Designation: D3319 – 11 (Reapproved 2017)

Standard Practice for the Accelerated Polishing of Aggregates Using the British Wheel[1]

This standard is issued under the fixed designation D3319; 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 practice covers a laboratory procedure by which an estimate may be made of the extent to which different coarse aggregates may polish.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard. Regarding sieves, per Specification E11, "The values stated in SI units shall be considered standard for the dimensions of the wire cloth openings and the diameter of the wires used in the wire cloth." When sieve mesh sizes are referenced, the alternate inch-pound designations are provided for information purposes and enclosed in parentheses.

1.3 *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.*

1.4 *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]

C778 Specification for Standard Sand

D75 Practice for Sampling Aggregates

D1415 Test Method for Rubber Property—International Hardness

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

E303 Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester

E501 Specification for Rib Tire for Pavement Skid-Resistance Tests

3. Terminology

3.1 *Definitions:*

3.1.1 *initial friction value (PV-i)*—the initial British Pendulum Tester readings on the test specimens before they are polished in the accelerated polishing machine.

3.1.2 *polish value (PV-n)*—a measure of the state of polish reached by a test specimen subjected to the specified hours (n) of accelerated polishing using the materials, equipment, and procedures described in this method. The measurement is made using the British pendulum tester as described in 5.3 and Test Method E303.

3.1.3 *residual polish value, (RPV-n)*—the residual polish value is obtained when a constant *PV-n* is achieved four consecutive times with repeated swings of the pendulum.

4. Significance and Use

4.1 This practice simulates the polishing action of vehicular traffic on coarse aggregates used in bituminous pavements.

4.2 A polish value is determined that may be used to rate or classify coarse aggregates for their ability to resist polishing under traffic.

NOTE 1—The quality of the results produced by this standard are dependant upon the competence of the personnel performing the procedure and the capability, calibration, and the maintenance of the equipment used. Agencies that meet the criteria of Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors: following the suggestions of Specification D3666 or similar acceptable guideline provides a means of evaluating and controlling some of those factors.

[1] This practice 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.

5. Apparatus

5.1 *Accelerated Polishing Machine*[3]—An accelerated polishing machine, also known as the British wheel, and based upon a 1958 design by the Road Research Laboratory of Great Britain. This machine shall be mounted on a firm, rigid, and level base. The equipment shall include the following:

5.1.1 *Cylindrical Wheel*—Hereafter referred to as the road wheel, and having a flat-surface periphery and of such size and shape as to permit 14 specimens described below to be clamped onto the periphery to form a continuous surface of aggregate particles, 1¾ in. (44.45 mm) wide and 16 in. (406.4 mm) in diameter.

5.1.2 A means of rotating the road wheel about its own axis at a speed of 320 ± 5 rpm.

5.1.3 A means of bringing the surface of a rubber-tired wheel 8 in. (203.2 mm) in diameter and 2 in. (50.8 mm) wide to bear on the aggregate specimens mounted on the surface of the road wheel with a total load of 88 ± 1 lbf (391.44 ± 4.45 N). The tire shall be treated, if necessary, to obtain a true running surface. The tire shall be free to rotate about its own axis, which should be parallel to the axis of the road wheel. The plane of rotation of the tire shall coincide with that of the road wheel. Before a new tire is used on a test, it shall be conditioned by a preliminary run of 6 h with a 150-grit silicon carbide using dummy specimens (extra or used) on the road wheel.

5.1.3.1 *Alternate Tire No. 1*—An industrial 8 by 2 pneumatic smooth-tread hand-truck tire (Note 2). The tire rubber hardness shall be 55 ± 5 IRHD measured in accordance with Test Method D1415. The tire shall be inflated to a pressure of 45 ± 2 psi (310.26 ± 13.79 kPa).

NOTE 2—This is the tire originally supplied with the Accelerated Polishing Machine[3] and known by the tire manufacturer's designation Dunlop RLI 8 by 2. Dunlop discontinued manufacturing of this tire in February 1979. It is retained as an alternate in this practice for those users who may still have a supply and in the event that Dunlop should resume manufacturing it in the future.

