Designation: ~~D8239 – 18~~ D8239 – 21

Standard Specification for Performance-Graded Asphalt Binder Using the Multiple Stress Creep and Recovery (MSCR) Test[1]

This standard is issued under the fixed designation D8239; 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 specification[2] covers asphalt binders graded by performance. Grading designations are related to the LTPPBind calculated maximum pavement design temperature, the minimum pavement design temperature, and the traffic loading.

NOTE 1—For more information on LTPPBind online, see https://infopave.fhwa.dot.gov/Tools/LTPPBindOnline accessed June 10, 2020.

1.2 This specification incorporates Test Method D7405 for determining non-recoverable creep compliance, J_{nr}. "S," "H," "V," or "E" designations must be specified for standard, ~~high,~~heavy, very ~~high,~~heavy, and extremely ~~high~~heavy traffic loading, respectively.

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

1.4 The text of this standard 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 standard.

NOTE 2—A guidance document for specifying bodies using R % for elastic properties is under development.

NOTE 3—For asphalt binders graded by penetration at 25 °C, see Specification D946/D946M. For asphalt binders graded by viscosity at 60 °C, see Specification D3381/D3381M. For performance-graded asphalt binder, see Specification D6373.

NOTE 4—AASHTO R 29 provides non-mandatory information for determining the performance grade of an asphalt binder.

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:*[3]

D8 Terminology Relating to Materials for Roads and Pavements

[1] This specification is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.40 on Asphalt Specifications.

Current edition approved ~~Dec. 1, 2018~~Feb. 1, 2021. Published ~~December 2018~~February 2021. Originally approved in 2018. Last previous edition approved in 2018 as D8239 – 18. DOI: ~~10.1520/D8239-18.~~10.1520/D8239-21.

[2] This specification is based on SHRP Product 1001, AASHTO M 320, and AASHTO M 332.

[3] 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.

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D140/D140M Practice for Sampling Asphalt Materials
D946/D946M Specification for Penetration-Graded Asphalt Binder for Use in Pavement Construction
D2042 Test Method for Solubility of Asphalt Materials in Trichloroethylene
~~D2170/D2170M Test Method for Kinematic Viscosity of Asphalts~~
~~D2171/D2171M Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer~~
D2872 Test Method for Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)
D3381/D3381M Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction
D4402/D4402M Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer
~~D5546 Test Method for Solubility of Asphalt Binders in Toluene by Centrifuge (Withdrawn 2017)[4]~~
D6373 Specification for Performance-Graded Asphalt Binder
D6521 Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
D6648 Test Method for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
D6723 Test Method for Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT) (Withdrawn 2021)[4]
D7175 Test Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer
D7405 Test Method for Multiple Stress Creep and Recovery (MSCR) of Asphalt Binder Using a Dynamic Shear Rheometer
D7553 Test Method for Solubility of Asphalt Materials in N-Propyl Bromide

2.2 *AASHTO Standards:*[5]

R 29 Practice for Grading or Verifying the Performance Grade of an Asphalt Binder
M 332 Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions for many terms common to asphalt binder are found in Terminology D8.

4. Ordering Information

4.1 When ordering under this specification, include in the purchase order the performance grade (PG) of asphalt binder required, including the designation for traffic loading (for example, D8239, PG 64V-22).

NOTE 5—Agencies may elect to specify PG grades not listed in the tables, either outside the table limits or between listed grades, based on specific design or performance criteria. For these PG grades it is still appropriate to test the original and RTFO DSR at the specified PG high temperature, and BBR at the specified PG low temperature +10 °C and PAV DSR at (PG high + PG low)/2 + 4) °C; for example, for PG 64-22, (64 + (–22))/2 + 4 = 25.

NOTE 6—The different generations of the LTPPBind program use different algorithms and weather databases for determining the PG high temperature for a location. The choice of which LTPPBind version to use is up to the specifier.

4.2 ~~The required environmental asphalt binder grades may be selected by following the procedures described in AASHTO M 323 and R 35, except do not use the "grade bumping" procedure in M 323.~~ Select the environmentally appropriate high and low temperature grades and the appropriate "S," "H," "V," or "E" grade for the expected traffic level and traffic load rate.

