



Designation: E 2532 – 06

Standard Test Methods for Evaluating Performance of Highway Traffic Monitoring Devices¹

This standard is issued under the fixed designation E 2532; 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 *Purpose*—The two test methods contained in this standard define acceptance tests for evaluating the performance of a Traffic Monitoring Device (TMD) according to the functions it performs, the data it provides, the required accuracy of the data, and the conditions under which the device operates. Acceptance tests are recommended whenever a TMD is purchased, installed, or performance validation is desired. The tests are performed in a field environment and result in an accept or a reject decision for the TMD under test.

1.2 *Exceptions*—Exceptions and options to the test methods may be included in any derivative test method presented by a user as part of the procurement process for TMDs. Sellers may offer exceptions and options in responding to an invitation to bid.

1.3 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units,² which are provided for information only and are not considered standard.

1.4 The following safety procedures apply to Sections 6 and 7, which describe the details of the acceptance test methods. When a test site accessible by the public (for example, a street or highway) is used for the acceptance test of the TMD, obtain approval from the public authority having jurisdiction over the site for the traffic control procedures to be used during the test. *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.*

¹ These test methods are under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and are the direct responsibility of Subcommittee E17.52 on Traffic Monitoring.

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² *Standard Practice for Use of the International System of Units (SI): The Modern Metric System*, IEEE/ASTM SI 10™-2002, The Institute of Electrical and Electronics Engineers (IEEE), Inc., 3 Park Avenue, New York, NY, 10016-5997, USA and American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA, ISBN 0-7381-3317-5.

2. Referenced Documents

2.1 *ASTM Standards*:³

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E 867 Terminology Relating to Vehicle-Pavement Systems

E 1318 Specification for Highway Weigh-In-Motion (WIM) Systems with User Requirements and Test Methods

E 2300 Specification for Highway Traffic Monitoring Devices

3. Terminology

3.1 Definitions of terms and definitions of terms specific to these test methods are given below.

3.2 *Definitions*:

3.2.1 *accepted reference value, n*—value attributed to a particular quantity (for example, vehicle class by number of axles and interaxle spacings, vehicle count, lane occupancy, or vehicle speed) and agreed upon by the user and seller in advance of testing of a TMD, which has an uncertainty appropriate for the given purpose. **E 2300**

3.2.2 *accuracy, n*—closeness of agreement between a value indicated by a TMD and an accepted reference value. **E 2300**

3.2.3 *axle, n*—axis oriented transversely to the nominal direction of vehicle motion, and extending the full width of the vehicle, about which the wheels at both ends rotate. **E 867, E 1318**

3.2.4 *axle count, n*—number of vehicle axles enumerated at a point on a lane or roadway during a specified time interval. **E 867**

3.2.5 *bias, n*—a generic concept related to a consistent or systematic difference between a set of test results from the process and an accepted reference value of the property being measured. **E 177**

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.

3.2.6 *data item, n*—characteristic associated with individual vehicles (for example, count, class, and speed) or the continuum of vehicles at a location (for example, density, flow rate, and queue length). **E 2300**

3.2.7 *detection area, n*—road surface area above which a sensor detects a vehicle or vehicle component. **E 2300**

3.2.8 *electronics unit, n*—device that provides power to one or more sensors, filters and amplifies the signals produced by the sensors, and may perform other functions such as sensitivity adjustment, failure indication, and delayed actuation of traffic control signals.⁴ **E 2300**

3.2.9 *flow rate, n*—number of vehicles passing a given point or section of a lane or roadway during a designated time interval, usually 15 min, but expressed as an equivalent hourly rate in vehicles/h. **E 2300**

3.2.10 *lane occupancy, n*—percent of selected time interval that vehicles are detected in the detection area of a sensor; the time interval during which the lane occupancy is measured is usually 20 to 30 s.⁵ **E 2300**

3.2.11 *precision, n*—a generic concept related to the closeness of agreement between test results obtained under prescribed like conditions from the measurement process being evaluated. **E 177**

3.2.12 *sensor, n*—device for acquiring a signal that provides data to indicate the presence or passage of a vehicle or of a vehicle component over the detection area with respect to time (for example, vehicle flow, number of axles and their spacing), or perhaps one or more distinctive features of the vehicle such as height or mass. **E 2300**

3.2.13 *speed, n*—rate of vehicle motion expressed as distance per unit of time. **E 2300**

3.2.14 *time stamp, n*—recorded date and time at which a measurement was made; information and format may be tailored to the application, but usually consists of month, day, year, hour, minute, second, and subsecond. **E 2300**

