Designation: E2300 – 09 (Reapproved 2017)

Standard Specification for Highway Traffic Monitoring Devices[1]

This standard is issued under the fixed designation E2300; 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 describes the recommended procedure for identifying the performance and operating requirements to be included in a purchase order for Traffic Monitoring Devices. As such, the specification can be referenced by the user and seller when determining compliance with each specified requirement. It is the intent of this specification to have the user require the seller to provide evidence that the brand and model of TMD offered by the seller has passed an applicable Type-approval Test. If the TMD has not previously passed a Type-approval Test, then it is the intent of this specification to have the device type-approved before it is accepted by the user. If the TMD has previously passed a Type-approval Test, then this specification requires that the production version of the device provided by the seller pass an On-site Verification Test before being accepted by the user.

1.2 *Traffic Monitoring Device*—A Traffic Monitoring Device (TMD) is equipment that counts and classifies vehicles and measures vehicle flow characteristics such as vehicle speed, lane occupancy, turning movements, intervehicle gaps, and other parameters typically used to portray traffic movement. TMDs usually contain a sensing element that converts the signal-generating phenomenon (such as, air pulse generated by a vehicle tire passing over a pneumatic tube) into an electrical signal and electronics that amplify, filter, and otherwise condition the signal. Some TMDs provide outputs as relay or solid-state switch closures, while others contain signal processing that translates the signal into the required vehicle and vehicle flow data. TMDs whose outputs are relay or solid state switch closures may be connected to roadside controllers, which process the switch-closure information and convert it into vehicle flow data.

1.3 *Characterization of Traffic Monitoring Devices*—This specification classifies Traffic Monitoring Devices by the functions they perform, the data they provide, the required accuracy of the data, and the conditions under which the device is expected to operate in conformity with the requirements developed through this specification.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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 *ASTM Standards:*[2]

E867 Terminology Relating to Vehicle-Pavement Systems

E1318 Specification for Highway Weigh-In-Motion (WIM) Systems with User Requirements and Test Methods

E2532 Test Methods for Evaluating Performance of Highway Traffic Monitoring Devices

3. Terminology

3.1 Definitions of terms and definitions of terms specific to this specification are given below.

3.2 *Definitions:*

3.2.1 *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. **(E867, E1318)**

3.2.2 *axle count, n*—number of vehicle axles enumerated at a point on a lane or roadway during a specified time interval. **(E867)**

3.2.3 *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. **(E867)**

3.3 *Definitions of Terms Specific to This Standard:*

[1] This specification is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.52 on Traffic Monitoring.

Current edition approved Jan. 1, 2017. Published January 2017. Originally approved in 2006. Last previous edition approved in 2009 as E2300 – 09. DOI: 10.1520/E2300-09R17.

[2] 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.

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

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

3.3.3 *correct detection, n*—an indication by a TMD that a vehicle actually passing over the detection area of the TMD is detected by the TMD.[3]

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

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

3.3.6 *device identifier, n*—information output by a TMD that includes, as a minimum, the model and serial number of the device.

3.3.7 *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]

3.3.8 *false detection, n*—an indication by a TMD that a vehicle not actually passing over the detection area of the TMD is detected by the TMD.[3]

3.3.9 *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.

3.3.10 *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 s to 30 s.[5]

3.3.11 *missed detection, n*—an indication by a TMD that a vehicle actually passing over the detection area of the TMD is not detected by the TMD.[3]

3.3.12 *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, flow rate or number of axles and their spacing), or one or more distinctive features of the vehicle such as height or mass.

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

3.3.14 *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.

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

3.3.16 *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 items typically used to portray traffic movement.

3.3.17 *vehicle class by axle, n*—characterization of a vehicle by its number of axles and interaxle spacing.

3.3.18 *vehicle class by length, n*—characterization of vehicles by their total length.

3.3.19 *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.