4.2.1 Standard Designation "S" in most typical situations will be for traffic levels fewer than 10 million equivalent single-axle loads (ESALs) and less than the standard traffic load rate (>70 km/h).

4.2.2 ~~High~~Heavy Designation "H" in most situations will be for traffic levels of 10 to 30 million ESALs or slow-moving traffic (20 to 70 km/h).

4.2.3 Very ~~High~~Heavy Designation "V" in most situations will be for traffic levels of greater than 30 million ESALs or standing traffic (<20 km/h).

4.2.4 Extremely ~~High~~Heavy Designation "E" in most situations will be for traffic levels of greater than 30 million ESALs and standing traffic (<20 km/h) such as toll plazas or port facilities.

[4] The last approved version of this historical standard is referenced on www.astm.org.
[5] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

NOTE 7—"Grade bumping" is accomplished by using the "H," "V," or "E" designation and not by increasing the PG high temperature ~~grade as recommended in Specification~~ grade.~~D6373~~.

4.2.5 The specification evaluates J_{nrdiff}, the change in compliance from the 0.1-kPa stress level to the 3.2-kPa stress level and restricts the change to 0.75 or 75 %. This is equivalent to 75 % of one grade change. In cases where the J_{nr} value is less than 0.5, this requirement for J_{nrdiff} is dropped. When the J_{nr} value is below 0.5, the binder is extremely stiff and, from precision and bias studies, there is likely to be higher variability with J_{nr} values below 0.5. In these cases, the issue of loss of stiffness due to shear thinning of the binder at increased stress is minimal and the requirement in not necessary.

5. Materials and Manufacture

5.1 Asphalt binder shall be prepared by the refining of crude petroleum, ~~from naturally occurring asphalt, or combinations thereof,~~ with or without the addition of modifiers.

5.2 Modifiers may be any materials of suitable manufacture that are used in virgin or recycled condition and that are capable of being dissolved, dispersed, or reacted in asphalt binder with the objective of improving its performance.

5.3 The asphalt binder shall be homogeneous, free from water and deleterious materials, and shall not foam when heated to 175 °C.

5.4 The asphalt binder shall be at least 99.0 % soluble, as determined by Test Method D2042 or D7553. Any insoluble component shall be substantially free of fibers.

5.5 This specification is not applicable for asphalt binders in which fibers or other discrete particles are larger than 250 µm in size.

5.6 The grades of asphalt binder shall conform to the requirements given in Table 1.

NOTE 8—Conformance with all of the parameters of this specification is not a guarantee that the asphalt concrete mix made from these products will perform in the field. The end user of asphalt binders should assess the suitability of the binder to meet the performance requirements of the projects on which they will be used.

6. Sampling

6.1 The material shall be sampled in accordance with Practice D140/D140M.

7. Test Methods

7.1 The properties outlined in 5.3, 5.4, and 5.6 shall be determined in accordance with Test Methods D92, D95, D2042 or D7553, D2872, D4402/D4402M, Practice D6521, Test Methods D6648 and D6723, and Test Methods D7175 and D7405.

8. Inspection and Certification

8.1 Inspection and certification of the material shall be agreed upon between the purchaser and the seller. Specific requirements shall be made part of the purchase contract. The seller shall provide material handling and storage procedures for each asphalt binder grade certified.

NOTE 9—A number of relevant research studies have suggested that limits for the loss of stiffness for the binder, $G^* \cdot \sin\delta$, in the ASTM and AASHTO PG binder specifications is, by itself, not a sufficient indicator of fatigue performance of an asphalt binder or the asphalt concrete in asphalt pavement structures, or both.

9. Rejection and Rehearing

9.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformity is performed as indicated in the purchase order or as otherwise agreed upon between the purchaser and the seller.

