WIM – WEIGH-IN-MOTION SYSTEMS – TENTATIVE CODE

WIM-23.1 I 2.26 Weigh-in-Motion Systems Used for Vehicle Direct Enforcement

Source:
New York City DOT, C2SMART, Kistler, and Maryland DOT

Purpose:
Provide a legal document that can be used by local and State agencies to certify Weigh-In-Motion (WIM) systems used for automated weight enforcement.

Item under Consideration:
Add Handbook 44 Weigh-In-Motions Systems Used for Vehicle Direct Enforcement Code as follows:

TABLE OF CONTENTS

Page

Section 2.26 Weigh-In-Motion Systems Used for Vehicle Direct Enforcement

A. APPLICATION

A.1. General . – This code applies to systems installed in a fixed location used to weigh vehicles, while in motion, for the purpose of direct enforcement of legal weight limits.

A.2. Exception. – This code does not apply to weighing systems intended for the collection of statistical traffic data and weighing systems used for vehicle enforcement screening.

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

S. SPECIFICATIONS

WHERE DID CLASS "E" COME FROM? WHAT IS CLASS E? WHERE ARE THE OTHER CLASSES OF SYSTEMS?

This reference is left over from when section was combined with tentative screening code.

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 E weigh-in-motion (WIM) system (WIM) system shall not be greater than 200 kg or 500 lb.

Why would we permit "d" greater than one hundred pounds or much less five hundred pounds? Class IIILis limited to a minimum of 2000 "d" and maximum of 10,000 "d".

***S.1.3.1. Number of System Divisions.* – The number of system divisions for Class E shall be a minimum of 50 and a maximum of 1,000.**

A 200,000 pound capacity system with 4,000 divisions with equals 50 pounds as the value of "d".

***S.1.3.2. Minimum Capacity.* – The minimum capacity in system divisions for Class E shall be 10.**

A systems with 200,000 capacity with value of "d" at 100 pounds would be legal with 2,000 divisions.

This section S.1.3 has been updated to align with OILM code which is most appropriate reference code.

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 affecting accuracy as specified in Table T.2.3. Maintenance Tolerances for Accuracy shall be presented to the operator in a clear and unambiguous means. No weight values shall be indicated or recorded when a fault condition is detected. The following fault conditions shall be identified:

(a) Vehicle speed is below the minimum or above the maximum system specified speed.

(b) The maximum number of vehicle axles as specified has been exceeded.

(c) A change in vehicle speed greater than that specified has been detected.

(d) Imbalanced weight between the left and right wheels has exceeded the specified values.

(e) Vehicle has changed lanes between or in the proximity of the first and the last sensors.

(f) Any axle or wheel, or part of each is not on the load-receiving element of the sensors.

(g) Vehicle direction of travel is not valid for the installation.

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:**

(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) identification and weight of axle groups;

(h) axle spacing;

(i) gross vehicle weight;

(j) total vehicle length;

(k) all fault conditions that occurred during the weighing of the vehicle, as identified in paragraph S.1.6. Identification of a Fault;

(l) violations, as identified in paragraph S.2.1. Violation Parameters, which occurred during the weighing of the vehicle; and

(m) time and date.

Note: 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. Violation thresholds may be dependent on additional items, not specified in this code.

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.

Note: Jurisdiction-defined weight limits for S.2.1 Violation Parameters (a) through (d) can be used to determine the violation.

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. – WIM systems meeting the requirements of this code shall be designated as accuracy 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. Design of Balance

S.5.2. Zero-Tracking Device. – A zero-tracking device shall have a range of 4% of the system capacity and operate only when:

On 200,000 pound capacity scale with 100 pound divisions, 4% would equal 8000 pounds.

(a) the system is in a no-load condition;

(b) is in stable equilibrium; and

(c) the corrections are not more than 0.5 d per second; and

~~(d)~~ This section S.1.3 has been updated to align with OILM code which is most appropriate reference code. Also please not section numbering correction in edits forwarded to S&T commitee

S.5.3. Totalizing Device. – A WIM system may be provided with a totalizing device for determining gross vehicle weight which operates:

(a) automatically, in which case the instrument shall be provided with a vehicle recognition device defined in S.5.4. Vehicle Recognition/Presence Device; or

(b) semi-automatically (e.g., it operates automatically following a manual command).

S.5.4. Vehicle Recognition/Presence Device. – WIM system which are able to operate without the intervention of an operator shall be provided with a vehicle recognition device. The device shall detect the presence of a vehicle in the weigh zone and shall detect when the whole vehicle has been weighed. WIM system shall not indicate or print the vehicle mass unless all wheel loads of the vehicle have been weighed.

S.6. Accidental Breakdown and Maladjustment. – WIM system shall be so constructed that an accidental breakdown or maladjustment of control elements likely to disturb its correct functioning cannot take place without its effect being evident.