5.1.3.2 *Alternate Tire No. 2*—An industrial 2.80 by 4 (8 in. OD by 4 in. ID), 4 NHS-4 ply, cross-hatch pattern tread hand-truck tire (Notes 3 and 4). The tire shall be inflated to a pressure of 35 ± 2 psi (241.32 ± 13.79 kPa).

NOTE 3—When it became known that the Dunlop tire (5.1.3.1) was no longer being manufactured, the necessity of finding a replacement tire for the practice was evident. A search and study by the Texas State Department of Highways and Public Transportation culminated in finding this tire, a Goodyear Industrial All Weather Hand-Truck tire size 2.80 by 4 (Goodyear product code 202-008-002), to give polish values equal to those obtained with the Dunlop tire.[4] A suitable inner tube such as Goodyear G250-4 (product code 199-010-700) is necessary. It was also found necessary to modify the 4-in. (101.6-mm) wheel furnished with the accelerated polish machine[3] to facilitate mounting the Goodyear tire. Approximately 0.10 in. (2.54 mm) should be removed from the wheel diameter and a larger hole provided for the value stem. This did not affect mounting and use of the Dunlop tire. Goodyear is no longer manufacturing this tire.

NOTE 4—A 1998 study conducted by the Texas Department of Transportation shows that the use of cross-hatch tire results in differential wear of the test specimen surface that mirrors the pattern of the tire. This differential wear pattern produces falsely higher polish values, particularly for softer aggregates. Other research has shown that increased tire wear has an effect of accentuating the polishing of the test specimens and resulting in lower polish values. Laboratory control specimens should be used to monitor the effect of the tire wear on accelerated polishing and tests results.

5.1.3.3 *Alternate Tire No. 3*—An 8-in. (203.2-mm) diameter solid rubber tire (Note 5). The tire rubber hardness shall be 69 ± 3 IRHD measured in accordance with Test Method D1415. It is necessary to move the cylindrical wheel approximately 3⁄16 in. (4.76 mm) away from the polishing machine to allow the tire to center over the test specimens. The tire shall be replaced when the *RPV-10* of the control specimens described in 7.2 have decreased by more than four points from the *RPV-10* obtained from a new tire.

NOTE 5—This is the tire presently supplied by the manufacturer of the accelerated polishing machine.[3] Research has shown that increased tire wear has an effect of accentuating the polishing of the test specimens and resulting in lower polish values. Laboratory control specimens should be used to monitor the effect of the tire wear on accelerated polishing and test results.

5.1.4 A means to feed the 150-grit silicon carbide abrasive at the rate given in 8.5. The grit shall be fed continuously and with a uniform distribution across the width of the specimens. The grit shall be applied directly onto the road wheel surface ahead of the point of contact with the rubber-tired wheel.

5.1.5 A means to feed the water at the rate given in 8.5 in such a way that the water is spread continuously and uniformly over the surface of the road wheel ahead of the point of contact with the rubber-tired wheel.

5.2 *Metal Molds*—A number of accurately machined metal molds for preparing specimens. The specimen formed is 3.5 by 1.75 by 0.63 in. (88.90 by 44.45 by 16.0 mm) and shall be curved to fit on a surface having an 8-in. (203.2-mm) radius of curvature.

5.3 *British Pendulum Tester*—A friction-measuring device. The British pendulum tester used shall conform to Test Method E303.

5.3.1 The slider contact path shall be 3 ± 1⁄16 in. (76.20 ± 1.59 mm).

5.3.2 The slider width shall be 1¼ in. (31.75 mm).

5.3.3 The rubber that is bonded to the slider shall be ¼ by 1 by 1¼ in. (6.35 by 25.4 by 31.75 mm).

5.3.4 The rubber shall meet the requirements of Specification E501.

5.3.5 The zero adjustment shall be checked before and after testing the specimens and as often as the operator deems necessary.

5.3.6 The calibration procedures of Test Method E303 shall be used. However, after calibration the small slider shall be inserted.

[3] Available from Wessex Engineering and Metal Craft Co., Ltd., Merchants Barton, Frome, Somerset, England. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1002. Contact ASTM Customer Service at service@astm.org.

