
Standard Method of Test for Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT)

AASHTO Designation: T 314-22¹

Technically Revised: 2022

Technical Subcommittee: 2b, Liquid Asphalt



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. This test method covers the determination of the failure strain and failure stress of asphalt binders by means of a direct tension test. It can be used with unaged or aged material using T 240 (RTFOT) or R 28 (PAV), or both. The test apparatus is designed for testing within the temperature range from +6 to −36°C.
- 1.2. This test method is limited to asphalt binders containing particulate material having dimensions less than 250 µm.
- 1.3. This test method is not valid for specimens exhibiting a failure strain of greater than 10 percent considered outside the brittle–ductile range.
- 1.4. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*
- 1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - M 320, Performance-Graded Asphalt Binder
 - M 339M/M 339, Thermometers Used in the Testing of Construction Materials
 - R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
 - R 28, Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
 - R 49, Determination of Low-Temperature Performance Grade (PG) of Asphalt Binders
 - T 240, Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)

- 2.2. *ASTM Standards:*
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
 - E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
 - E4, Standard Practices for Force Verification of Testing Machines
 - E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
 - E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
 - E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
 - E2877, Standard Guide for Digital Contact Thermometers
- 2.3. *International Electrotechnical Commission Standards:*
- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
 - IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors
- 2.4. *ISO/IEC Standard:*
- ISO/IEC 17025, General Requirements for the Competence of Testing and Calibration Laboratories

3. TERMINOLOGY

- 3.1. *Definitions:*
- 3.1.1. *asphalt binder*—an asphalt-based cement that is produced from petroleum residue either with or without the addition of particulate organic modifiers of size less than 250 µm.
- 3.2. *Description of Terms Specific to This Standard:*
- 3.2.1. *brittle*—type of failure in a direct tension test where the stress–strain curve is essentially linear up to the point of failure and the failure is by sudden rupture of the test specimen without appreciable reduction in cross section of the specimen.
- 3.2.2. *brittle-ductile*—type of failure in a direct tension test where the stress–strain curve is curvilinear and the failure is by sudden rupture of the test specimen. Limited reduction in cross-section of the specimen occurs before rupture.
- 3.2.3. *ductile*—type of failure in a direct tension test where the specimen does not rupture but fails by flow at large strains.
- 3.2.4. *tensile strain*—axial strain resulting from the application of a tensile load and calculated as the change in length of the effective gauge length caused by the application of the tensile load divided by the original unloaded effective gauge length.
- 3.2.5. *tensile stress*—axial stress resulting from the application of a tensile load and calculated as the tensile load divided by the original area of cross-section of the specimen.
- 3.2.6. *failure*—point at which the tensile load reaches a maximum value as the test specimen is pulled at a constant rate of elongation.

- 3.2.7. *failure stress*—the tensile stress on the test specimen when the load reaches a maximum value during the test method specified in this standard.
- 3.2.8. *failure strain*—the tensile strain corresponding to the failure stress.
- 3.2.9. *gauge section*—the central portion of the specimen where the cross-section does not change with length. For this geometry, the gauge section is 18 mm in length (see Figure 1).

