Designation: D6373 – 16

Standard Specification for Performance Graded Asphalt Binder[1]

This standard is issued under the fixed designation D6373; 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 average seven-day maximum pavement design temperature, and minimum pavement design temperature. This specification contains Table 1 and Table 2. Table 2 incorporates Practice D6816 for determining the critical low cracking temperature using a combination of Test Method D6648 and Test Method D6723 test procedures. If no table is specified, the default is Table 1.

NOTE 1—For asphalt cements graded by penetration at 25°C, see Specification D946. For asphalt cements graded by viscosity at 60°C see Specification D3381.

NOTE 2—AASHTO R 29 provides non-mandatory information for determining the performance grade of an asphalt binder.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D8 Terminology Relating to Materials for Roads and Pavements
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 Practice for Sampling Bituminous Materials
D946 Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
D2042 Test Method for Solubility of Asphalt Materials in Trichloroethylene
D2170 Test Method for Kinematic Viscosity of Asphalts (Bitumens)
D2171 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 Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
D4402 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
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)
D6816 Practice for Determining Low-Temperature Performance Grade (PG) of Asphalt Binders
D7175 Test Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer
D7553 Test Method for Solubility of Asphalt Materials in N-Propyl Bromide

2.2 *AASHTO Standards:*[4]

AASHTO R 29 Grading or Verifying the Performance Grade of an Asphalt Binder
AASHTO M 320 Standard Specification for Performance-Graded Asphalt Binder

3. Terminology

3.1 *Definitions:*

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *asphalt binder, n*—an asphalt-based cement that is produced from petroleum residue either with or without the addition of modifiers.

[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 Sept. 1, 2016. Published September 2016. Originally approved in 1999. Last previous edition approved in 2015 as D6373 – 15. DOI: 10.1520/D6373-16.

[2] This specification is based on SHRP Product 1001 and AASHTO MP1.

[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.

[4] 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.

TABLE 1 Performance Graded Asphalt Binder Specification

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
Average 7-day maximum Pavement Design Temperature, °C	<46	<52	<58	<64	<70	<76	<82
Minimum Pavement Design Temperature,° C[A]	> –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:[B] max. 3 Pa·s, Test Temp., °C	135						
Dynamic Shear, D7175:[C] G*/sinδ, min. 1.00 kPa 25 mm Plate, 1 mm Gap 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	1.00						
Dynamic Shear, D7175: G*/sinδ, min. 2.20 kPa 25 mm Plate, 1 mm Gap Test Temp. at 10 rad/s,°C	46	52	58	64	70	76	82
Pressure Aging Vessel Residue (Practice D6521)							
PAV Aging Temperature, °C[D]	90	90	100	100	100 (110)	100 (110)	100 (110)
Dynamic Shear, D7175: G*·sinδ, max 5000 kPa 8 mm Plate, 2 mm Gap 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:[E] 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:[E] 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]Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPP Bind software program, or are provided by the specifying agency.

[B]The referee method shall be D4402 using a #21 spindle at 20RPM, however alternate methods may be used for routine testing and quality assurance. If the binder is too stiff to test with the No. 21 Spindle, the No. 27 spindle shall be used. The spindle size and shear rate shall be reported. 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.

[C]For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for 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 Methods D2170 or D2171) or rotational viscometry.

[D]The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures 90°C, 100°C or 110°C. Normally the PAV aging temperature is 100°C for PG 58–xx and above. However, in desert climates, the PAV aging temperature for PG 70–xx and above may be specified as 110°C

[E]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.