10. Keywords

10.1 asphalt binder; direct tension; flash point; modifier; multiple stress creep and recovery (MSCR); performance specifications;

TABLE 1 Performance-Graded Asphalt Binder Specification[A]

Performance Grade	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
	34 40 46	10 16 22 28 34 40 46	16 22 28 34 40	10 16 22 28 34 40	10 16 22 28 34 40	10 16 22 28 34	10 16 22 28 34
LTPPBind algorithm max pavement design temp, °C[B]	<46	<52	<58	<64	<70	<76	<82
Min pavement design temp, °C[B]	>–34 >–40 >–46	>–10 >–16 >–22 >–28 >–34 >–40 >–46	>–16 >–22 >–28 >–34 >–40	>–10 >–16 >–22 >–28 >–34 >–40	>–10 >–16 >–22 >–28 >–34 >–40	>–10 >–16 >–22 >–28 >–34	>–10 >–16 >–22 >–28 >–34
Original Binder							
Flash point temp, D92, min °C	230						
Viscosity, D4402/D4402M:[C] max 3 Pa·s, Test temp, °C	135						
~~Dynamic Shear, D7175:[D] G*/sinδ, min 1.00 kPa[E] Test temp at 10 rad/s, °C~~	~~46~~	~~52~~	~~58~~	~~64~~	~~70~~	~~76~~	~~82~~
Dynamic Shear, D7175: G*/sinδ, min 1.00 kPa Test temp at 10 rad/s, °C	46	52	58	64	70	76	82
Rolling Thin Film Oven (Test Method D2872)							
~~Mass change, max, percent[E]~~	~~1.00~~						
Mass change, max, percent[D]	1.00						
MSCR, D7405: Standard Traffic "S" $J_{nr3.2}$, max 4.5 kPa^{-1} J_{nrdiff}, max 75 % Test temp, °C	46	52	58	64	70	76	82
MSCR, D7405: Heavy Traffic "H" $J_{nr3.2}$, max 2.0 kPa^{-1} J_{nrdiff}, max 75 % Test temp, °C	46	52	58	64	70	76	82
MSCR, D7405: Very Heavy Traffic "V" $J_{nr3.2}$, max 1.0 kPa^{-1} J_{nrdiff}, max 75 % Test temp, °C	46	52	58	64	70	76	82
MSCR, D7405: Extremely Heavy Traffic "E" $J_{nr3.2}$, max 0.5 kPa^{-1} Test temp, °C	46	52	58	64	70	76	82
Pressure Aging Vessel Residue (Practice D6521)							
~~PAV aging temp, °C[G]~~	~~90~~	~~90~~	~~100~~	~~100~~	~~100 (110)~~	~~100 (110)~~	~~100 (110)~~
PAV conditioning temp, °C[E]	90 (100, 110)	90 (100, 110)	100 (110)	100 (110)	100 (110)	100 (110)	100 (110)
~~Dynamic Shear, D7175: "S" G*·sinδ, max 5000 kPa[E] Test temp at 10 rad/s, °C~~	~~10 7 4~~	~~25 22 19 16 13 10 7~~	~~25 22 19 16 13~~	~~31 28 25 22 19 16~~	~~34 31 28 25 22 19~~	~~37 34 31 28 25~~	~~40 37 34 31 28~~
Dynamic Shear, D7175: "S" G*·sinδ, max 5000 kPa Test temp at 10 rad/s, °C	10 7 4	25 22 19 16 13 10 7	25 22 19 16 13	31 28 25 22 19 16	34 31 28 25 22 19	37 34 31 28 25	40 37 34 31 28