3.2.15 *tolerance, n*—allowable deviation of a value indicated by the device under test or a device in service from an accepted reference value. **E 2300**

3.2.16 *traffic monitoring device, n*—equipment that counts and classifies vehicles and measures vehicle flow characteristics such as vehicle speed, lane occupancy, turning movements, and other parameters typically used to portray traffic movement. **E 2300**

3.2.17 *vehicle class by axle, n*—characterization of a vehicle by its number of axles and interaxle spacings. **E 2300**

3.2.18 *vehicle class by length, n*—characterization of vehicles by their total length. **E 2300**

3.2.19 *vehicle count (volume), n*—total number of vehicles observed or predicted to pass a point on a lane or roadway during a specified time interval. **E 2300**

3.2.20 *vehicle, n*—one or more mobile units coupled together for travel on a highway; a vehicle contains one powered

unit and may include one or more non-powered full-trailer or semi-trailer units. **E 867**

3.2.21 *vehicle passage, n*—sensor output pulse signal produced when an initial vehicle detection is made in the detection area of the sensor. **E 2300**

3.2.22 *vehicle presence, n*—sensor output signal produced the entire time a vehicle is detected in the detection area of the sensor. **E 2300**

3.3 Definitions of Terms Specific to This Standard:

3.3.1 *aliasing, n*—phenomenon that occurs when a signal containing frequencies greater than one half the sampling frequency is digitized, causing those frequencies in excess of one half the sampling frequency to be folded back into the digitized signal spectrum.

3.3.2 *straddling vehicle, n*—a vehicle that has one or more tires in an adjacent lane or shoulder.

3.3.3 *vehicle density, n*—number of vehicles occupying a given length of a lane or roadway at a particular instant, usually expressed in units of vehicles/lane-mile (lane-km).

4. Summary of Acceptance Test Methods

4.1 Two categories of acceptance tests are described. The first, the Type-approval Test, is intended for TMDs that have never been type approved. The second, the On-site Verification Test, is applicable to production versions of TMDs that have previously passed a Type-approval Test, but are now being installed at a new location or have been repaired. Fig. 1 illustrates the procedure for determining which of the tests is applicable. The rigorous Type-approval Test verifies the functionality of all features of the TMD and provides information for evaluating the accuracy of the data item outputs when monitoring vehicle flows consisting of a mix of all anticipated vehicle classes under a specified range of operating conditions. The On-site Verification Test provides the TMD user and seller with a means for determining whether the production version of a TMD installed at a particular site meets the performance and user requirements identified in Specification E 2300. Both categories of acceptance tests compare the outputs of the TMD under test with those of equipment that produce acceptable reference values. If all features of the TMD function properly and the output data are within the agreed upon tolerances, then the TMD is reported to have passed the acceptance test. If not, the TMD is reported to have failed the test.

5. Device Classification

5.1 *Type, Tolerance, and Operating Conditions*—The type, tolerance, and operating conditions of the TMD to be tested shall be specified according to Specification E 2300.

5.2 *Use of Measured Data in Support of Other Applications*—Additional vehicle flow parameters may be calculated from the recorded data. Among these parameters are vehicle flow rate, density, headway, intersection delay, vehicle gap in time or distance, queue length, and turning movements. Other highway system performance measures, such as volume-to-capacity ratio, total vehicle hours traveled, total vehicle miles traveled, average travel speed, number and categories of accidents, pollutant emissions, and fuel consumption may also be calculated from data recorded by appropriate sensors. These test methods do not address the ability of the TMD to measure

⁴ Klein, L. A., Mills, M. K., and Gibson, D. R. P., *Traffic Detector Handbook*, FHWA-HRT-06-108, U.S. Department of Transportation, Federal Highway Administration, Washington, DC, 2006.

⁵ Different sensor models or technologies used to measure lane occupancy may have different detection area sizes and, hence, produce different occupancy values, although all devices are operating properly.