TABLE 2 Performance Graded Asphalt Binder Specification

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
Average 7-day maximum Pavement Design Temperature, °C	<46	<52	<58	<64	<70	<76	<82
Minimum Pavement Design Temperature,° C[A]	> –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:[B] max. 3 Pa·s, Test Temp., °C	135						
Dynamic Shear, D7175:[C] G*/sinδ, min. 1.00 kPa 25 mm Plate, 1 mm Gap 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	1.00						
Dynamic Shear, D7175: G*/sinδ, min. 2.20 kPa 25 mm Plate, 1 mm Gap Test Temp. at 10 rad/s,°C	46	52	58	64	70	76	82
Pressure Aging Vessel Residue (Practice D6521)							
PAV Aging Temperature, °C[D]	90	90	100	100	100 (110)	100 (110)	100 (110)
Dynamic Shear, D7175: G*·sinδ, max 5000 kPa 8 mm Plate, 2 mm Gap 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
Critical Low Cracking Temperature, D6816,:[E] PASS Test Temp °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]Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPP Bind software program, or are provided by the specifying agency.

[B]The referee method shall be D4402 using a #21 spindle at 20RPM, however alternate methods may be used for routine testing and quality assurance. If the binder is too stiff to test with the No. 21 Spindle, the No. 27 spindle shall be used. The spindle size and shear rate shall be reported. 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.

[C]For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for 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 Methods D2170 or D2171) or rotational viscometry.

[D]The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures 90°C, 100°C or 110°C. Normally the PAV aging temperature is 100°C for PG 58–xx and above. However, in desert climates, the PAV aging temperature for PG 70–xx and above may be specified as 110°C

[E]For verification of grade, at a minimum perform D6648 at the test temperature and at the test temperature minus 6°C, and D6723 at the test temperature. Testing at additional temperatures for D6648 may be necessary if 300 MPa is not bracketed at the initial two test temperatures. Compare the failure stress from D6723 to the calculated induced thermal stress as per D6816. If the failure stress exceeds the induced thermal stress, the asphalt binder is deemed a “PASS” at the specification temperature. 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 critical low cracking temperature requirements at the test temperature minus 6°C.

4. Ordering Information

4.1 When ordering under this specification, include in the purchase order the performance grade (PG) of asphalt binder required and the table used (for example, PG 52-16, Table 1 or PG 64-34, Table 2). If no table is specified, the default is Table 1.

NOTE 3—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.

5. Materials and Manufacture

5.1 Asphalt binder shall be prepared by the refining of crude petroleum, from naturally occurring asphalt, or combinations thereof, by suitable methods, 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.

NOTE 4—This specification is not intended to address the grading of asphalt binders containing particulate or fibrous materials larger than 250 µm in size.

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 Methods D2042, D7553, or D5546. Any insoluble component shall be substantially free of fibers.

5.5 The grades of asphalt binder shall conform to the requirements given in Table 1 or Table 2

NOTE 5—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.

7. Test Methods

7.1 The properties outlined in 5.3, 5.4 and 5.5 shall be determined in accordance with Test Methods D92, D95, D2042, D2872, D4402, D5546, Practice D6521, Test Methods D6648 and D6723, Practice D6816, and Test Methods D7553 or D7175.

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 6—A number of relevant research studies have suggested that limits for the loss stiffness for the binder, $G^*\cdot\sin\delta$, in the ASTM and AASHTO PG Binder Specification is, by itself, not a sufficient indicator of fatigue performance of an asphalt cement, 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; asphalt cement; direct tension; flash point; modifier; performance specifications; pressure aging; rheology

APPENDIX

(Nonmandatory Information)

X1. SUMMARY OF DIFFERENCES BETWEEN SPECIFICATION D6373 AND AASHTO M 320–10

X1.1 This specification was originally developed under the sponsorship of the American Association of State Highway and Transportation Officials (AASHTO) as part of the Strategic Highway Research Program (SHRP). ASTM's version of this specification (Specification D6373) was modeled after, and is similar to the comparable AASHTO specification (AASHTO M-320, formerly known as PP 1).

X1.1.1 The 2013 and 2015 revisions of the ASTM specification include several changes that bring the ASTM and AASHTO standards into closer alignment. To help the user understand the relationship between these standards, and in the interest of promoting further harmonization, the remaining differences are summarized below. Note that ASTM and AASHTO may use slightly different formats and section

numbering, so this summary is intended for general information only. Please consult the corresponding ASTM and AASHTO standards to determine the exact differences.

