
Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test

AASHTO Designation: M 332-14¹



**American Association of State Highway and Transportation Officials
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Standard Specification for

Performance-Graded Asphalt
Binder Using Multiple Stress
Creep Recovery (MSCR) Test

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1. SCOPE

- 1.1. This specification covers asphalt binders graded by performance using the multiple stress creep recovery (MSCR) test. Grading designations are related to the average seven-day maximum pavement design temperature, minimum pavement design temperature, and traffic loading.
- 1.2. This specification incorporates T 350 for determining non-recoverable creep compliance, J_{nr} . “S,” “H,” “V,” or “E” designations must be specified for standard, high, very high, or extremely high traffic loading, respectively.
- Note 1**—For asphalt cements graded by viscosity at 60°C, see M 226.
- Note 2**—For performance-graded asphalt binder, see M 320.
- 1.3. To ensure that the asphalt binder exhibits elastic response, the specifying agency may require compliance with Appendix X1.

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- M 226, Viscosity-Graded Asphalt Cement
 - M 320, Performance-Graded Asphalt Binder
 - M 323, Superpave Volumetric Mix Design
 - R 28, Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
 - R 29, Grading or Verifying the Performance Grade (PG) of an Asphalt Binder
 - R 35, Superpave Volumetric Design for Asphalt Mixtures
 - R 66, Sampling Asphalt Materials
 - T 44, Solubility of Bituminous Materials
 - T 48, Flash and Fire Points by Cleveland Open Cup
 - T 240, Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
 - T 313, Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
 - T 314, Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT)
 - T 315, Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

- T 316, Viscosity Determination of Asphalt Binder Using Rotational Viscometer
- T 350, Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

2.2. *ASTM Standards:*

- D8, Standard Terminology Relating to Materials for Roads and Pavements
- D5546, Standard Test Method for Solubility of Asphalt Binders in Toluene by Centrifuge

3. TERMINOLOGY

3.1. *Definitions:*

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

3.1.2. *asphalt binder*—an asphalt-based cement that is produced from petroleum residue either with or without the addition of nonparticulate organic modifiers.

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 (e.g., M 332, PG 64V-22).

4.1.1. If required to comply with the elastic response requirements in Appendix X1, include reference to Appendix X1 in the purchase order (e.g., M 332, PG 64V-22, Appendix X1).

4.2. The required environmental asphalt binder grades may be selected by following the procedures described in 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 more than the standard traffic speed (>70 km/h).

4.2.2. High 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 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 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.

Note 3—“Grade bumping” is accomplished by using “H,” “V,” or “E” designations and not by increasing the PG high-temperature grade as recommended in M 323.

5. MATERIALS AND MANUFACTURE

5.1. Asphalt binder shall be prepared by the refining of crude petroleum by suitable methods, with or without the addition of modifiers.

5.2. Modifiers may be any organic material of suitable manufacture that is used in virgin or recycled condition and that is dissolved, dispersed, or reacted in asphalt binder to enhance its performance.

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- 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 percent soluble as determined by T 44 or ASTM D5546.
- 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.
- 5.7. If required to exhibit an elastic response, the asphalt binder shall conform to the requirements of Appendix X1.

6. SAMPLING

- 6.1. The material shall be sampled in accordance with R 66.

7. TEST METHODS

- 7.1. The properties outlined in Sections 5.3, 5.4, and 5.6 shall be determined in accordance with R 28, T 44, or ASTM D5546, T 48, T 240, T 313, T 314, T 315, T316, and T 350.

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 part of the purchase contract. The seller shall provide material handling and storage procedures to the purchaser for each asphalt binder grade certified.

9. REJECTION AND RETESTING

- 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; multiple stress creep recovery (MSCR); performance specifications; pressure aging; rheology.

