NIST | OFFICE OF WEIGHTS AND MEASURES

Examination Procedure Outlines (EPOs) for Commercial Weighing and Measuring Devices

EPO No. 13

Vehicle and Axle-Load Scales and Weigh-in-Motion Vehicle Scales

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EPO No. 13
NIST Examination Procedure Outline (EPO) for
Vehicle and Axle-Load Scales and Weigh-in-Motion Vehicle Scales

1. Scope.

It is recommended this outline be followed as minimum criteria for examining vehicle and axle-load scales. EPO No. 13 is divided into two parts: (1) Part I – Electronic Digital Indicating for Vehicle and Axle-Load Scales and (2) Part II – Mechanical-Analog Indicating for Vehicle and Axle-Load Scales. Part I applies to vehicle and axle-load scales (load receiving elements) equipped with electronic digital indicators and to weigh-in-motion (WIM) vehicle scales that fall clearly within and are covered by the requirements of NIST Handbook (HB) 44 Section 2.20 Scales Code. This outline is not intended for use in the examination of other WIM Systems used in applications such as vehicle enforcement screening (addressed in HB 44 Section 2.25). It is also recommended that the portions of the outline designated only for WIM systems are applied after initially applying requirements identified as relevant to both static and dynamic (WIM) weighing vehicle and axle-load scales. When applying the outline in this EPO to the WIM functionality of the vehicle scale, the scale must be operating in dynamic weighing mode (i.e., weigh-in-motion). Part II applies to vehicle and axle-load scales equipped with weighbeams and/or mechanical dials.

Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk (*). Nonretroactive requirements are followed by the applicable date in parentheses.

2. Safety Notes.

When excerpting this Examination Procedure Outline for duplication, the "Safety Considerations" section and the "Glossary of Safety Key Phrases" should be duplicated and included with the outline.

Safety policies and regulations vary among jurisdictions. It is essential that inspectors or servicepersons be aware of all safety regulations and policies in place at the inspection site and to practice their employer's safety policies. The safety reminders included in this EPO contain general guidelines useful in alerting inspectors and servicepersons to the importance of taking adequate precautions to avoid personal injury. These guidelines can only be effective in improving safety when coupled with training in hazard recognition and control.

Prior to beginning any inspection, the inspector should read and be familiar with the EPO Safety Annex - "Safety Considerations and Glossary of Safety Key Phrases." The terms and key phrases in each safety reminder of this outline are found in the glossary of the EPO Safety Annex. The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. As a minimum, the following safety precautions should be noted and followed during the inspection.

- **Chemicals, Petroleum Products, and Other Hazardous Materials**
- **Clothing**
- **Electrical Hazards**
- **Emergency Action Plan/Procedures**
- **First Aid Kit**
- **Lifting**
  - e.g., maneuvering weights when loading and unloading WIM test vehicles
- **Location**

- **Obstructions**
- **Overhead Hazards**
- **Personal Protection Equipment**
  - e.g., Safety Shoes, Hard Hat (for protection from overhead hazards)
- **Safety Cones/Warning Signs/Other Types of Barriers**
- **Support – for Scale, Test Weights, and Test Equipment**
- **Traffic**
  - e.g., dynamic testing of WIM vehicle scales - requiring the operation of multiple test vehicles, nearby or witnessing reference vehicle test procedures
- **Transportation of Equipment**
- **Weather**
- **Wet and Slick Conditions**

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Learn the nature of hazardous products used at or near the inspection site.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure a first aid kit is available and the kit is appropriate for the type of inspection activity.**

3. Equipment List.

NOTE: The equipment list section is based on performing a gravimetric test procedure to verify the performance of the reference scale that is used to determine the weight of reference vehicles used in testing the weigh-in-motion vehicle scale. See Appendix D. "Verification of the Weigh-in Motion Scale Reference Vehicles" Procedure for the Reference Scale" for the procedure to use for verifying a scale suitable for assessing the accuracy of reference vehicles used as test loads on the weigh-in motion vehicle scale under test.

The following criteria should be considered when selecting equipment for the gravimetric test method.

