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## Section 2.25. Weigh-In-Motion Systems Used for Vehicle Screening and Enforcement—~~Tentative Code~~

~~This tentative code has a trial or experimental status and is not intended to be enforced. The requirements are designed for study prior to the development and adoption of a final code. Officials wanting to conduct an official examination of a device or system are advised to see paragraph G A.3. Special and Unclassified Equipment.~~

### A. Application

**A.1. General.** – This code applies to **fixed (not portable)** systems used to weigh vehicles, while in motion, for the purpose of screening and sorting the vehicles based on the vehicle weight to determine if a static weighment is necessary **(Class A), and enforcing the weight limit of road vehicles (Class E).**

**A.2. Exception.** – This code does not apply to weighing systems intended for the collection of statistical traffic data.

**A.3. Additional Code Requirements.** – In addition to the requirements of this code, weigh-in-motion **screening** systems shall meet the requirements of Section 1.10. General Code.

### S. Specifications

#### S.1. Design of Indicating and Recording Elements and of Recorded Representations.

**S.1.1. Ready Indication.** – The system shall provide a means of verifying that the system is operational and ready for use.

**S.1.2. Value of System Division Units.** – The value of a system division “d” expressed in a unit of weight shall be equal to:

- (a) 1, 2, or 5; or
- (b) a decimal multiple or submultiple of 1, 2, or 5.

Examples: divisions may be 10, 20, 50, 100; or 0.01, 0.02, 0.05; or 0.1, 0.2, 0.5, etc.

**S.1.2.1. Units of Measure.** – The system shall indicate weight values using only a single unit of measure.

**S.1.3. Maximum Value of Division.** – The value of the system division “d” for a **Class A and Class E**, weight-in-motion system shall not be greater than 50 kg (100 lb).

#### S.1.4. Value of Other Units of Measure.

**S.1.4.1. Speed.** – Vehicle speeds shall be measured in miles per hour or kilometers per hour.

**S.1.4.2. Axle-Spacing (Length).** – The center-to-center distance between any two successive axles shall be measured in:

- (a) meters and decimal submultiples of a meter;
- (b) feet and inches; or
- (c) feet and decimal submultiples of a foot.

**S.1.4.3. Vehicle Length.** – If the system is capable of measuring the overall length of the vehicle, the length of the vehicle shall be measured in feet and/or inches, or meters.

**S.1.5. Capacity Indication.** – An indicating or recording element shall not display nor record any values greater than 105 % of the specified capacity of the load receiving element.

**S.1.6. Identification of a Fault.** – Fault conditions shall be presented to the operator in a clear and unambiguous means. The following fault conditions shall be identified:

- (a) Vehicle speed is below the minimum or above the maximum speed as specified.
- ~~(b) The maximum number of vehicle axles as specified has been exceeded.~~
- (b) A change in vehicle speed greater than that specified has been detected.
- (c) **Imbalanced weight between the left and right wheels has exceeded the specified values.**
- (d) **The vehicle changes lanes within the sensor locations.**

**S.1.7. Recorded Representations.**

**S.1.7.1. Values to be Recorded.** – At a minimum, the following values shall be printed and/or stored electronically for each vehicle weighment. **Consult the specific jurisdictional legislation for additional values that may be required to issue enforcement violations. All gross vehicle, axle, and axle group weights must be printed and/or stored with the corrected values that include any necessary reductions due to the system tolerance and adopted violation thresholds.**

- (a) transaction identification number;
- (b) **station ID;**
- (c) lane identification (required if more than one lane at the site has the ability to weigh a vehicle in motion);
- (d) vehicle speed;
- (e) number of axles;
- (f) weight of each axle;
- (g) **weight of each axle group;**
- (h) identification and weight of axle groups;
- (i) axle spacing;
- (j) total vehicle weight;
- (k) **weight limits as specified in paragraph S.2.1;**
- (l) **total vehicle length;**
- (m) all fault conditions that occurred during the weighing of the vehicle;

- (n) violations, as identified in paragraph S.2.1. Violation Parameters, which occurred during the weighing of the vehicle; and
- (o) time and date.

**S.1.8. Value of the Indicated and Recorded System Division.** – The value of the system’s division “(d),” as recorded, shall be the same as the division value indicated.

## **S.2. System Design Requirements.**

**S.2.1. Violation Parameters.** – The instrument shall be capable of accepting user-entered violation parameters for the following items:

- (a) single axle weight limit;
- (b) axle group weight limit;
- (c) gross vehicle weight limit; and
- (d) bridge formula maximum.