S.7. Marking Requirements. – In addition to the marking requirements in G-S.1. Identification, 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;

(h) minimum and maximum load; and

(i) any restrictions specified in the NTEP Certificate of Conformance.

S.7.1. Location of Marking Information. – The marking information required in Section 1.10. General Code, G-S.1. Identification and S.7. 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.1.6 Test Procedures shall be performed with vehicles of these three types, at a minimum.

Exactly how many runs minimum would the examination require?

For 3 test vehicles with the different combinations, it would be 90 runs

(a) 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) a three-axle, single-unit truck or FHWA Class 6; and

(c) a five-axle, single-trailer truck or FHWA Class 9 (3S2 Type).

(d) The gross vehicle weights shall be as stated in N.1.2.2. *Dynamic Test Loads.*

I count a minimum of 30 test runs per type of vehicle = 90 runs minimum. Where does the inspector get the vehicles for the test runs? What is considered a non-shifting load? Where does the inspector get loads? Liquid loads not included in the category.

For 3 test vehicles 90 runs is correct. Vehicles can be rented or provided DOT as they typically have the vehicles in their fleet. Each jurisdiction would determine their best option. materials that don't shift from movement, language is similar to that used in OILM.

Note 1: Consideration should be made for testing the system using vehicles which are typical to the roadway in which the system is installed if different than the types listed in (a) through (c) above.

Note 2: If the WIM system will be used to enforce the weight limit for vehicles with liquid loads, a vehicle with a liquid load shall be included in the selection of test vehicles.

N.1.1.1. Weighing of Test Vehicles. – All test vehicles shall be weighed statically on a reference scale, meeting the requirements of Appendix A, before being used to conduct dynamic tests.

N.1.1.2. Determining Reference Weights for Axles, 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. **– Test vehicles used for dynamic testing shall be loaded as specified below. Except when testing for liquid loads, the "load" shall be non-shifting and shall be positioned to present as close as possible, an equal side-to-side load.**

(a) a half load condition (60-80% of the legal load limit of the test vehicle) for a minimum of 10 runs per test vehicle type;

(b) a full load condition (> 85% of the legal load limit for the test vehicle) for a minimum of 20 runs per test vehicle type; and

(c) When it is anticipated that a system will be used to enforce weight limits for vehicles that may be unloaded, e.g., an unloaded Class 9 vehicle crossing a bridge with a 20 TN maximum capacity, tests shall include unloaded vehicles as part of the test load.

How does the inspector determine what range of the legal load he has applies? Where does the inspector get the equipment to load the test vehicle? Is there any data provided the accuracy of this testing?

Legal weight limits are defined for every state. Vehicles can be obtained as described above. Test data was provided from the demonstration and is on the NCWM website.

N.1.3. Reference Scale. – Each reference vehicle shall be weighed statically on a multiple platform vehicle scale or a single-platform vehicle scale.

It appears in this test procedure, split-weighing is permitted on a single platform scale

See revisions to the language per discussion with NIST/S&T committee

The scale shall be tested prior to using it to establish reference test loads per direction from the jurisdiction and in no case more than 4 weeks prior. To qualify for use as a suitable reference scale, it must meet NIST Handbook 44, Class III L maintenance tolerances

Who would an inspector even think of testing a reference scale any days prior to the day of testing

To allow flexibility to jurisdiction max limit for reference scale testing timeline is provided. Inspector may determine a tighter timeline per jurisdictional practice.

N.1.3.1. Multi-Platform Vehicle Scale. **– It is 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 one 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 gross vehicle weight shall be determined by summing all the single axles and axle groups.

This is split-weighing

***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.**

This nearly impossible in a lot cases?

From demonstration it was determined that fuel consumption has very limited impact on the test results, however to address time constraints during testing and to ensure reference scale is in the general vicinity of the test site, note is added for user consideration.

N.1.4. Test Speeds. – All dynamic tests shall be conducted at two designated speeds.

(a) **at a high speed – posted speed limit (Vmax); and**

(b) **at a low speed – site-specific minimum speed, not below manufacturer's requirement (Vmin).**

N.1.5. Reference Axle Spacings. – To establish reference axle spacing, b*efore measuring the axle spacing, the test vehicle shall be positioned straight, and the driving axle shall also be straight. A steel tape measure shall be used for measurement. Both left and right axle spacing shall be measured, and the average of two measurements shall be recorded by the nearest cm (inches). Each axle spacing shall be made by a single measurement.*

N.1.6. Test Procedures.