3.1. Reference Scale.

The reference vehicle scale shall be of the same accuracy class as the WIM vehicle scale that is under test, i.e., accuracy Class III L. (See Appendix D. "Verification of the Weigh-in-Motion Scale Reference Vehicles).

3.2. Mass Standards.

In accordance with NIST Handbook 44, Appendix A. "Fundamental Considerations", Section 3. "Testing Apparatus" and paragraph 3.2. "Tolerances for Standards", the combined error and uncertainty of any standard used for testing must be less than one-third the applicable device tolerance. The use of the mass standards indicated for the scale accuracy class listed below will ensure conformance with this fundamental consideration.

- Class III L Scales: NIST Class F (or an ASTM or OIML Class equivalent), or standards of greater accuracy.

Also see EPO 13 Appendix B. "Strain-Load and Substitution Load Methods of Testing and Strain-Load Testing Using Error Weights".

3.3. Reference Vehicles.

For verification of WIM vehicle scale (See EPO 13 Appendix D. "Verification of the Weigh-in-Motion Scale Reference Vehicles").

Part I – Electronic Digital Indicating

4. Inspection.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

When a specific code requirement is applicable to a certain type of weighing device that kind of device is identified by a single letter designation. The specific "Code Reference:" is immediately followed on the next line by the statement "Code Applies to:" and the appropriate letter designation for each device type. A key to identify the meaning of each device-type letter designation appears at the beginning of each inspection and test section of the EPO.

Key to the letter designation used to identity the type of weighing device(s) the "Code Applies to:" are as follows:

E = Electronic digital scales

WIM = Weigh-in-Motion vehicle scales

4.1. Accessibility and Assistance in Inspecting, Testing, and Sealing.

Device must be readily accessible for purposes of testing. Assistance shall be provided by the firm if needed.

Code Reference: 1.10: G-UR.2.3., G-UR.4.4., 2.20: UR.2.5.

4.2. Zero-Load Balance and Level Condition.

Check the zero-load balance and level conditions as found. If the device is not indicating a zero-balance and/or level condition, the user should be made aware of these requirements and a warning issued if necessary.

Code Reference: 1.10: G-UR.3.1, 2.20: UR.4.1., UR.4.2.

4.2.1. Zero Indication.

4.2.1.1. Zero Indication – General.

- Indicate or record zero-balance condition. If indication is by other than a continuous digital zero, then an automatic means to inhibit weighing or to return to a continuous digital indication when in an out-of-balance condition.
  Code Reference: 2.20: S.1.1.(a), S.1.1.(c).

- Automatic-indicating scale or balance indicator shall indicate or record an out-of-balance condition on both sides of zero.
  Code Reference: 2.20: S.1.1.(b).

4.2.1.2. Zero Indication – Digital.

- Display of digital zero.
  Code Reference: 1.10: G-S.5.2.2.(d) (1/1/86).

- Digital zero representation of balance condition.
  Code Reference: 2.20: S.1.1.1.(a).
- Digital center-of-zero indication.
  Code Reference: 2.20: S.1.1.1.(c) (1/1/93).