The instrument shall display and/or record violation conditions when these parameters have been exceeded.

## **S.3. Design of Weighing Elements.**

**S.3.1. Multiple Load-Receiving Elements.** – An instrument with a single indicating or recording element, or a combination indicating-recording element, that is coupled to two or more load-receiving elements with independent weighing systems, shall be provided with means to prohibit the activation of any load-receiving element (or elements) not in use, and shall be provided with automatic means to indicate clearly and definitely which load receiving element (or elements) is in use.

## **S.4. Design of Weighing Devices, Accuracy Class.**

**S.4.1. Designation of Accuracy.** – Weigh-in-motion systems meeting the requirements of this code shall be designated as accuracy Class A and Class E.

**Note:** This does not preclude higher accuracy classes from being proposed and added to this Code in the future when it can be demonstrated that weigh-in-motion systems grouped within those accuracy classes can achieve the higher level of accuracy specified for those devices.

**S.5. Marking Requirements.** – In addition to the marking requirements in G-S.1. Identification (except G.S.1.(e)), the system shall be marked with the following information:

- (a) accuracy class;
- (b) value of the system division “d”;
- (c) operational temperature limits;
- (d) number of instrumented lanes (not required if only one lane is instrumented);
- (e) minimum and maximum vehicle speed;
- (f) maximum number of axles per vehicle;

- (g) maximum change in vehicle speed during weighment; and
- (h) minimum and maximum load.

**S.5.1. Location of Marking Information.** – The marking information required in Section 1.10. General Code, G-S.1. Identification and Section 2.25. Weigh-in-Motion Systems, S.5. Marking Requirements shall be visible after installation. The information shall be marked on the system or recalled from an information screen.

## N. Notes

### N.1. Test Procedures.

**N.1.1. Selection of Test Vehicles.** – All dynamic testing associated with the procedures described in each of the subparagraphs of N.1.5 shall be performed with ~~a minimum of two~~ the following test vehicles for each Class A and Class E.

**N.1.1.1. Selection of Test Vehicles for Class A – A minimum of two vehicles below shall be used.**

- (a) The first test vehicle may be a two-axle, six-tire, single-unit truck; that is, a vehicle with two axles with the rear axle having dual wheels. The vehicle shall have a maximum gross vehicle weight of 10 000 lb.
- (b) The second test vehicle shall be a five-axle, single-trailer truck with a maximum gross vehicle weight of 80 000 lb.

**N.1.1.2. Selection of Test Vehicles for Class E – A minimum of three vehicles below shall be used.**

- (a) The first test vehicle may be a two-axle, six-tire, single-unit truck or Federal Highway Administration (FHWA) Class 5; that is, a vehicle with two axles with the rear axle having dual wheels
- (b) The second test vehicle shall be a five-axle, single-trailer truck or FHWA Class 9 3S2 Type.
- (c) The third test vehicle shall be a three-axle, single-unit truck or FHWA Class 6.
- (d) The gross vehicle weights shall be as stated in N.1.2.3.

**Note 1:** Consideration should be made for testing the systems using vehicles which are typical to the system's daily operation. Violation thresholds may be dependent on additional items, not specified in this code.

**Note 2:** Vehicles with liquid loads to be excluded from the testing and from enforcement

**~~N.1.1.4.3.~~ Weighing of Test Vehicles.** – All test vehicles shall be weighed on a reference scale, meeting the requirements of Appendix A, before being used to conduct the dynamic tests.

**~~N.1.1.2.4.~~ Determining Reference Weights for Axle, Axle Groups, and Gross Vehicle Weight.** – The reference weights shall be the average weight value of a minimum of three static weighments of all single axles, axle groups, and gross vehicle weight on a reference scale before being used to conduct the dynamic tests.

**Note:** The axles within an axle group are not considered single axles.

### N.1.2. Test Loads.

**N.1.2.1. Static Test Loads.** – All static test loads shall use certified test weights.

**N.1.2.2. Dynamic Test Loads for Class A.** – Test vehicles used for dynamic testing shall be loaded to 85 % to 95 % of their legal maximum Gross Vehicle Weight for a minimum of 20 runs per test vehicle type. The “load” shall be non-shifting and shall be positioned to present as close as possible, an equal side-to-side load.

**N.1.2.3. Dynamic Test Loads for Class E.** – Test vehicles used for dynamic testing shall be loaded in two (2) different load conditions. The “load” shall be non-shifting and shall be positioned to present as close as possible, an equal side-to-side load.