TABLE 1 *Continued*

Performance Grade	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
	34 40 46	10 16 22 28 34 40 46	16 22 28 34 40	10 16 22 28 34 40	10 16 22 28 34 40	10 16 22 28 34	10 16 22 28 34
~~Dynamic Shear, D7175: "H," "V," "E" G*·sinδ, max 6000 kPa[E] Test temp at 10 rad/s, °C~~	~~10 7 4~~	~~25 22 19 16 13 10 7~~	~~25 22 19 16 13~~	~~31 28 25 22 19 16~~	~~34 31 28 25 22 19~~	~~37 34 31 28 25~~	~~40 37 34 31 28~~
Dynamic Shear, D7175: "H," "V," "E" G*·sinδ, max 6000 kPa Test temp at 10 rad/s, °C	10 7 4	25 22 19 16 13 10 7	25 22 19 16 13	31 28 25 22 19 16	34 31 28 25 22 19	37 34 31 28 25	40 37 34 31 28
~~Creep stiffness, D6648:[H] *S*, max 300 MPa *m*-value, min 0.300 Test temp at 60 s, °C~~	~~–24 –30 –36~~	~~0 –6 –12 –18 –24 –30 –36~~	~~–6 –12 –18 –24 –30~~	~~0 –6 –12 –18 –24 –30~~	~~0 –6 –12 –18 –24 –30~~	~~0 –6 –12 –18 –24~~	~~0 –6 –12 –18 –24~~
Creep stiffness, D6648:[F] *S*, max 300 MPa *m*-value, min 0.300 Test temp at 60 s, °C	–24 –30 –36	0 –6 –12 –18 –24 –30 –36	–6 –12 –18 –24 –30	0 –6 –12 –18 –24 –30	0 –6 –12 –18 –24 –30	0 –6 –12 –18 –24	0 –6 –12 –18 –24
~~Direct tension, D6723:[H] Failure strain, min 1.0 % Test temp at 1.0 mm/min, °C~~	~~–24 –30 –36~~	~~0 –6 –12 –18 –24 –30 –36~~	~~–6 –12 –18 –24 –30~~	~~0 –6 –12 –18 –24 –30~~	~~0 –6 –12 –18 –24 –30~~	~~0 –6 –12 –18 –24~~	~~0 –6 –12 –18 –24~~
Direct tension, D6723:[F] Failure strain, min 1.0 % Test temp at 1.0 mm/min, °C	–24 –30 –36	0 –6 –12 –18 –24 –30 –36	–6 –12 –18 –24 –30	0 –6 –12 –18 –24 –30	0 –6 –12 –18 –24 –30	0 –6 –12 –18 –24	0 –6 –12 –18 –24

[A] MSCR testing on RTFO residue should be performed at the PG grade based on the environmental high pavement temperature. Grade bumping is accomplished by requiring a lower J_{nr} value while testing at the environmental temperature.

[B] Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPPBind program, or are provided by the specifying agency, excluding provisions for grade bumping.

[C] The referee method shall be Test Method D4402/D4402M using a ~~#21~~ No. 21 spindle at 20 RPM. This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

~~[D] For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be used to supplement dynamic shear measurements of G*/sinδ at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary viscometry (Test Method D2170/D2170M or D2171/D2171M) or rotational viscometry.~~

~~[E] G*/sinδ = high temperature stiffness and G*·sinδ = intermediate temperature stiffness.~~

[D] The mass change shall be less than 1.00 % for either a positive (mass gain) or a negative (mass loss) change. The J_{nrdiff} requirement shall not apply to asphalt binders having a J_{nr}3.2 value of 0.5 kPa–1 or lower at the selected test temperature.

[E] The PAV ~~aging~~conditioning temperature is based on simulated climatic conditions and is one of three temperatures: 90 °C, ~~100 °C~~100 °C, or 110 °C. Normally the PAV ~~aging~~conditioning temperature is 100 °C for PG 58-xx and above. However, in desert climates, the PAV ~~aging~~conditioning temperature for PG 70-xx and above may be specified as ~~110 °C~~110 °C. However, when the binder is being used in a different climate or a softer binder is being used due to blending, the PAV conditioning temperature may be specified as 100 °C when used in climates requiring PG 58-xx to PG 64-xx, or 110 °C when used in climates requiring PG 70-xx and above.

[F] If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The *m*-value requirement must be satisfied in both cases. ~~If the creep stiffness and m-value data are unobtainable because the binder is too soft at the test temperature, the asphalt binder will be deemed to pass at that grade temperature if it meets the creep stiffness and m-value requirements at the test temperature minus 6 °C.~~