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

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

4. Significance and Use

4.1 The accuracy required of a TMD for data acquisition and characterization of vehicles and traffic flow parameters is related to the traffic management or data reporting task supported by the device. The TMD to be procured shall be specified by designating a Type from Table 1, a tolerance for each data item required, and the conditions under which the device is expected to operate within the requirements developed through this specification. For example, if a Traffic Counting device is desired to provide axle counts to within ±5 % tolerance, then specify a Type I-1, 5 % tolerance device. If a Speed Monitoring device is desired to provide the number of vehicles correctly detected to within ±5 % tolerance and speed to within ±10 % tolerance, then specify a Type IV-1 device with a 5 % tolerance on the number of individual vehicles correctly detected and a 10 % tolerance on vehicle speed measurement. If a combination Speed Monitoring and Traffic Signal Control device is desired to provide the number of vehicles correctly detected to within ±5 % tolerance, speed to within ±10 % tolerance, vehicle presence to within ±10 % tolerance, and lane occupancy to within ±20 % tolerance, then specify a combination Type IV-1 device with a 5 % tolerance on the number of individual vehicles correctly detected and a 10 % tolerance on vehicle speed measurement and Type VI-1 device with a 10 % vehicle presence tolerance and a 20 % lane occupancy tolerance. The associated operating conditions shall

[3] The terms ‘correct detection,’ ‘false detection,’ and ‘missed detection,’ rather than the aggregated vehicle count metric, are recommended as metrics for determining the ability of a TMD to accurately detect vehicles. Aggregated measurements, such as vehicle count over a time interval, can obscure the actual accuracy of a TMD since failures to detect are often canceled by false detections. Therefore, evaluation methods based upon aggregated metrics can provide misleading conclusions concerning the ability of a TMD to correctly detect vehicles.

[4] Klein, L. A., Gibson, D., and Mills, M. K., *Traffic Detector Handbook: Third Edition*, FHWA-HRT-06-108 (Vol. I) and FHWA-HRT-06-139 (Vol. II), U.S. Department of Transportation, Federal Highway Administration, Washington, DC, Oct. 2006. Also available at: http://www.tfhrc.gov/its/pubs/06108/ and http://www.tfhrc.gov/its/pubs/06139/.

[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.

TABLE 1 Traffic Monitoring Device Functions, Types, Detected Vehicle Characteristics, and Data Recorded/Specified Time Interval

Function	Type	Detected Vehicle Characteristic	Data Recorded/Specified Time Interval[A]
I—Traffic Counting	I-1	axle passage	number of axles
	I-2	vehicle passage	number of vehicles
	I-3	vehicle presence	number of vehicles
II—Traffic Counting/Classifying	II-1 (classification by number of axles and interaxle spacings)	vehicle passage, number of axles, and interaxle spacings during vehicle passage	number of axles, number of vehicles per class, vehicle speed, vehicle class by number of axles and interaxle spacings
	II-2 (classification by length)	vehicle passage and speed	number of vehicles, vehicle speed, vehicle length and class, vehicle presence, lane occupancy
III—Incident Detection Data	III-1	vehicle passage, presence, and speed	number of vehicles, vehicle speed, vehicle presence, or lane occupancy
IV—Speed Monitoring	IV-1	speed	number of vehicles, vehicle speed
V—Metering Data (Ramp, Mainline, or Freeway-to-Freeway)	V-1	vehicle presence	number of vehicles, vehicle presence, or lane occupancy
VI—Signal Control Data	VI-1	vehicle presence	number of vehicles, vehicle presence, or lane occupancy
VII—Enforcement Aid	VII-1 (speed)	speed	vehicle speed
	VII-2 (red signal)	location of front of vehicle, red signal indication	number of vehicles and violations
	VIII-3 (dimension)	vehicle location and specified overall dimensions	vehicle presence, specified overall dimensions

[A]The user shall specify the recording of device identifier and time stamp data when needed.