5.3.7 *Sanding Block*—A rigid metal block with a planed surface of 7.5-in. (190.5-mm) radius of curvature that is consistent with the radius of curvature of the road wheel bearing surface.

6. Materials and Supplies

6.1 *Water*—A supply of tap water for use where water is required for any purpose in this method.

6.2 *Fine Sand*—A supply of fine sand for sifting into the interstices of the aggregate prior to placing of the bonding material. Standard sand conforming to Specification C778 has been found suitable for this purpose.

6.3 *Mold Release Agent*—The use of a mold release agent is optional. A mold release agent may be used to prevent bonding between the mold and the bonding material. Silicon release agent and paste wax as used for automobiles and floors has been found suitable. The user should use care to prevent this agent from being absorbed by the aggregate, as it could affect the measured polish value.

6.4 *Silicon Carbide Grit*—A supply of silicon carbide grit (150-grit size) to be used as the polishing agent. Grit should be checked for gradation using Nos. 150-µm (No. 100), 106-µm (No. 140) and 75-µm (No. 200) sieves and separated if necessary to maintain a uniform gradation passing the No. 150-µm (No. 100) sieve and retained on the No. 75-µm (No. 200) sieve.

6.5 *Bonding Agent*—A supply of polyester resin and catalyst (or another suitable bonding material, such as an epoxy resin) having a pot life of 20 to 30 min and a curing time of 3 to 6 h. This bonding agent shall not be so fluid as to flow through the fine sand.

6.5.1 An optional bonding agent may be used to eliminate use of the fine sand. This bonding agent must be quite viscous so that it will not flow completely around the aggregate particles and become part of the surface of the test specimen. Examples of suitable materials are given in Appendix X1.

6.5.2 Follow the manufacturer's precautions concerning storage and use of resin and catalyst.

6.6 *Coarse Aggregate*—Approximately a ½-ft^3 (0.014-m^3) supply of coarse aggregate to be tested and sampled in accordance with Practice D75. The aggregate shall be normal plant run but laboratory-crushed material may be tested, if so identified.

7. Test and Control Specimens

7.1 Five test specimens for each coarse aggregate shall be tested.

7.2 Standard laboratory control specimens shall be included in each run to develop consistency in specimen preparation and polishing. Four control specimens shall be included with two sets containing five test specimens each for each run. Aggregates used for fabrication of control specimens should be of consistent property and *RPV-10* test history.

NOTE 6—It has been found that the polishing surface of control specimens can be successfully replicated by filling the bottom of the metal mold with a uniform mixture of four parts 20–30 grade Ottawa sand and one part polyester resin. The backing of the Ottawa sand control specimens should be 100 % polyester resin to facilitate preparation of the surface bearing against the road wheel.

7.3 The aggregate to be tested shall pass the 12.5-mm (½-in) sieve and shall be retained on a 9.5-mm (⅜-in.) sieve.

NOTE 7—Aggregate gradation may be varied to meet the needs of the user if reported with the test results. However, aggregates larger than 12.5 mm (½ in.) may not be accommodated by the mold, and aggregates smaller than 9.5 mm (⅜ in.) may not be adequately bonded in the specimen molding process to be retained for the duration of the test. For laboratories and agencies evaluating and monitoring multiple aggregate sources, an alternate aggregate size of passing 9.5-mm (⅜-in.) sieve and retained on a 6.3-mm (¼-in.) sieve may be used to represent the critical size of the bituminous mixture. The two aggregate sizes described should not be used alternately for quality monitoring of friction aggregates.

7.4 Thoroughly wash and dry the aggregate to be tested at 230 ± 9 °F (110 ± 5 °C) to essentially constant weight.

7.5 Coat the mold with mold release agent.

7.6 Each specimen shall contain a single layer of dry aggregate placed by hand as densely as possible with a flat surface down to cover the bottom 3.5 by 1.75-in. (88.9 by 44.45-mm) surface of the mold.