4.2.2. Zero-Load Adjustment.

4.2.2.1. General Means.
Code Reference: 2.20: S.2.1.1.

4.2.2.2. Manual and Semi-Automatic Zero-Setting, Direct Sales.
Code Reference: 2.20: S.2.1.2.(a).

4.2.2.3. Automatic Zero-Tracking (scales manufactured between 1/1/81 and 1/1/07).
Code Reference: 2.20: S.2.1.3.1.(b).

4.2.2.4. Automatic Zero-Tracking (scales manufactured on or after 1/1/07).
Code Reference: 2.20: S.2.1.3.2.(a).

4.2.2.5. Level Condition.
Code Reference: 2.20: UR.4.2.

4.3. Selection and Suitability.

4.3.1. Suitability, General.
Code Reference: 1.10: G-UR.1.1., G-UR.1.2., 2.20: UR.1.

4.3.2. Special Designs.
Code Reference: 2.20: UR.3.6.

4.3.3. Adjustable Components.
Code Reference: 2.20: S.1.10.

4.3.4. Electronic Adjustable Components.
Code Reference: 1.10: G-S.8. (1/1/90), 2.20: S.1.11.

4.3.5. Design of Weighing Devices, Accuracy Class.
Code Reference: 2.20: S.5.*

4.3.5.1. Designation of Accuracy Class.
Code Reference: 2.20: S.5.1. (1/1/86), UR.1.1.

4.3.5.2. Parameters for Accuracy Class.
Code Reference: 2.20: S.5.2. (1/1/86).

4.3.6. Typical Class for Weighing Applications.
Code Reference: 2.20: UR.1.1., Table 7a. and Table 7b.

4.3.7. Recommended Minimum Load.
Code Reference: 2.20: UR.3.1.

4.3.8. Maximum Load.
Code Reference: 2.20: UR.3.2.

4.3.9. Environment.

4.3.9.1. Suitable for the environment in which it is used.
Code Reference: 1.10: G-UR.1.2.

4.3.9.2. Protection from Environmental Factors.
Code Reference: 2.20: UR.2.3.

4.3.10. Permanence.
Code Reference: 1.10: G-S.3.

4.4. Installation.

4.4.1. In Accordance with Manufacturer's Instructions.
Code Reference: 1.10: G-UR.2.1.

4.4.2. Indicating and Recording Elements.
Code Reference: 1.10: G-UR.2.2.

SAFETY REMINDER!!!

- **Check to be sure the scale supports are adequate to support the scale and test weights equal to the capacity of the scale!**

4.4.3. Foundation, Supports, and Clearance – Soundness of the scale's support structure and clearance of its parts from any impedance.
Code Reference: 2.20: UR.2.4.

4.4.4. Approaches.
Code Reference: 2.20: UR.2.6.

4.4.4.1. Vehicle Scales.
Code Reference: 2.20: UR.2.6.1.

4.4.4.2. Axle-Load Scales.
Code Reference: 2.20: UR.2.6.2.

4.4.5. Visibility of Identification – Installation to ensure ready visibility of markings.
Code Reference: 1.10: G-UR.2.1.1.

4.4.6. Position of Equipment.
Code Reference: 1.10: G-UR.3.3.

4.4.7. Length of WIM Vehicle Scale.
Code Reference: 2.20: S.3.4.
Code Applies to: WIM only.

4.5. Use.

4.5.1. Facilitation of Fraud.
Code Reference: 1.10: G-S.2.

4.5.2. Method of Operation.
Code Reference: 1.10: G-UR.3.1.

4.5.3. Special Designs.
Scales designed and marked for special applications shall not be used for other than the intended purpose.
Code Reference: 1.10: G-UR.3.1., 2.20: UR.3.6.

4.5.4. Operation with Associated and Nonassociated Equipment.
Code Reference: 1.10: G-UR.3.2.

4.5.5. Recommended Minimum Load.
Code Reference: 2.20: UR.3.1.

4.5.6. Minimum Load on a Vehicle Scale.
Code Reference: 2.20: UR.3.8.

4.5.7. Maximum Load.
Code Reference: 2.20: UR.3.2.

4.5.8. Single Draft Vehicle Weighing.
Code Reference: 2.20: UR.3.3.

4.5.9. Weighing of Axle Loads and Axle-Group Loads.
Code Reference: 2.20: UR.3.4.

4.6. Maintenance.

4.6.1. Maintenance of Equipment, General.
Code Reference: 1.10: G-UR.4., G-UR.4.1.

4.6.2. Abnormal Performance.
Code Reference: 1.10: G-UR.4.2.

4.6.3. Scale Modification.
Code Reference: 2.20: UR.4.3.

4.6.4. Use of Adjustments.
Code Reference: 1.10: G-UR.4.3.

4.6.5. Check for the presence security seals on any component designed to be sealed.
Code Reference: 1.10: G-UR.4.5.

4.7. Design of Weighing Device.

4.7.1. Designation of Accuracy Class.
Code Reference: 2.20: S.5.1. (1/1/86), UR.1.1.

4.7.2. Parameters for Accuracy Class.
Code Reference: 2.20: S.5.2. (1/1/86).

4.7.3. Multi-Interval and Multiple Range.
Code Reference: 2.20: S.5.3.

4.7.4. Relationship of Scale Interval to Load Cell Verification Interval.
Relationship of the minimum load cell verification interval (v_{min}) to the value of the scale interval (e).