(a) an empty load condition for a minimum of 15 runs per test vehicle type, and

(b) a fully load condition (> 90% of the legal load limit for the roadway) for a minimum of 30 runs per test vehicle type

**N.1.3. Reference Scale.** – Each reference vehicle shall be weighed statically on a multiple-platform vehicle scale comprised of three individual weighing/load-receiving elements, each an independent scale. The three individual weighing/load receiving elements shall be of such dimension and spacing to facilitate:

the single-draft weighing of all reference test vehicles;

- (a) the simultaneous weighing of each single axle and axle group of the reference test vehicles on different individual elements of the scale; and
- (b) gross vehicle weight determined by summing the values of the different reference axle and reference axle groups of a test vehicle.

**N.1.3.2. Single Platform Vehicle Scale** – Each individual axle or axle group of the reference test vehicles shall be measured on the single platform vehicle scale. Only the single axle or axle group for measurement shall be on the single platform, while other single axles or axle groups shall be off the platform. The GVW shall be determined by summing all the single axles and axle groups.

The scale shall be tested immediately prior to using it to establish reference test loads and in no case more than 2 weeks prior. To qualify for use as a suitable reference scale, it must meet NIST Handbook 44, Class III L maintenance tolerances.

**N.1.3.3. Location of a Reference Scale.** – The location of the reference scale must be considered since vehicle weights will change due to fuel consumption.

**N.1.4. Test Speeds.** – All dynamic tests shall be conducted at the designated speed(s).

**N.1.4.1. Test Speeds for Class A** – Speed shall be at the posted speed limit.

**N.1.4.2. Test Speeds for Class E** – Three speeds shall be used.

(a) high speed – maximum posted speed limit.

(b) low speed – 10 mph.

(c) operation speed – average between N.1.4.2.(a) high speed and N.1.4.2.(b) low speed.

**N.1.5. Test Procedures.**

**N.1.5.1. Dynamic Load Test for Class A.** – The dynamic test for Class A shall be conducted using the test vehicles defined in N.1.1.1, Selection of Test Vehicles for Class A. The test shall consist of a minimum of 20 runs for each test vehicle at the speed as stated in N.1.4.1, Test Speeds for Class A.

At the conclusion of the dynamic test, there will be a minimum of 20 weight readings for each single axle, axle group, and gross vehicle weight of ~~the each~~ test vehicle. The tolerance for each weight reading shall be based on the percentage values specified in Table T.2.2-~~1~~ Tolerances for Accuracy Class A.

**N.1.5.2. Vehicle Position Test for Class A.** – During the conduct of the dynamic testing for Class A, ensure the vehicle stays within the defined roadway along the width of the sensor. The test shall be conducted with 10 runs with the vehicle centered along the width of the sensor; 5 runs with the vehicle on the right side along the width of the sensor; and 5 runs with the vehicle on the left side along the width of the sensor. Only gross vehicle weight is used for this test and the tolerance for each weighment shall be based on the tolerance value specified in T.2.3. Tolerance Value for Vehicle Position Test.

**N.1.5.3. Dynamic Load Test for Class E.** – The dynamic test for Class E shall be conducted using the test vehicles defined in N.1.1.2. Selection of Test Vehicles for Class E. The test shall consist of a minimum of 45 runs for each test vehicle. A minimum of 15 runs at empty load condition and a minimum of 30 runs at fully load condition.

At the conclusion of the dynamic test, there will be a minimum of 45 weight readings or 15 weight readings at each speed for each single axle, axle group, and gross vehicle weight. The tolerance for each weight reading shall be based on the percentage values specified in Table T.2.2-2 Tolerances for Accuracy Class E.

**N.1.5.4. Vehicle Position Test for Class E.** – During the conduct of the dynamic testing for Class E, ensure the vehicle stays within the defined roadway along the width of the sensor. Only gross vehicle weight is used for this test and the tolerance for each weighment shall be based on the tolerance value specified in T.2.3. Tolerance Value for Vehicle Position Test.

(a) Empty load condition. – The test shall be conducted with 15 runs in total or 5 runs at each speed as stated in N.1.4.2. Test Speeds for Class E. The test shall be conducted with 9 runs with the vehicle centered along the width of the sensor (3 runs per speed); 3 runs with the vehicle on the right side along the width of the sensor (1 run per speed); and 1 run with the vehicle on the left side along the width of the sensor (1 run per speed).