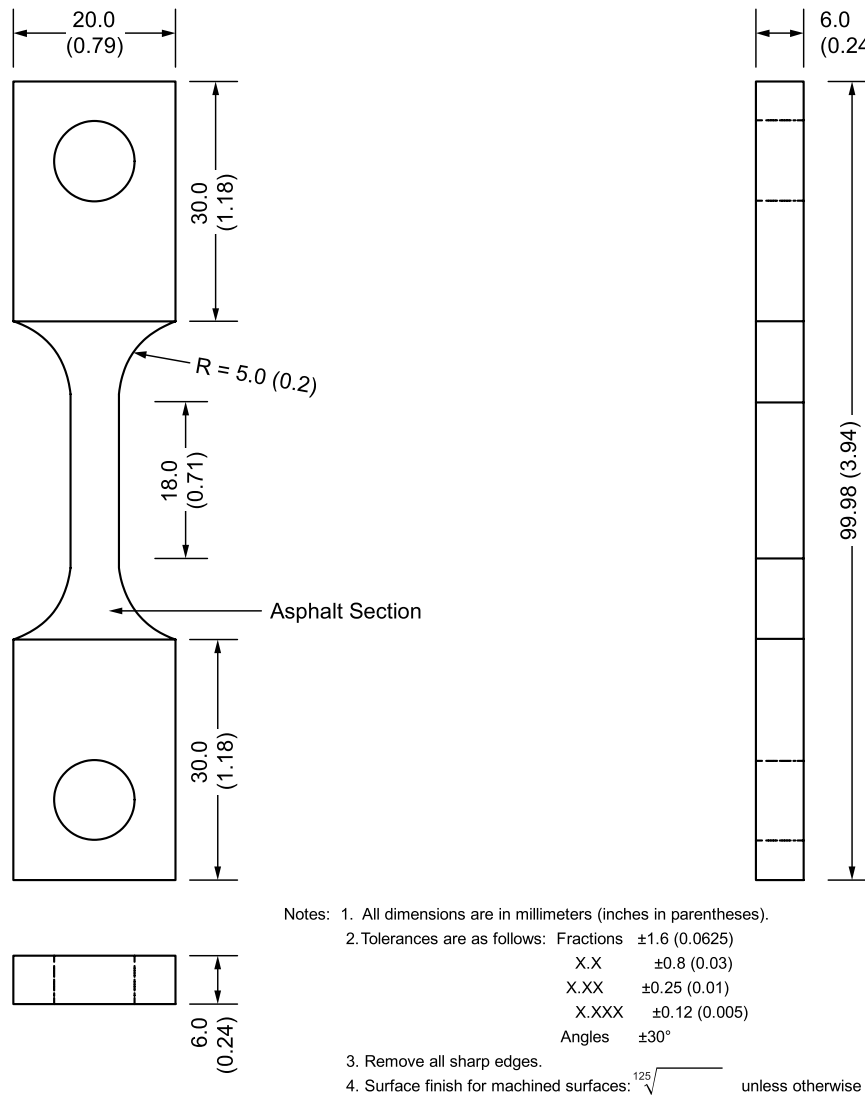


Figure 1—Superpave Direct Tension Specimen Geometry

- 3.2.10. *effective gauge length*—for specimens used in this test, the effective gauge length, L_e , has been determined to be 33.8 mm. This is an effective gauge length that represents the portion of the specimen that contributes to the majority of the strain.

4. SUMMARY OF TEST METHOD

- 4.1. This method describes the procedure used to measure the stress at failure and strain at failure in an asphalt binder test specimen pulled at a constant rate of elongation. Test specimens are prepared

by pouring hot asphalt binder into a suitable mold. Two G10 phenolic end tabs are used to bond the asphalt binder during the test and to transfer the tensile load from the test machine to the asphalt binder.

- 4.2. This test method was developed for asphalt binders at temperatures where they exhibit brittle or brittle-ductile failure. A brittle or brittle-ductile failure will result in a fracture of the test specimen as opposed to a ductile failure in which the specimen simply stretches without fracturing. The test is not applicable at temperatures where failure is by ductile flow.
- 4.3. A displacement transducer is used to measure the elongation of the test specimen as it is pulled in tension at a constant rate of 1 mm/min. The load developed during the test is monitored and the tensile strain and stress in the test specimen when the load reaches a maximum are reported as the failure strain and failure stress, respectively.

5. SIGNIFICANCE AND USE

- 5.1. Stress at failure is used in a mechanistic pavement cracking model to compute critical cracking temperature. The procedure to compute critical cracking temperature is described in AASHTO R 49. The critical cracking temperature is then used in specifying the low-temperature grade of asphalt binder in accordance with M 320.
- 5.2. The test is designed to measure the strength of the asphalt binder at the critical cracking temperature. The asphalt binder has limited ability to resist stress without cracking. In the asphalt binder specification failure, stress is used to determine the critical cracking temperature.
- 5.3. For evaluating an asphalt binder for conformance to M 320, the elongation rate of the gauge section is 1.0 mm/min and the test temperature is selected from Table 1 of M 320 according to the grade of asphalt binder. Other rates of elongation and test temperatures may be used to test asphalt binders.