Code Reference: 2.20: S.5.4. (1/1/94).

Relationship of the verification scale interval (e) of a weighing/load-receiving element to the value of the scale division (d). Except for dynamic monorail scales and weight classifiers, the value of "e" must be equal to "d" on Class III, IIL, and IIII scales.

Code Reference: 2.20: S.1.2.2.2.

4.7.5. Extended Display Mode.
Code Reference: 2.20: S.1.2.2.3.

4.8. Markings.

4.8.1. Markings – Overview.

4.8.1.1. Identification.
Code Reference: 1.10: G-S.1., G-S.1.1. (1/1/04), G-S.1.2.

4.8.1.2. Size and character; designation and marking of subordinate values.
Code Reference: 1.10: G-S.5.2.3.

4.8.1.3. Values.
Code Reference: 1.10: G-S.5.2.4.

4.8.1.4. Permanence of Markings.
Code Reference: 1.10: G-S.5.2.5.

4.8.1.5. Accuracy Class.
Code Reference: 2.20: S.5.1.

4.8.1.6. Location.
Code Reference: 2.20: S.6.2.

4.8.1.7. Specific Scales' Code markings.
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

4.8.1.8. Special Design.
Code Reference: 2.20: Table S.6.3.a. and Table S.6.3.b. (1/1/86), UR.3.6.

Scales designed for special application appropriately marked to restrict its use (e.g., postal scale, prepack scale, weight classifier).
Code Reference: Table S.6.3.b. Note 13 (Nonretroactive 1/1/86).

4.8.2. Marking Requirements – All Devices.

4.8.2.1. General.
Code Reference: 2.20: S.6.

4.8.2.2. Identification.
Code Reference: 1.10: G-S.1.

4.8.2.2.1. Name, Initials, or Trademark of Manufacturer or Distributor.
Code Reference: 1.10: G-S.1.(a) Retroactive.

4.8.2.2.2. Model Identifier.
Code Reference: 1.10: G-S.1.(b) Retroactive.

Model identifier prefix and acceptable abbreviation for "model" and "number."
Code Reference: 1.10: G-S.1.(b)(1) (1/1/03).

4.8.2.2.3. Nonrepetitive Serial Number.
Code Reference: 1.10: G-S.1.(c) (1/1/68).

Serial number prefix.
Code Reference: 1.10: G-S.1.(c)(1) (1/1/86).

Acceptable abbreviations for "serial" and "number."
Code Reference: 1.10: G-S.1.(c)(2) (1/1/01).

4.8.2.2.4. As of 2004 the current software version or revision identifier for not-built-for-purpose software-based devices and as of 2022 the current software version or revision identifier for all software-based devices.

Code Reference: 1.10: G-S.1.(d) (1/1/04), G-S.1.(d) (1/1/22).

Software Version or Identifier.

Code Reference: 1.10: G-S.1.(d).

(1) Preface identifying it as such.
Code Reference: 1.10: G-S.1.(d)(1)*i*. (1/1/07).

(2) Continuously displayed or accessible via display.
Code Reference: 1.10: G-S.1.(d)(1)*ii*. (1/1/22).

(3) Acceptable abbreviations for “Version,” “Number,” and “Revision."
Code Reference: 1.10: G-S.1.(d)(2) (1/1/07).

4.8.2.2.5. NTEP CC Number for Devices with NTEP CC.

Code Reference: 1.10: G-S.1.(e) (1/1/03).

Preface by the terms “NTEP CC,” “CC,” or “Approval” followed by either the word or an acceptable abbreviation of “Number.”

Code Reference: 1.10: G-S.1.(e) (1/1/03).

4.8.2.3. Location of Marking Information for Not-Built-For-Purpose, Software-Based Devices.

Code Reference: 1.10: G-S.1.1. (1/1/04).

4.8.2.4. Devices or Main Elements Remanufactured as of January 1, 2002.

Code Reference: 1.10: G-S.1.2. (1/1/02).