NOTE 8—Particles selected should be representative of the material to be evaluated. Flat, elongated, or unusually shaped particles can cause difficulty in placement and bonding. Misleading polish values can result from inadequate surface area for polishing.

7.7 Fill the interstices between the aggregate with the fine sand, described in 6.2, from one-fourth to one-half of the aggregate depth.

7.7.1 An optional method eliminates the sand by using a viscous polyester resin. This material is described in 6.5.

7.8 Prepare the bonding agent described in 6.5 and in accordance with the manufacturer's instructions. The consistency of the bonding agent shall be such that it will flow freely between the aggregate particles but not so thin as to impregnate the sand or to bond this sand to the specimen surface later preventing its removal. An ideal consistency would be such that the bonding agent must be forced into the voids between the aggregate particles by gentle hand pressure with a spatula.

7.8.1 The optional bonding agent requires a heavier consistency such that it will not flow except with the aid of a spatula.

7.9 Fill the prepared mold to overflowing with the bonding material.

NOTE 9—Care should be used to ensure that the bonding agent is not allowed to penetrate near the aggregate surface to be polished in such a way that the rubber slider may contact it.

7.10 When the bonding material has stiffened sufficiently, strike off the excess material even with the curved sides of the mold.

7.11 When the bonding material has cured properly (3 to 6 h) remove the specimen from the mold.

NOTE 10—When warping of the test specimens occurs due to shrinkage of the polyester resin, this can cause poor fit on the road wheel and bouncing and slipping of the polishing tire. The hardened polyester resin may be heated while remaining in the mold in a 100 °C oven for 2 to 4 h to allow the specimens to be re-conformed to the specified curvature through the use of mechanical clamping and through a cool-down period.

7.12 If sand was used, remove all free and excess sand from the face of the specimen.

7.13 Dress the bottom of the specimens by hand sanding over the sanding block (5.3.7). The prepared specimens shall have uniform thickness and all four corners bearing uniformly on the same plane to ensure a proper fit of the road wheel. Respirators shall be used to prevent breathing the dust.

7.14 Mark on the bottom of the test specimens the sample identification information and direction of rotation. Mark on only one side of the test specimens the number sequence of each aggregate sample.

7.15 *Calibration Specimens:*

7.15.1 Two sets of four calibration specimens shall be prepared and used to calibrate the British pendulum tester before each day's use. The two sets of calibration specimens shall have average residual polish values (*RPV*) of 29 ± 1 and 38 ± 1, respectively.

NOTE 11—The *RPV-10* of Ottawa sand control specimens may be used to meet the requirements of 29 ± 1. The requirement of 38 ± 1 may be met by the *RPV-0* of blank specimens with a single layer of 20–30 grade Ottawa sand firmly bonded to the surface of a specimen made of 100 % polyester resin. A quickset two-part epoxy can be used as the bonding agent. The single layer of Ottawa sand can be achieved by rolling the blank specimen (surfaced with the bonding agent) in a pan of sand and immediately afterward rolled against a firm surface.

8. Procedure

8.1 Determine the initial friction value of each prepared test specimen in accordance with Test Method E303 using the slider specified in 5.3. Take all readings from the permanent scale.

8.2 Clamp 14 specimens around the periphery of the road wheel (using rubber O-rings near the edge of the specimens) to form a continuous strip of particles upon which the tired wheel shall ride freely without bumping or slipping. The test and control specimens shall be alternately placed without duplicating the same aggregate sample in consecutive sequence and with the permanent side markings facing away from the polishing machine. Inserts of varying thickness made of cutouts of blank polyester specimens may be used to fill in the gap(s).

8.3 Maintain the temperature of the specimens, water, and apparatus at 75 ± 5 °F (23.9 ± 2.8 °C) during the entire time of the test.

8.4 Bring the road wheel to a speed of 320 ± 5 rpm, and bring the pneumatic-tired wheel to bear on the surface of the specimen with a total load of 88 ± 1 lbf (391.44 ± 4.45 N).

8.5 Feed the No. 150 silicon carbide grit at a rate of 6 ± 2 g⁄min for the desired testing time (Note 12). Feed the water at the rate of 50 to 75 mL/min.