(b) Fully load condition. – The test shall be conducted with 30 runs in total or 10 runs at each speed as stated in N.1.4.2. Test Speeds for Class E. The test shall be conducted with 18 runs with the vehicle centered along the width of the sensor (6 runs per speed); 6 runs with the vehicle on the right side along the width of the sensor (2 run per speed); and 6 runs with the vehicle on the left side along the width of the sensor (2 run per speed).

See Table N.1.5. below to summarize all the test runs.

<b><u>Table N.1.5.</u></b> <b><u>Number of Test per Each Test Vehicle for Class E</u></b>		
<b><u>Load Condition</u></b>	<b><u>Speed</u></b>	<b><u>Vehicle Position</u></b>
<b><u>Fully Load</u></b> <b><u>(30 runs)</u></b>	<b><u>High Speed (10 runs)</u></b>	<b><u>Left (2 runs), Center (6 runs), Right (2 runs)</u></b>
	<b><u>Low Speed (10 runs)</u></b>	<b><u>Left (2 runs), Center (6 runs), Right (2 runs)</u></b>
	<b><u>Operation Speed (10 runs)</u></b>	<b><u>Left (2 runs), Center (6 runs), Right (2 runs)</u></b>



<b>Table N.1.5.</b> <b>Number of Test per Each Test Vehicle for Class E</b>		
<b><u>Load Condition</u></b>	<b><u>Speed</u></b>	<b><u>Vehicle Position</u></b>
<b><u>Empty Load</u></b> <b><u>(15 runs)</u></b>	<b><u>High Speed (5 runs)</u></b>	<b><u>Left (1 run), Center (3 runs), Right (1 run)</u></b>
	<b><u>Low Speed (5 runs)</u></b>	<b><u>Left (1 run), Center (3 runs), Right (1 run)</u></b>
	<b><u>Operation Speed (5 runs)</u></b>	<b><u>Left (1 run), Center (3 runs), Right (1 run)</u></b>
<b><u>45 runs</u></b>	<b><u>15 runs x 3 speeds</u></b>	<b><u>9 runs (left) + 27 runs (center) + 9 runs (right)</u></b>

**N.1.5.3.5. Axle Spacing Test.** – The axle spacing test is a review of the displayed and/or recorded axle spacing distance of the test vehicles. The tolerance value for each distance shall be based on the tolerance value specified in T.2.4. Tolerance Value for Axle Spacing.

## **T. Tolerances**

### **T.1. Principles.**

**T.1.1. Design.** – The tolerance for a weigh-in-motion system is a performance requirement independent of the design principle used.

### **T.2. Tolerance Values for Accuracy Class A and Class E.**

**T.2.1. Tests Involving Digital Indications or Representations.** – To the tolerances that would otherwise be applied in paragraphs T.2.2. Tolerance Value for Dynamic Load Test and T.2.3. Tolerance Value for Vehicle Position Test, there shall be added an amount equal to one-half the value of the scale division to account for the uncertainty of digital rounding.

**T.2.2. Tolerance Values for Dynamic Load Test.** – The tolerance values applicable during dynamic load testing are as specified in Table T.2.2-1 **for screening as well as enforcement purposes**.

#### **T.2.2.1. Tolerance Value for Class A for Screening Purpose and Class E for Enforcement Purposes**

<b>Table T.2.2-1.</b> <b>Tolerances for Accuracy</b>	
<b>Load Description*, ^</b>	<b>Tolerance as a Percentage of Applied Test Load</b>
<b>Axle Load</b>	<b>± 20 %</b>
<b>Axle Group Load</b> <b>(including bridge formula)</b>	<b>± 15 %</b>
<b>Gross Vehicle Weight</b>	<b>± 10 %</b>
<b>Class A for Screening Purposes: No more than 5 % of the weighments in each of the load description subgroups shown in this table shall exceed the applicable tolerance.</b>	
<b>^ Class E for Enforcement Purposes: All weighments shall be 100% compliance.</b>	

**T.2.3. Tolerance Value for Vehicle Position Test.** – The tolerance value applied to each gross vehicle weighment is ± 10 % of the applied test load.

**T.2.4. Tolerance Value for Axle Spacing.** – The tolerance value applied to each axle spacing measurement shall be ± 0.15 m (0.5 ft).

**T.3. Influence Factors.** – The following factor is applicable to tests conducted under controlled conditions only.

**T.3.1. Temperature.** – Systems shall satisfy the tolerance requirements under all operating temperature unless a limited operating temperature range is specified by the manufacturer.