Name, Initials, or Trademark of last Remanufacturer or Distributor.

Code Reference: 1.10: G-S.1.2.(a) (1/1/02).

Model Designation if different from original model designation.

Code Reference: 1.10: G-S.1.2.(b) (1/1/02).

4.8.2.5. Operational Controls, Indications, and Features.

Code Reference: 1.10: G-S.6. (1/1/77).

4.8.2.6. Lettering.

Code Reference: 1.10: G-S.7.

4.8.2.7. Visibility of Identification – installation to ensure ready visibility of markings.

Code Reference: 1.10: G-UR.2.1.1.

4.8.2.8. Interchange or Reversal of Parts.

Code Reference: 1.10: G-S.4.

4.8.3. Marking Requirements – Weighing, load-receiving, and indicating element in same housing or covered on the same CC (in addition to marking requirements for all devices).

Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

4.8.3.1. Accuracy Class.

Code Reference: Table S.6.3.b. Note 17 (Nonretroactive 1/1/86).

4.8.3.2. Nominal Capacity.

Code Reference: Table S.6.3.b. Note 3 Retroactive and Note 18 Retroactive.

Where the value of "e" is equal to the value of "d," the nominal capacity shall be shown together with the value of the scale division "d" or the verification scale interval "e."

Code Reference: 2.20: Table S.6.3.b. Note 3 (Nonretroactive 1/1/83).

For any scale that has no "d", the nominal capacity shall be shown together with the verification scale interval "e."

Code Reference: Table S.6.3.b. Note 4(a) (Nonretroactive 1/1/86).

4.8.3.3. Concentrated Load Capacity.

Indicating and weighing/load-receiving elements manufactured prior to 1/1/89 are required to be marked with a section capacity rating. However, it is acceptable for these devices to be marked with a CLC instead. It is not permissible, however, to substitute a section rating for a CLC on devices manufactured or placed into service on or after 1/1/89.

Code Reference: 2.20: Table S.6.3.b. Note 12 (portions Nonretroactive), Note 20 (1/1/00), Note 22 (Nonretroactive 1/1/03).

4.8.3.4. Temperature Limits.

Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).

Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

4.8.4. Marking Requirements – Indicating element not permanently attached or covered on separate CC (in addition to marking for all devices).

Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

4.8.4.1. Accuracy Class.

Code Reference: 2.20: Table S.6.3.b. Note 8 (Nonretroactive 1/1/88).

4.8.4.2. Nominal Capacity.

Code Reference: 2.20: Table S.6.3.b. Note 3 Retroactive and Note 18 Retroactive.

Where the value of "e" is equal to the value of "d," the nominal capacity shall be shown together with the value of the scale division "d" or the verification scale interval "e."

Code Reference: 2.20: Table S.6.3.b. Note 3 (Nonretroactive 1/1/83).

For any scale that has no "d," the nominal capacity shall be shown together with the verification scale interval "e."

Code Reference: 2.20: Table S.6.3.b. Note 4(a) (Nonretroactive 1/1/86).

4.8.4.3. Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).

Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

4.8.4.4. Maximum Number of Verification Scale Intervals (n_{max}).

Code Reference: 2.20: Table S.6.3.b. Note 6 (Nonretroactive 1/1/88).

4.8.5. Marking Requirements – Weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices).

Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

4.8.5.1. Accuracy Class.

Code Reference: 2.20: Table S.6.3.b. Note 19 (Nonretroactive 1/1/88).

4.8.5.2. Nominal Capacity.

Code Reference: 2.20: Table S.6.3.b. Note 3 Retroactive and Note 18 Retroactive.

4.8.5.3. Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).

Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

4.8.5.4. Maximum Number of Verification Scale Intervals (n_{max}).

Code Reference: 2.20: Table S.6.3.b. Note 19 (Nonretroactive 1/1/88).

4.8.5.5. Minimum verification scale division for which device complies with the requirements (e_{min} or d).

Code Reference: 2.20: Table S.6.3.b. Note 19 (Nonretroactive 1/1/88).

4.8.6. Marking Requirements – Load cell with Certificate of Conformance (in addition to marking for all devices).

Code Reference: 2.20: S.6.3., S.5.4. (1/1/94).