TABLE 2 Installation and Operating Requirements for Potential Inclusion in TMD Purchase Specifications

•*Environment*
ambient temperature
humidity
lighting
sun position and angle
precipitation types (snow, rain, hail)
other atmospheric obscurants (fog, dust)
vibration and shock
wind

•*Vehicle Characteristics*
vehicle class mix
vehicle-to-vehicle gaps required to define vehicle flow rate and to evaluate TMD detection accuracy

•*Output Data Items*
data recording interval
data communication link

data interface
data display

•*Installation*
weight and size limitations
mounting or other installation constraints
power availability
power surge and lightning resistance
input power interface
special cables and connectors

•*Setup and Calibration*
operating and calibration software
operating, installation, and repair manuals

•*Miscellaneous*

fail safe operation if device fails
warranty
software upgrades and product maintenance
other pertinent items affecting installation, operation, maintenance, and storage

be specified by the user through consideration of requirements such as those shown in Table 2.

5. Ordering Information

5.1 *Type*—The user shall specify a TMD by a type identifier (that is, indicator of the vehicle characteristics detected by the TMD to support the function) as described in Table 1, a tolerance for each required data item as described in 5.2, and the conditions under which the device will be operated. Table 1 also lists the detected vehicle characteristics (that is, data acquired by the TMD by which a vehicle or vehicle flow condition is distinguished) and the data recorded per specified time interval for each type of TMD. In addition, the user shall specify the recording of a device identifier and time stamp data when needed. The same data may support more than one function as shown by the entries in the last column of the table. The measurement units that typically correspond to TMD data are listed in Table 3. Weigh-in-motion sensors and systems are treated in Specification E1318.

5.2 *Tolerance*—The user shall specify a tolerance for each required data item output by the TMD. A TMD that records or outputs multiple data items may have different tolerances specified for each data item as explained in Section 4. If the TMD is a vehicle classifier, the tolerance may be specified by the user to apply to the individual classes identified by the device or to the aggregate of all vehicle classes identified. The tolerance should be specified by the user in a manner that is consistent with the application supported by the TMD output data. Accordingly, the tolerance of the TMD may be specified in three ways, namely as percent difference, single-interval absolute value difference, or multiple-interval absolute value difference.

5.2.1 *Percent Difference*—Percent difference is defined as an absolute value given by:

NOTE 1—In the following equations, ARV = Accepted Reference Value.

$$\text{Percent Difference} = \frac{\left|\text{TMD Output Value} - \text{ARV}\right|}{\text{ARV}} \times 100 \quad (1)$$

Examples of tolerances that are specified as a percent difference value are 1, 5, 10, or 20 %. Thus a tolerance of 10 % implies an allowable deviation of ±10 % from the comparable accepted reference value for the data item indicated. Tolerance in percent is equal to 100 minus the accuracy when accuracy is expressed as a percent.

5.2.1.1 The percent difference for the number of correctly detected vehicles is given by

$$\text{Percent Difference} = \frac{\left|\text{TMD Output Value for Correctly Detected Vehicles} - \text{ARV}\right|}{\text{ARV}} \times 100 \quad (2)$$

Thus a TMD that correctly detects 1539 vehicles when the accepted reference value is 1600 is said to have correctly measured the number of vehicles to within a ±3.8 % tolerance.

5.2.1.2 The percent difference for the number of falsely detected vehicles is given by

$$\text{Percent Difference} = \frac{\left|\text{TMD Output Value for Falsely Detected Vehicles} - \text{ARV}\right|}{\text{ARV}} \times 100 \quad (3)$$

For example, if the number of falsely detected vehicles is 40 and the accepted reference value is 1600, the TMD is said to have falsely detected ±2.5 % of the vehicles.

5.2.1.3 The percent difference for the number of missed detections is given by

$$\text{Percent Difference} = \frac{\left|\text{TMD Output Value for Missed Detections} - \text{ARV}\right|}{\text{ARV}} \times 100 \quad (4)$$

For example, if the number of missed vehicle detections is 15 and the accepted reference value is 1600, the TMD is said to have missed the detection of ±0.9 % of the vehicles.

5.2.2 *Single-interval Absolute Value Difference*—A single-interval absolute value difference (SAVD) specifies a single maximum allowable deviation of the TMD output with respect to the comparable accepted reference value. Thus,

$$\text{SAVD} = \left|\text{TMD Output Value} - \text{ARV}\right| \quad (5)$$

The SAVD expressed by Eq 5 is stated in units that correspond to the data item indicated. For example, a maximum difference of 3 mph (5 km/h) is specified for the measurement of vehicle speed within a single user-defined speed interval, say 10 to 80 mph (16 to 130 km/h), inclusive.