Table 1—Performance-Graded Asphalt Binder Specification^a

Performance Grade	PG 46			PG 52								PG 58				
	34	40	46	10	16	22	28	34	40	46	16	22	28	34	40	
Average 7-day max pavement design temp, °C ^b	<46			<52								<58				
Min pavement design temp, °C ^b	>−34	>−40	>−46	>−10	>−16	>−22	>−28	>−34	>−40	>−46	>−16	>−22	>−28	>−34	>−40	
Original Binder																
Flash point temp, T 48, min °C	230															
Viscosity, T 316: ^c max 3 Pa•s, test temp, °C	135															
Dynamic shear, T 315: ^d G*/sinδ, min 1.00 kPa ^e test temp @ 10 rad/s, °C	46			52								58				
Rolling Thin-Film Oven Residue (T 240)																
Mass change, max, percent ^f	1.00															
MSCR, T 350: Standard Traffic “S” $J_{nr3.2}$, max 4.5 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	46			52								58				
MSCR, T 350: Heavy Traffic “H” $J_{nr3.2}$, max 2.0 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	46			52								58				
MSCR, T 350: Very Heavy Traffic “V” $J_{nr3.2}$, max 1.0 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	46			52								58				
MSCR, T 350: Extremely Heavy Traffic “E” $J_{nr3.2}$, max 0.5 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	46			52								58				
Pressurized Aging Vessel Residue (R 28)																
PAV aging temp, °C ^g	90			90								100				
Dynamic shear, T 315: “S” G* sinδ, max 5000 kPa ^e test temp @ 10 rad/s, °C	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	
Dynamic shear, T 315: “H,” “V,” “E” G* sinδ, max 6000 kPa ^e test temp @ 10 rad/s, °C	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	
Creep stiffness, T 313: ^h S, max 300 MPa m-value, min 0.300 test temp @ 60 s, °C	−24	−30	−36	0	−6	−12	−18	−24	−30	−36	−6	−12	−18	−24	−30	
Direct tension, T 314: ^h Failure strain, min 1.0% test temp @ 1.0 mm/min, °C	−24	−30	−36	0	−6	−12	−18	−24	−30	−36	−6	−12	−18	−24	−30	

^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 LTPP Bind program, may be provided by the specifying agency, or by following the procedures as outlined in M 323 and R 35, excluding the provisions for “grade bumping.”

^c 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.

^e G*/sinδ = high temperature stiffness and G* sinδ = intermediate temperature stiffness.

^f The mass change shall be less than 1.00 percent for either a positive (mass gain) or a negative (mass loss) change.

^g 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.

^h 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.

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Table 1—Performance-Graded Asphalt Binder Specification^a (continued)

Performance Grade	PG 64						PG 70					
	10	16	22	28	34	40	10	16	22	28	34	40
Average 7-day max pavement design temp, °C ^b	<64						<70					
Min pavement design temp, °C ^b	>−10	>−16	>−22	>−28	>−34	>−40	>−10	>−16	>−22	>−28	>−34	>−40
Original Binder												
Flash point temp, T 48, min °C	230											
Viscosity, T 316: ^c max 3 Pa•s, test temp, °C	135											
Dynamic shear, T 315: ^d G*/sinδ, min 1.00 kPa ^e test temp @ 10 rad/s, °C	64						70					
Rolling Thin-Film Oven Residue (T 240)												
Mass change, max, percent ^f	1.00											
MSCR, T 350: Standard Traffic “S” $J_{nr3.2}$, max 4.5 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	64						70					
MSCR, T 350: Heavy Traffic “H” $J_{nr3.2}$, max 2.0 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	64						70					
MSCR, T 350: Very Heavy Traffic “V” $J_{nr3.2}$, max 1.0 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	64						70					
MSCR, T 350: Extremely Heavy Traffic “E” $J_{nr3.2}$, max 0.5 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	64						70					
Pressurized Aging Vessel Residue (R 28)												
PAV aging temp, °C ^g	100						100 (110)					
Dynamic shear, T 315: “S” G* sinδ, max 5000 kPa ^e test temp @ 10 rad/s, °C	31	28	25	22	19	16	34	31	28	25	22	19
Dynamic shear, T 315: “H,” “V,” “E” G* sinδ, max 6000 kPa ^e test temp @ 10 rad/s, °C	31	28	25	22	19	16	34	31	28	25	22	19
Creep stiffness, T 313: ^h S, max 300 MPa m-value, min 0.300 test temp @ 60 s, °C	0	−6	−12	−18	−24	−30	0	−6	−12	−18	−24	−30
Direct tension, T 314: ^h Failure strain, min 1.0% test temp @ 1.0 mm/min, °C	0	−6	−12	−18	−24	−30	0	−6	−12	−18	−24	−30

^a MSCR test 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 LTPP Bind program, may be provided by the specifying agency, or by following the procedures as outlined in M 323 and R 35, excluding the provisions for “grade bumping.”

^c 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.

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Table 1—Performance-Graded Asphalt Binder Specification^a (continued)