Note: Requires information on a data plate attached to the load cell or in an accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document.

Code Reference: 2.20: Table S.6.3.b. Note 11 (Nonretroactive 1/1/88).

4.8.6.1. G-S.1. information, including the following shall be marked on both the load cell and in accompanying documents.

Code Reference: 2.20: Table S.6.3.b. Note 11 (Nonretroactive 1/1/91).

- Manufacturer's Name or Trademark.
- Model Designation.
- Model Designation Prefix.
  Code Reference: 1.10: G-S.1.(b) (Nonretroactive 1/1/03).
- Serial Number.
  Code Reference: 1.10: G-S.1.(c) (Nonretroactive 1/1/68).
- Serial Number Prefix.
  Code Reference: 1.10: G-S.1.(c)(1) (Nonretroactive 1/1/86).
- Abbreviation for word "Serial."
  Code Reference: 1.10: G-S.1.(c)(2) (Nonretroactive 1/1/01).

4.8.6.2. Accuracy Class.

Code Reference: 2.20: Table S.6.3.b. Note 17 (Nonretroactive 1/1/86).

4.8.6.3. Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).
Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

4.8.6.4. Maximum number of verification scale intervals (n_{max}).
Code Reference: 2.20: Table S.6.3.b. Note 6 (Nonretroactive 1/1/88).

4.8.6.5. "S" or "M" for single or multiple cell applications.
Code Reference: 2.20: Table S.6.3.b. Note 7 (Nonretroactive 1/1/88).

4.8.6.6. Direction of Loading, if not obvious.
Code Reference: 2.20: Table S.6.3.b. Note 15 (Nonretroactive 1/1/88).

4.8.6.7. Minimum Dead Load, Maximum Capacity, and Safe Load Limit.
Code Reference: 2.20: Table S.6.3.a. and Table S.6.3.b. Note 11 (Nonretroactive 1/1/88).

4.8.6.8. Load Cell Verification Interval (v_{min}) stated in mass units.
Code Reference: 2.20: Table S.6.3.b. Note 21 (Nonretroactive 1/1/01).

4.8.7. Marking Requirements – Additional Markings for Weigh-in-Motion Vehicle Scales.

4.8.7.1. WIM Minimum and Maximum Vehicle Speed Limitations.
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b. Note 25.
Code Applies to: WIM only.

4.8.7.2. WIM Maximum Vehicle Speed Change During the Weighment.
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b. Note 26.
Code Applies to: WIM only.

4.8.7.3. WIM Vehicle Scale Travel Direction.
If vehicle cannot travel in both directions on the WIM scale, scale must be marked "Uni-directional."
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b. Note 27.
Code Applies to: WIM only.

4.8.7.4. WIM Vehicle Scale Restrictions.
If applicable mark restriction on used in terms specified on the NTEP Certificate of Conformance.
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b. Note 28.
Code Applies to: WIM only.

4.9. Indicating and Recording Elements.

4.9.1. Appropriateness of Design.

4.9.1.1. Accuracy Class.
Code Reference: 2.20: S.5.

4.9.1.2. Indicating and Recording Elements, General Design.
Code Reference: 1.10: G-S.5.1.

4.9.1.3. Capacity Indication, Weight Ranges, and Unit Weights.
Code Reference: 2.20: S.1.7.

4.9.1.4. Recommended Minimum Load.
Code Reference: 2.20: UR.3.1.

4.9.1.5. Maximum Load.
Code Reference: 2.20: UR.3.2.

4.9.2. Display Height. For electronic cash registers (ECRs) and point-of-sale systems (POS systems) the display of measurement units, including those part of video displays and other user-provided indicating elements shall be a minimum of 9.5 mm (3/8 inch) in height.
Code Reference: 2.20: S.1.1.1.(d) (1/1/21), UR.2.10 (1/1/21).

