
Standard Method of Test for

Determination of Asphalt Binder Resistance to Ductile Failure Using Double-Edge-Notched Tension (DENT) Test

AASHTO Designation: T 405-23¹

Adopted without Revisions: 2023

Technical Subcommittee: 2b, Liquid Asphalt



American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, D.C. 20004

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1. SCOPE

- 1.1. This test method covers the determination of an asphalt binder's resistance to ductile failure using a double-edge-notched tension (DENT) test.
- 1.2. The test is conducted after thermal conditioning to determine the essential work of failure, the plastic work of failure, and an approximate critical crack tip opening displacement at a specified temperature and rate of loading.
- 1.3. The values stated in SI units are to be regarded as the standard.
- 1.4. *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.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - < M 339M/M 339, Thermometers Used in the Testing of Construction Materials
 - < R 28, Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
 - < T 240, Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
 - < T 300, Force Ductility Test of Asphalt Materials
- 2.2. *ASTM Standards:*
 - < E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
 - < 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

3. TERMINOLOGY

3.1. Definitions:

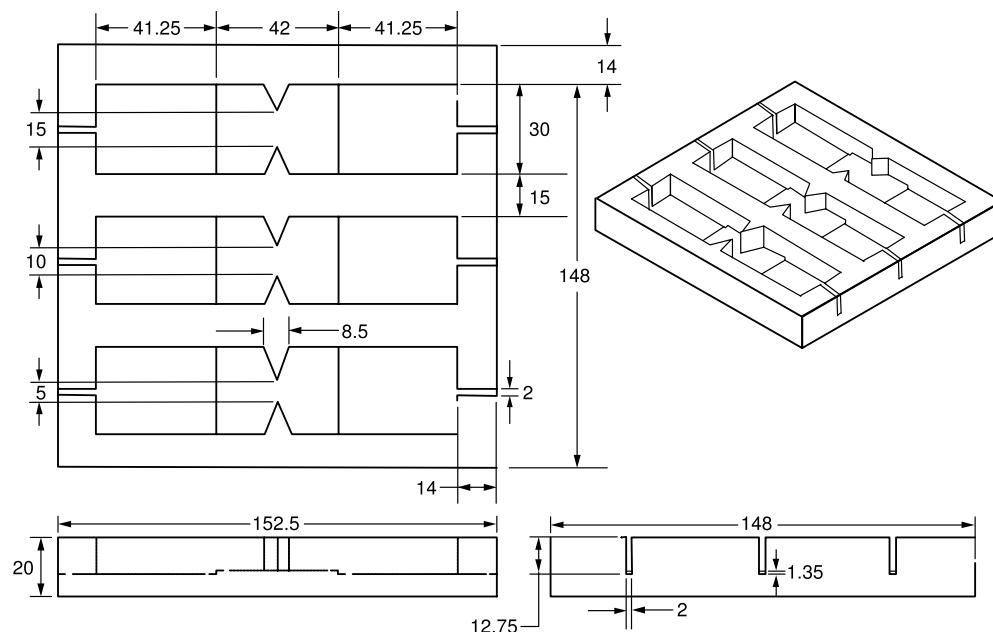
- 3.1.1. W_t —total work of failure, area under the load versus load-line displacement curve, J (cal).
- 3.1.2. w_t —specific total work of failure ($W_t/B\ell$), kJ/m² (kcal/in.²).
- 3.1.3. w_e —specific essential work of failure, the energy required to fracture or break the sample without plastic deformation away from the fracture zone, kJ/m² (kcal/in.²).
- 3.1.4. w_p —specific plastic work of failure term, the non-essential work dissipated during the deformation of a volume of asphalt around the failure zone, MJ/m³ (Mcal/in.³).
- 3.1.5. β —geometric constant describing the shape of the plastic zone.
- 3.1.6. δ_r —critical crack tip opening displacement also referred to as CTOD, mm (in.).
- 3.1.7. P —load, N (lbf).
- 3.1.8. d —displacement in test, m (in.).
- 3.1.9. B —sample thickness, m (in.).
- 3.1.10. ℓ —ligament length, the space between the notches, m (in.).
- 3.1.11. σ_n —net section stress of sample, N/m² (psi).

4. APPARATUS

- 4.1. *Testing Apparatus*—A constant rate of displacement device capable of maintaining displacement at rates of 100 ± 2.5 mm/min (4 ± 0.1 in./min). The maximum stroke for the instrument(s) shall be 1000 mm (39.5 in.) or greater. The apparatus shall have a set of loading pins that ensure precise alignment of the sample during the test. The apparatus shall be able to determine displacement to an accuracy of ± 0.05 mm (± 0.002 in.).
Note 1—The DENT testing apparatus is commonly a force-ductility apparatus installed in a ductilometer.
- 4.2. *Load Sensor*—The sensitivity of the load sensor and recording electronics shall allow the load, P , to be measured every 0.3 s during the test with an accuracy of at least ± 1 percent. The load sensor shall be capable of measuring a nominal maximum force of up to 133 N (30 lbf).
- 4.3. *Temperature-Controlled Bath for Testing*—The bath shall be large enough to contain the testing apparatus and samples in their molds prior to testing under 25 mm (1 in.) of water. The equipment shall be capable of maintaining the water at the testing temperature to an accuracy of at least $\pm 0.5^\circ\text{C}$ (0.9°F). The thermometer for measuring the temperature of the bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 10 to 30°C (50 to 86°F), and an accuracy of $\pm 0.1^\circ\text{C}$ ($\pm 0.18^\circ\text{F}$) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, special order.

- 4.4. *Temperature-Controlled Bath for Conditioning*—A bath capable of maintaining a minimum of 25 mm (1 in.) of water over the sample at the conditioning temperature requirements to within $\pm 0.5^{\circ}\text{C}$ ($\pm 0.9^{\circ}\text{F}$). Typically, the temperature-controlled bath and thermometer for testing are utilized.
- 4.5. *Metal Stirring Rod*—Stick capable of stirring the hot asphalt binder vigorously.
- 4.6. *Base Plates*—The base plates shall be made of non-absorbent material of sufficient thickness to prevent deformation and of a sufficient size to hold from one to three molds, but still able to fit in the temperature-controlled bath for conditioning. The plate shall be uniformly flat to ensure that the bottom surfaces of each mold will touch it throughout.
- 4.7. *Mold*—Consists of two end pieces for each sample and a silicone mold.
- Note 3**—User agencies and asphalt binder suppliers may agree on an all metal design for the molds provided it does not deviate from the dimensions and tolerances given.
- 4.7.1. *Silicone Mold*—Consists of a silicone mold with the dimensions shown in Figure 1 with capability of forming three samples.



Note: All dimensions in mm, and general tolerance is 0.2 mm (0.008 in.).

Figure 1—Dimensions of Silicone Molds

- 4.7.1.1. *DENT End Pieces*—For three samples, six aluminum end pieces with dimensions given in Figure 2.