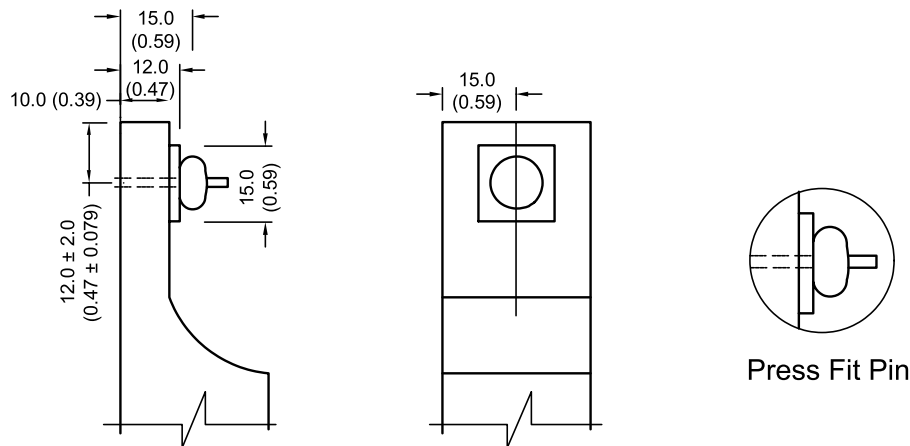
6. APPARATUS

- 6.1. *Direct Tension Test System*—A direct tension test system consisting of (1) a closed feedback loop displacement-controlled tensile loading machine; (2) a specimen gripping system; (3) either a fluid bath or an insulated chamber for reliable, accurate, and uniform temperature control during testing and conditioning of specimen; (4) real-time load measuring and recording devices; (5) real-time elongation measuring and recording devices; (6) a real-time temperature detection and recording device; and (7) real-time data acquisition and display devices.

The system shall have an electromechanical or a servohydraulic loading unit capable of applying and measuring tension and compression forces of at least 500 N and actuator travel of 20 mm (0.78 in.). The system stiffness shall be at least 3 mN/m including the load cell and the loading pins. The unit shall have a transducer to measure and control grip separation and provide a feedback for strain control with a displacement resolution of 1.0 μ m. The system shall be capable of closed-loop elongation rate control accurate to at least 1 percent of the commanded specimen elongation rate using feedback from a displacement transducer mounted between the loading pins or a noncontact extensometer measuring the elongation of the specimen.
- 6.1.1. *Tensile Loading Machine Equipped with Temperature Control*—A tensile loading machine with a controlled-displacement loading frame capable of producing at least a 500-N load is required. The loading frame shall be table mounted. The gripping system (loading pins and platens) shall be completely submerged under the cooling fluid if a fluid-based system is used. The gripping system shall be a minimum of 25 mm (1 in.) under the cooling fluid surface. Loading shall be accomplished by pulling directly in tension in the plane of the specimen. The distance between the

load frame's loading points (between loading pins) shall accommodate specimens with total length (including the end tabs) of at least 100 mm (see Figure 1). If an air-cooled system is used, the testing frame shall be equipped with two standards (columns) with sufficient clear space between the standards so that an insulated temperature control chamber can be placed between the standards.

- 6.1.2. *Specimen Gripping System*—The gripping system must produce a self-aligning uniaxial test load and accept the end tabs described in Section 6.1.2.1 and be designed so that test specimens can be easily mounted in the machine. The system shall include two grips. Each grip shall include a specially shaped pin that is mounted rigidly to the loading platens of the testing machine. Figure 2 shows a typical grip and loading pin assembly. One grip shall be fixed and remain stationary during the test while the other grip is displaced at the desired elongation rate.



Typical Grip Showing the Pin Press-Fitted
Two grips are needed.

- Notes: 1. All dimensions are in millimeters (inches in parentheses).
2. Tolerances are as follows: Fractions ± 1.6 (0.0625)
X.X ± 0.8 (0.03)
X.XX ± 0.25 (0.01)
X.XXX ± 0.12 (0.005)
Angles $\pm 30^\circ$
3. Remove all sharp edges.
4. Surface finish for machined surfaces: $\sqrt{125}$ unless otherwise specified.

Figure 2—Loading Pin and Grip Assembly for the Superpave Direct Tension Test

- 6.1.2.1. *Specimen End Tabs*—End tabs made from G10 phenolic sheets having the dimensions specified in Figures 3, 4, and 5 shall be bonded to both ends of the test specimen to transfer the tensile load to the asphalt binder. The end tabs shall be machined from a standard G10 phenolic sheet. Each end tab shall contain a precisely machined hole lined with a 304 stainless steel ring. The diameter of the lined hole shall be 10 ± 0.05 mm. Gripping of the specimen is accomplished through the bond (adhesion) between the asphalt binder test specimen and the end tab. Each end tab shall be mounted on a specially shaped pin that is part of the gripping system. The specimen shall be mounted on the grips by positioning the end tabs in the test machine such that the end tabs fit onto the pins and are indexed against the face of the grips. Matching the coefficient of thermal expansion of the asphalt binder and the end tabs is necessary to reduce thermal shrinkage stresses at the interface that otherwise cause bond failures.