing may be changed to a minimum of one sample every month.

11.3 *Trend Chart Use*—The percent loss of the last 20 samples of reference material shall be plotted on a trend chart in order to monitor the variation in results (Fig. 2).

12. Report

12.1 The report shall include the following:

12.1.1 The maximum size of the aggregate tested and the grading used.

12.1.2 The percent loss of the test sample to one decimal place.

12.1.3 The percent loss of the calibration aggregate, tested closest to the time at which the aggregate was tested, to the nearest 0.1 %.

12.1.4 The percent loss of the last 20 samples of calibration aggregate on a trend chart.

13. Precision and Bias[3]

13.1 *Precision*—For 19.0-mm maximum size aggregate with abrasion losses in the range from 5 % to 20 %, the single-operator coefficient of variation has been found to be

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1029. Contact ASTM Customer Service at service@astm.org.

3.4 %.[4] Therefore, results of two properly conducted tests on samples of the same aggregate by the same operator using the same equipment are not expected to differ by more than 9.6 %[4] of their average, 95 % of the time. The multilaboratory coefficient of variation has been found to be 5.6%.[4] Therefore, the results of two properly conducted tests by different laboratories on samples of the same aggregate are not expected to differ by more than 15.8 %[4] of their average, 95 % of the time.

[4] These numbers represent, respectively, the (1s %) and (d2s %) limits as described in Practice C670.

13.2 *Bias*—The procedure in this test method for measuring resistance to abrasion has no bias because the resistance to abrasion can only be defined in terms of the test method.

14. Keywords

14.1 abrasion resistance; coarse aggregate; micro deval

APPENDIX

(Nonmandatory Information)

X1. INTERPRETATION OF TEST RESULTS

X1.1 In studies of the performance of aggregates in this test,[5,6,7] the limits in Table X1.1 have been found useful for separating aggregates of satisfactory performance from those of fair or poor performance. The use of a single test by itself for estimating likely aggregate performance is not as useful as using a combination of tests which measure complementary properties. Further discussion on this topic will be found in Rogers[5] and Lang et al.[7]

[5] Rogers, C., "Canadian Experience with the Micro-Deval Test for Aggregates," *Advances in Aggregates and Armourstone Evaluation*, Latham, J. P., ed., The Geological Society, London, 1998, pp. 139–147.

[6] Kandhal, P. S., and Parker Jr., F., "Aggregate Tests Related to Asphalt Concrete Performance in Pavements," Final Report Prepared for National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., May 1997.

[7] Lang, A. P., Range, P. H., Fowler, D. W. and Allen, J. J., "Prediction of Coarse Aggregate Performance by Micro-Deval and Other Soundness, Strength, and Intrinsic Particle Property Tests," *Transportation Research Record: Journal of the Transportation Research Board*, Vol 2026, 2007, pp. 3–8.

TABLE X1.1 Referenced Micro-Deval Limits for Aggregate Applications

Application	Maximum Micro-Deval Abrasion Loss (%)
Granular sub-base	30[A]
Granular base	25[A]
Open graded base course	17[A]
Structural Concrete	17[A] 21[B]
Concrete Pavement	13[A]
Asphalt concrete base course and secondary road surface course	21[A]
Asphalt concrete surface course	17[A] 18[C]

[A]Rogers, C., "Canadian Experience with the Micro-Deval Test for Aggregates," *Advances in Aggregates and Armourstone Evaluation*, Latham, J. P., ed., The Geological Society, London, 1998, pp. 139–147.
[B]Lang, A. P., Range, P. H., Fowler, D. W. and Allen, J. J., "Prediction of Coarse Aggregate Performance by Micro-Deval and Other Soundness, Strength, and Intrinsic Particle Property Tests," *Transportation Research Record: Journal of the Transportation Research Board*, Vol 2026, 2007, pp. 3–8.
[C]Kandhal, P. S., and Parker Jr., F., "Aggregate Tests Related to Asphalt Concrete Performance in Pavements," Final Report Prepared for National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., May 1997.