5.2.2.1 The SAVD for correctly detected vehicles, falsely detected vehicles, and missed detections is defined by Eq 6, Eq 7, and Eq 8, respectively, as

TABLE 3 Data Items and Units

Data Item	Unit
axle count	axle
interaxle spacing	foot (metre)[A]
vehicle count	vehicle
(also implies vehicle passage)	(binary on/off)
speed	mph (km/h)[A]
vehicle class by number of axles and spacing	FHWA class number or other scheme[B]
vehicle class by length	foot (metre)[A]
vehicle presence	second[A]
lane occupancy	percent[A]
time stamp	month, day, year, hour, minute, second, subsecond
enforcement specific (marker synchronized to traffic signal red indication, over all vehicle dimension	binary (on/off); foot (metre)[A]

[A]Subunits to be specified by the user.
[B]See Specification E1318, paragraph 5.2 or Test Methods E2532, paragraph 7.2.7.5.

$$SAVD = |\text{TMD Output Value for Correctly Detected Vehicles} - ARV| \quad (6)$$

$$SAVD = |\text{TMD Output Value for Falsely Detected Vehicles} - ARV| \quad (7)$$

$$SAVD = |\text{TMD Output Value for Missed Detections} - ARV| \quad (8)$$

5.2.3 *Multiple-interval Absolute Value Difference*—A multiple-interval absolute value difference (MAVD) specifies a different allowable deviation in TMD output with respect to the comparable accepted reference value for each interval of data item values included in the TMD specification. Thus, the MAVD permits different deviations to be established for distinct intervals of the measured data item. The MAVD is calculated using Eq 5-8, but with the appropriate accepted reference value inserted for the interval under consideration. The difference is stated in units that correspond to the data item indicated. For example, a maximum difference of 3 mph (5 km⁄h) is required when measuring the speed of vehicles traveling at or above 55 mph (88 km/h), but a maximum difference of 1 mph (2 km/h) is required for vehicles traveling below 55 mph (88 km/h).

5.3 *Conditions Under Which TMD Will Perform*—The user shall specify operating and test conditions that are applicable to the TMD being procured, such as those listed in Table 2.

5.4 *Caution with Respect to Over Specifying Requirements*—Specifying performance requirements beyond those actually needed for the application may place unnecessary burdens on the sellers and may increase purchase, test, and service costs.

6. Acceptance Test

6.1 One of two categories of acceptance tests shall be specified by the user as described in Test Methods E2532. The first, the Type-approval Test, is intended for a brand and model of TMD that has 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 and are being offered to the user by the seller. The rigorous Type-approval Test verifies the functionality of all features of the TMD and the accuracy of the data item outputs when monitoring vehicle flows consisting of a mix of all anticipated vehicle classes under the specified operating conditions. The On-site Verification Test provides the TMD user and seller with a means for determining whether the production verison of a TMD installed at a particular site meets the performance and user requirements identified in this specification.

7. Product Marking

7.1 The user shall specify information to be marked on the label or tag attached to the device. Such information shall include the name, brand, or trademark of the manufacturer; model number; serial number; ASTM standard used to specify or test the device; and any other desired information.

8. Quality Assurance

8.1 When included in the TMD specification, this requirement shall be qualified by the statement: "When specified in the purchase order or contract, the user shall be furnished with evidence that the purchased TMD has satisfied the requirements of [insert here the reference to a suitable standard, such as those approved by ASTM International, ANSI, MIL, IEEE, and so forth]."

9. Keywords

9.1 correct detection; data item; detector; false detection; incident detection; interaxle spacing; lane occupancy; missed detection; sensor; traffic monitoring device; vehicle classification; vehicle counter; vehicle detector; vehicle flow measurement; vehicle passage; vehicle presence; vehicle sensor; vehicle speed