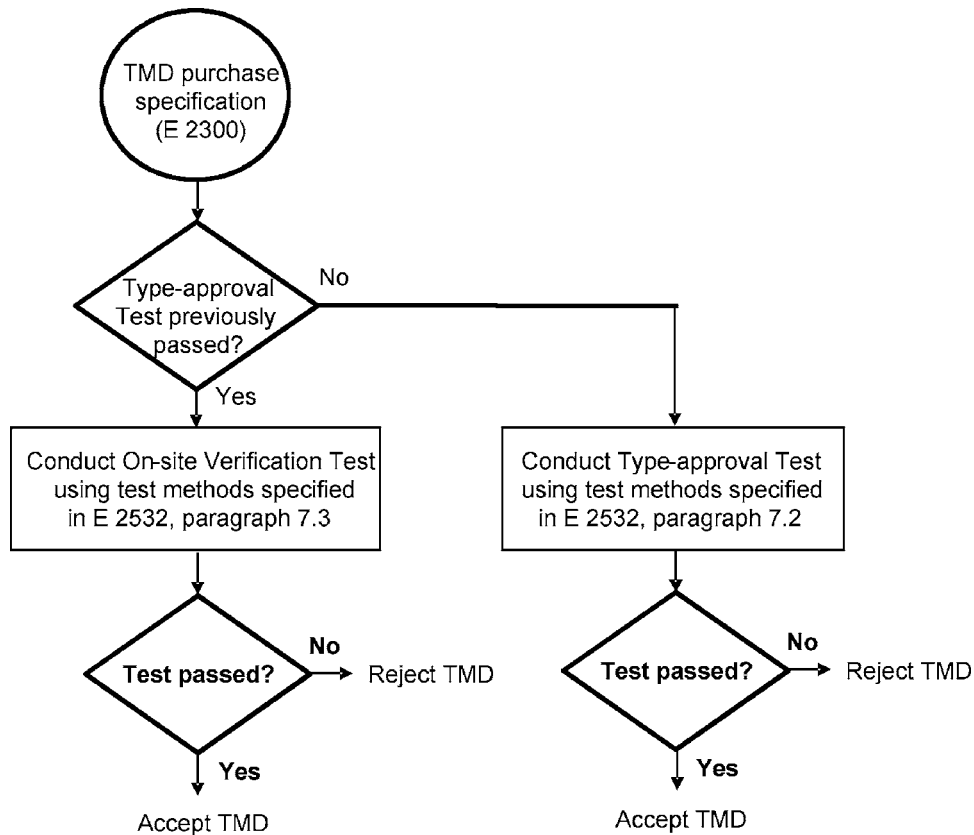


FIG. 1 Process for Determining Applicable TMD Acceptance Test

or provide data for these additional vehicle flow parameters or highway system performance measures.

6. Standardization of Acceptance Test Conditions

6.1 Installation Requirements—It shall be the responsibility of the user to install the TMD under test in accordance with the manufacturer’s requirements. Conditions that are typically specified when installing and evaluating TMDs are described in 6.2 through 6.9.

6.2 Vehicle Flow Rates and Vehicle Classes—The TMD shall be tested under flow rates that include vehicle-to-vehicle gaps both less than and greater than 1 s and a mix of vehicle classes characteristic of the operating conditions in which the device will be used. The vehicle classes shall be specified by the user.

6.3 Lighting—The TMD shall be tested under lighting characteristic of the operating conditions in which the device will be used. Lighting conditions may include day, night, dawn, dusk, and other hours where artifacts or unusual conditions such as shadows and sun glint occur. The lighting conditions and times of day for the test will depend on the technology used in the TMD under test. The user shall specify the specific lighting conditions, if any, required for the tests. Table 1 contains lighting and environmental factors that shall be considered when evaluating TMDs.

6.4 Temperature—The user shall specify the maximum and minimum ambient air temperatures in which the TMD under test (including sensor components installed on, under, or above the roadway and components installed in roadside cabinets) is expected to operate properly and under which it will be tested.

TABLE 1 Lighting and Weather Factors That May be Included as Part of TMD Testing

Lighting and Weather Factors ^A
1. Dawn ambient lighting
2. Dusk ambient lighting
3. Nighttime ambient lighting
4. Sun glint
5. Rain characterized by rain rate
6. Fog or dust characterized by human visual range
7. Snow characterized by snow fall rate and snow flake size

^A Data gathered to verify TMD operation under these conditions may be gathered simultaneously with data used to verify operation at the vehicle flow rates and mix of vehicle classes specified in 6.2.

6.5 Other Environmental Conditions—The user shall specify other environmental conditions under which the TMD shall be tested. These include rain and rain rates, fog and visibility range, snow and snowfall rate, wind-borne dust, movement caused by wind and vibration, and any other conditions that are perceived by the user to affect the performance of the TMD.

6.6 Evidence that TMD can Operate Under Specified Environmental Conditions—If applicable, the seller shall supply evidence that the device offered has been tested and found capable of operating under the specified environmental conditions.

6.7 Power—The user shall provide and maintain electrical power at each test site or specify an optional power source that can supply the power required by the TMD and the data recording equipment.