**T.4. Radio Frequency Interference (RFI) and Other Electromagnetic Interference Susceptibility.** – The difference between the weight indication due to the disturbance and the weight indication without the disturbance shall not exceed the tolerance value as stated in Table T.2.2 Tolerances for Accuracy ~~Class A~~.

## UR. User Requirements

**UR.1. Selection Requirements.** – Equipment shall be suitable for the service in which it is used with respect to elements of its design, including but not limited to, its capacity, number of scale divisions, value of the scale division, or verification scale division and minimum capacity.

**UR.1.1. General.** – The typical class or type of device for particular weighing applications is shown in Table 1. Typical Class or Type of Device for Weighing Applications.

Table 1. Typical Class or Type of Device for Weighing Applications	
Class	Weighing Application
A	Screening and sorting of vehicles based on axle, axle group, and gross vehicle weight.
<u>E</u>	<u>Enforcing of vehicles based on axle, axle group, and gross vehicle weight</u>
<b>Note:</b> A WIM system with a higher accuracy class than that specified as “typical” may be used.	

**UR.2. User Location Conditions and Maintenance.** – The system shall be installed and maintained as defined in the manufacturer’s recommendation.

**UR.2.1. System Modification.** – The dimensions (e.g., length, width, thickness, etc.) of the load receiving element of a system shall not be changed beyond the manufacturer’s specifications, nor shall the capacity of a scale be increased beyond its design capacity by replacing or modifying the original primary indicating or recording element with one of a higher capacity, except when the modification has been approved by a competent engineering authority, preferably that of the engineering department of the manufacturer of the system, and by the weights and measures authority having jurisdiction over the system.

**UR.2.2. Foundation, Supports, and Clearance.** – The foundation and supports shall be such as to provide strength, rigidity, and permanence of all components.

On load-receiving elements, which use moving parts for determining the load value, clearance shall be provided around all live parts to the extent that no contacts may result when the load-receiving element is empty, nor throughout the weighing range of the system.

**UR.2.3. Access to Weighing Elements.** – If necessary, adequate provision shall be made for inspection and maintenance of the weighing elements.

**UR.3. Maximum Load.** – A system shall not be used to weigh a load of more than the marked maximum load of the system.

## Appendix D. Definitions

The specific code to which the definition applies is shown in the [brackets] at the end of the definition. Definitions for the General Code [1.10] apply to all codes in NIST Handbook 44.

### A

**axle.** – The axis oriented transversely to the nominal direction of vehicle motion, and extending the full width of the vehicle, about which the wheel(s) at both ends rotate. [2.25]

**axle-group load.** – The sum of all tire loads of the wheels on a group of adjacent axles; a portion of the gross-vehicle weight. [2.25]

**axle load.** – The sum of all tire loads of the wheels on an axle; a portion of the gross-vehicle weight. [2.25]

**axle spacing.** – The distance between the centers of any two axles. When specifying axle spacing, the axels used also need to be identified. [2.25]

### S

**single-axle load.** – The load transmitted to the road surface by the tires lying on the same longitudinal axis (that axis transverse to the movement of the vehicle and about which the wheels rotate). [2.25]

### T

**tandem-axle load.** – The load transmitted to the road surface by the tires of two single-axles lying on the same longitudinal axis (that axis transverse to the movement of the vehicle and about which the wheels rotate). [2.25]

**triple-axle load.** – The load transmitted to the road surface by the tires of three single-axles lying on the same longitudinal axis (that axis transverse to the movement of the vehicle and about which the wheels rotate). [2.25]

### W

**weigh-in-motion (WIM).** – A process of estimating a moving vehicle's gross weight and the portion of that weight that is carried by each wheel, axle, or axle group, or combination thereof, by measurement and analysis of dynamic vehicle tire forces. [2.25]

**weigh-in-motion screening scale.** – A weigh-in-motion system used to identify potentially overweight vehicles. [2.25]

**wheel weight.** – The weight value of any single or set of wheels on one side of a vehicle on a single axle. [2.25]

**WIM System.** – A set of sensors and supporting instruments that measure the presence of a moving vehicle and the related dynamic tire forces at specified locations with respect to time; estimate tire loads; calculate speed, axle spacing, vehicle class according to axle arrangement, and other parameters concerning the vehicle; and process, display, store, and transmit this information. This standard applies only to highway vehicles. [2.25]

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