NOTE 12—Aggregates should be subjected to a polishing action of 10 h, unless maximum polish is achieved in a shorter time. Maximum polish is achieved when no change is detected on successive measurements.

8.6 Remove the specimens from the road wheel and wash thoroughly to remove grit.

8.7 After cleaning, test each specimen to determine the polish value in accordance with Test Method E303 using the slider specified in 5.3. Take all readings from the permanent scale. When clamping the test and control specimens for polish value determinations, the permanent side marking on the test and control specimens should face toward the permanent scale.

8.8 If the rate of polish is desired, repeat the procedure in 8.2 – 8.7 at regular intervals of machine time such as 1, 2, 4, 6, 8, and 10 h.

9. Report

9.1 Report the following information as is appropriate to the needs of the user:

9.1.1 Identification of the coarse aggregate tested (and the control aggregate if used) including gradation of aggregate,

9.1.2 Initial friction value for specimens containing aggregates to be evaluated and for control specimens if used,

9.1.3 Polish values for specimens containing aggregates evaluated and for control specimens,

9.1.4 Adjusted polish values of the test specimens based on the change in the average polish value of control specimens,

9.1.5 Type of tire used for accelerated polishing of aggregates,

9.1.6 Control chart for the polish value of the control specimens with the corresponding hours of tire usage,

9.1.7 Control chart of the average polish value of the calibration specimens,

9.1.8 Length of time and interim polish value of specimens tested for rate-of-polish determination,

9.1.9 Temperature during testing period, and

9.1.10 Dates of testing period.

10. Keywords

10.1 aggregates; friction; polishing; polish value

APPENDIX

(Nonmandatory Information)

X1. SUITABLE BONDING AGENT

X1.1 The following formulation is a polyester bonding agent that has been found to successfully eliminate the need for sand as described in Section 7.

Parts by Weight	Component	Supplier
100	Polylite 32-773 Polyester Resin[5]	Reichhold Chemical Co.
30	Wollastonite NYAD 400 Extender Pigment[6]	Interpace Corp.*
5 to 6	Santocel Z Silica Aerogel,[7] Aerosil 200,[8] or Cab-O-Sil M-5 Colloidal Silica[9]	Monsanto Chemical Co. Degussa, Inc. Godfrey L. Cabot, Inc.
0.5	6 % Cobalt Naphthenate Solution[5]	Reichhold Chemical Co.

X1.2 Prepare the grout as follows:

X1.2.1 Add the Wollastonite NYAD 400 to the polyester resin and disperse with a laboratory model Cowles disperser or similar equipment which will give a good, uniform mix. Then the Santocel Z or Cab-O-Sil M-5 and grind in with the Cowles disperser until a good gel is obtained. The amount of gelling agent may be varied depending upon the stiffness desired. The thixotropy or gel can also be increased by stirring in a maximum of 0.1 part by weight glycerine following dispersal of the gelling agent. Stir in the cobalt naphthenate.

X1.2.2 Just prior to use, add approximately 0.7 weight % of 60 % methyl ethyl ketone peroxide catalyst[5] to the basic polyester grout and stir well. The amount of catalyst may also be varied depending upon the pot life or working time and the speed of cure desired.

X1.3 The working time of a 200-g batch of the catalyzed material is 15 to 20 min at 77 °F (25 °C). The cast specimens will cure adequately in 12 h at 77 °F (25 °C) to perform the accelerated polish test.

NOTE X1.1—Other formulations may also be suitable and easily obtained locally. One such material is Preco, Gold Label, Non-Sagging Resin and Powder.[10]

[5] Available from Reichhold Chemical Co., 523 N. Broadway, White Plains, NY 10603. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[6] Available from Interpace Corp., Customer Service Div., Willsboro, NY 12996. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[7] Available from Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis, MO 63166. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[8] Available from Degussa, Inc., Route 46 at Hollister Rd., Teterboro, NJ 07608. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[9] Available from Cabot Corp., Cab-O-Sil Div., Tuscole, IL 61953. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[10] Available from Preco Industries, Ltd., 55 Skyline Dr., Plainview, NY 11803. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.