X1.2 Differences in the Scope Section (Section 1 in both standards)

X1.2.1 The ASTM standard references ASTM test method while the AASHTO standard references AASHTO test methods.

X1.3 Differences in the Referenced Documents Section (Section 2 in both standards)

X1.3.1 In most cases, the ASTM Standard references ASTM documents, while the AASHTO Standard references AASHTO documents. The correspondence between the referenced documents is given in the following table. These differences occur in the referenced document section (Section 2), as well as within the body of each standard.

ASTM Standard	AASHTO Standard	Subject
D8	...	Terminology
D92	T 48	Flash Point
D95	T 55	Water Content
D140	T 40	Sampling
D946	M 20	Penetration Graded Specification
D2042	T 44	Solubility in Trichloroethylene
D2170	T 201	Kinematic Viscosity
D2171	T 202	Absolute VIscosity
D2872	T 240	Rolling Thin Film Oven Test
D3381	M 226	Viscosity Graded Specification
D4402	T 316	Rotational Viscosity
D5546	–	Solubility by Centrifuge
D6373	M 320	Performance Graded Specification
D6521	R 28	Pressure Aging Vessel
D6648	T 313	Bending Beam Rheometer
D6723	T 314	Direct Tension
D6816	PP R 49	Low Temperature Grade
D7175	T 315	Dynamic Shear Rheometer
D7553		Solubility in N-Propyl Bromide
	PP 28/R 35	Volumetric Design
	R 29	Verifying/Grading
	M 323	Volumetric Mix Design

X1.4 Differences in the Terminology Section (Section 3 in both standards)

X1.4.1 There is no difference between the two standards.

X1.5 Differences in the Ordering Information Section (Section 4 in both standards)

X1.5.1 The AASHTO standard indicates that M 323 or R 35 may be used to select asphalt grades. The ASTM standard does not include a comparable statement.

X1.5.2 The ASTM standard includes Note 3 while the AASHTO standard does not.

X1.6 Differences in the Materials and Manufacture Section (Section 5 in both standards)

X1.6.1 The ASTM standard allows naturally occurring asphalts to be used for manufacturing PG graded binders. The AASHTO standard only allows asphalt binders from the refining of crude petroleum.

X1.6.2 The AASHTO standard only allows organic modifiers for asphalt binders.

X1.6.3 Both ASTM and AASHTO require the binder to be 99.0 % soluble. However the ASTM standard requires that "any insoluble component shall be substantially free of fibers." The AASHTO standard does not include this requirement.

X1.6.4 AASHTO allows for the use of either AASHTO test method T 44 or ASTM Test Method D5546 for solubility. ASTM allows the use of either Test Method D2042, D5546, or D7553 for solubility.

X1.7 Differences in Other Sections

X1.7.1 Sections 6, 7, 8, 9, and 10 are essentially identical, except for any referenced documents as noted above and for the addition of Note 6.

X1.7.2 The AASHTO standard does not include this Appendix

X1.8 Differences in the Body of Table 1 and Table 2 (these comments apply to both tables)

X1.8.1 ASTM defines the required gap for each of the DSR measurements, while AASHTO does not.

X1.9 Differences in the Footnotes for Table 1 and Table 2 (these comments apply to both tables)

X1.9.1 In note A, AASHTO provides additional options for determining the grade selection temperature, while ASTM does not.

X1.9.2 In note B, ASTM gives testing guidance for the rotational viscosity test, while AASHTO does not.

X1.9.3 In note C there is a minor difference in wording.

X1.9.4 AASHTO adds note D: "G*/sinδ = high temperature stiffness and G* sinδ = intermediate temperature stiffness." ASTM does not have this note.

X1.9.5 AASHTO adds note E: "The mass change shall be less than 1.00 percent for either a positive (mass gain) or negative (mass loss) change." ASTM does not have this note.

X1.9.6 AASHTO Note F is the same as ASTM note D

X1.9.7 AASHTO Note G is the same as ASTM note E, except that ASTM gives guidance for when the binder is too soft to be properly tested.