***N.1.6.1. Dynamic Load Test.* – The dynamic test shall be conducted using the test vehicles defined in N.1.1. Selection of Test Vehicles and at the load condition as stated in N.1.2. Test Loads and at the speed as stated in N.1.4. Test Speeds. The number of runs shall be per Table N.1.5.**

At the conclusion of the dynamic test, there shall be a minimum of 20 weight readings for each single axle, axle group, and gross vehicle weight of each test vehicle. The tolerance for each weight reading shall be based on the percentage values specified in Table T.2.3. Maintenance Tolerances for Accuracy Class E.

Note. Any vehicle records identified as fault conditions listed in S.1.6. Identification of a Fault or jurisdiction defined fault conditions shall be excluded from the minimum weight readings in N.1.5.1. Dynamic Load Test.

See Table N.1.6 below to summarize the minimum number of test runs.

Table N.1.6 Minimum Number of Test Runs per Each Test Vehicle	
Load Condition	**Speed**
Half Load (10 runs)	**High Speed Vmax (5 runs)**
	Low Speed Vmin (5 runs)
Full Load (20 runs)	**High Speed Vmax (10 runs)**
	Low Speed Vmin (10 runs)

Is this posted speed of minimum and maximum speed?

As noted N.1.4 it is the posted speed.

N.1.6.2. 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 vehicle scale is a performance requirement independent of the design principle used.

What does this mean exactly?

This is meant to clarify that regardless of the type of WIM system, load plate, quartz or some other design, WIM systems intended for this use shall be subject to the same tolerance.

T.2. Tolerance Values for Accuracy.

T.2.1. Acceptance Tolerance. – Acceptance tolerance shall be 50% of tolerances in Table T.2.3. Maintenance Tolerances for Accuracy. The acceptance tolerance shall apply to a new installation or within 30 days of a new installation being placed in service or when an existing system undergoes major reconditioning or overhaul.

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

Are there systems in use not using digital indication?

Acknowledged. All digital systems have built in digital rounding.

T.2.3. Maintenance Tolerance Values for Dynamic Load Test. – The tolerance values applicable during dynamic load testing are as specified in Table T.2.3. for direct enforcement purposes.

Table T.2.3. Maintenance Tolerances for Accuracy	
Load Description*	**Tolerance as a Percentage of Applied Test Load**
Axle Load	**± 20 %**
Axle Group Load (including bridge formula)	**± 15 %**
Gross Vehicle Weight	**± 10 %**
*** All weight readings shall be 100% in compliance.**	

These tolerances are way out of bounds for the provided use and does not promote uniformity of the principles of the NCWM.

On a system with a capacity of 200,000 pounds and 100 pound division:

A axle with a 12,000 pounds of axle test load has an allowable tolerance of 2,400 pounds.

An axle group weighing 34,000 pounds of axle test load has allowable tolerance of 5,100 pounds

A vehicle weighing 80,000 pounds would have an allowable tolerance of 8,000 pouunds.

The tolerances are in line with international standard (OIML R134-1), European standard (COST 323), and all countries around the world that are implementing direct enforcement. See additional discussion and response from Open Hearing.

T.2.4. Tolerance Value for Axle Spacing. – The tolerance value applied to each axle spacing measurement shall be ± 0.15 m (6 inches) at 100% compliance.

T.3. Influence Factors. – The following factors are applicable to tests conducted under controlled conditions only.

T.3.1. Temperature. –The instrument shall operate within tolerance throughout the specified operational temperature range.

T.3.2. Temperature Effect on Zero-Load Balance. – The zero-load indication shall not vary by more than one division per 5°C (9°F) change in temperature.

T.3.3. Power Supply. – System shall satisfy the tolerance requirements in Table T.2.3. Maintenance Tolerance for Accuracy under voltage ranges of -15% to +10% of the marked nominal line voltage(s) at 60 Hz or the voltage range marked by the manufacturer at 60 Hz. The battery-operated systems shall satisfy the tolerance requirements in Table T.2.3. Maintenance Tolerance for Accuracy when the battery power output is not excessive or deficient.

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.2.3. Maintenance Tolerances for Accuracy.

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 system divisions, value of the system division, or verification system 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
E	Enforcing of vehicles based on axle, axle group, and gross vehicle weight.

Where did Class E come from? It should be defined in this code.

This reference is left over from when section was combined with tentative screening code.

UR.2. Installation and Maintenance.

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 sensor 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.

UR.4 Enforcement Guidance. – Prior to the issuance of an enforcement violation, the user shall ensure compliance with specific jurisdictional legislation and/or protocols. 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.

Add the following definitions to Appendix D:

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. [2.26]

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. [2.26]

axle load. – The sum of all tire loads of the wheels on an axle; a portion of the gross-vehicle weight. [2.26]

axle spacing. – The distance between the centers of any two axles. When specifying axle spacing, the axels used also need to be identified. [2.26]

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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. [2.26]

WIM System. – A set of load receptors 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. [2.26]