Performance Grade	PG 76					PG 82				
	10	16	22	28	34	10	16	22	28	34
Average 7-day max pavement design temp, °C ^b	<76					<82				
Min pavement design temp, °C ^b	>−10	>−16	>−22	>−28	>−34	>−10	>−16	>−22	>−28	>−34
Original Binder										
Flash point temp, T 48, min°C	230									
Viscosity, T 316: ^c max 3 Pa•s, test temp, °C	135									
Dynamic shear, T 315: ^d G*/sin δ, min 1.00 kPa ^e test temp @ 10 rad/s, °C	76					82				
Rolling Thin-Film Oven Residue (T 240)										
Mass change, max, percent ^f	1.00									
MSCR, T 350: Standard Traffic “S” $J_{nr3.2}$, max 4.5 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	76					82				
MSCR, T 350: Heavy Traffic “H” $J_{nr3.2}$, max 2.0 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	76					82				
MSCR, T 350: Very Heavy Traffic “V” $J_{nr3.2}$, max 1.0 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	76					82				
MSCR, T 350: Extremely Heavy Traffic “E” $J_{nr3.2}$, max 0.5 kPa ^{−1} $J_{nr\text{diff}}$, max 75% test temp, °C	76					82				
Pressurized Aging Vessel Residue (R 28)										
PAV aging temp, °C ^g	100 (110)					100 (110)				
Dynamic shear, T 315: “S” G* sinδ, max 5000 kPa ^e test temp @ 10 rad/s, °C	37	34	31	28	25	40	37	34	31	28
Dynamic shear, T 315: “H,” “V,” “E” G* sinδ, max 6000 kPa ^e test temp @ 10 rad/s, °C	37	34	31	28	25	40	37	34	31	28
Creep stiffness, T 313: ^h S, max 300 MPa m-value, min 0.300 test temp @ 60 s, °C	0	−6	−12	−18	−24	0	−6	−12	−18	−24
Direct tension, T 314: ^h Failure strain, min 1.0% test temp @ 1.0 mm/min, °C	0	−6	−12	−18	−24	0	−6	−12	−18	−24

^a MSCR test 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 LTPP Bind program, may be provided by the specifying agency, or by following the procedures as outlined in M 323 and R 35, excluding the provisions for “grade bumping.”

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^h 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.

APPENDIX

(Nonmandatory Information)

X1. INDICATIONS OF ELASTIC RESPONSE

X1.1. For an asphalt binder tested according to T 350, the percent recovery is intended to provide a means for determining the presence of elastic response and stress dependence of polymer modified and unmodified asphalt binders. Figure X1.1 may be used as an indicator of the presence of an elastomeric polymer.

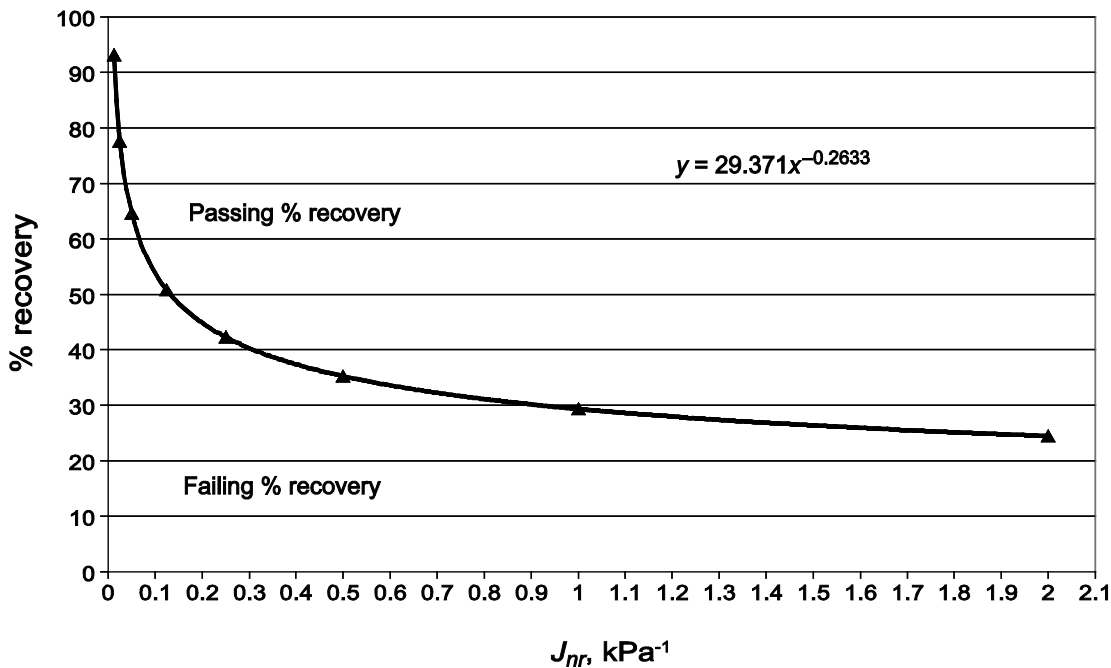


Figure X1.1—Nonrecoverable Creep Compliance Versus Percent Recovery

- X1.2. On the graph in Figure X1.1, plot the average percent recovery at 3.2 kPa, $R_{3.2}$, versus the average nonrecoverable creep compliance at 3.2 kPa, $J_{nr3.2}$, measured at the same temperature.
- X1.3. If the plotted point falls on or above the line on the graph, the indication is that the asphalt binder is modified with an acceptable elastomeric polymer. If the plotted point falls below the line on the graph, the indication is that the asphalt binder is not modified with an elastomeric polymer.

¹ Formerly AASHTO Provisional Standard MP 19. First published as a full standard in 2014.