4.9.3. Value of Scale Division and/or Interval.

4.9.3.1. Value – General.
Code Reference: 1.10: G-S.5.3., G-S.5.3.1., 2.20: UR.1.1.(b).

4.9.3.2. Value of Scale Units.
Code Reference: 2.20: S.1.2.* (1/1/86).

4.9.3.3. Digital Indicating Scales, Units.
Code Reference: 2.20: S.1.2.1. (1/1/89).

4.9.3.4. Except for dynamic monorail scales and weight classifiers, the value of "e" must be equal to "d" on Class III, III L, and IIII scales.
Code Reference: 2.20: S.1.2.2.2.*

4.9.3.5. Extended Display Mode.
Code Reference: 2.20: S.1.2.2.3.*

4.9.3.6. Recorded scale division shall be the same as the value of indicated division, except for Class I scales.
Code Reference: 2.20: UR.1.3. (1/1/86), UR.1.3.1.(a).

4.9.3.7. Multi-Interval and Multiple-Range Scales.
Code Reference: 2.20: S.5.3.

4.9.4. Price Computing.

4.9.4.1. Recorded Representations, Point-of-Sale Systems.
Code Reference: 2.20: S.1.8.5.

4.9.4.2. Money Values, Mathematical Agreement.
Verify that the sales information recorded by cash registers interfaced with a weighing element shall contain the following for items weighed in a checkout stand and that all descriptors are appropriate:

- Net weight;

- Unit price;
- Total price;
- Product class, name, or code number; and
- Tare weight (1/1/25).
  Code Reference: 1.10: G-S.5.5.

4.9.5. Tare.

4.9.5.1. Value of Tare Division.
Code Reference: 2.20: S.2.3. (1/1/83).

4.9.5.2. Tare Mechanism.
Code Reference: 2.20: S.2.3.

4.9.5.3. Combined Zero-Tare ("0/T") Key.
Code Reference: 2.20: S.2.1.6.

4.9.6. Repeatability.
Code Reference: 1.10: G-S.5.4.

4.9.7. Recorded Representations.

4.9.7.1. Recorded Representations, General.
Code Reference: 1.10: G-S.5.6., 2.20: UR.1.3. (1/1/86).

4.9.7.2. Indicated and Recorded Representation, Abbreviations of Units.
Code Reference: 1.10: G-S.5.6.1.

- Equipment manufactured on or after January 1, 2008.
  Code Reference: 1.10: G-S.5.6.1.(a).
- Equipment manufactured prior to January 1, 2008.
  Code Reference: 1.10: G-S.5.6.1.(b).

4.9.7.3. Recorded Representation, Multi-Independent Platform Vehicle Scale Systems.
Code Reference: 2.20: S.1.15.

4.9.7.4. Axle and Axle-Group Loads.
Code Reference: 2.20: S.1.15.1.

4.9.7.4.1. Total Vehicle Weight.
Code Reference: 2.20: S.1.15.2.

4.9.8. Damping Means.
Code Reference: 2.20: S.2.5.

4.9.8.1. Motion Detection, Digital Indicating Elements.
Code Reference: 2.20: S.2.5.1.(a).

4.9.9. Adjustable Components.
Code Reference: 2.20: S.1.10.

4.9.10. Manual Weight Entries.
Code Reference: 2.20: S.1.12. (1/1/93 and 1/1/05), UR.3.10.

4.10. Weighing Elements.

4.10.1. Antifriction Means.
Code Reference: 2.20: S.4.1.

4.10.2. Adjustable Components.
Code Reference: 2.20: S.1.10., S.4.2.

4.10.3. Multiple Load-Receiving Elements.
Code Reference: 2.20: S.4.3.

4.11. Provision for Sealing.

4.11.1. Sealing, General.
A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism.
Code Reference: 1.10: G-S.8. (1/1/90).

A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.
Code Reference: 1.10: G-S.8., 2.20: S.1.11.2.

Except for devices and systems adjusted using a removable digital storage device and Class I scales, the following provisions for sealing apply:
Code Reference: 2.20: S.1.11.2.

> Provision shall be made for applying a security seal in a manner that requires the security seal to be broken before an adjustment can be made to any component affecting the performance of an electronic device.
> ***Code Reference:*** 2.20: S.1.11.2.(a) (1/1/79).
>
> A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism.
> ***Code Reference:*** 2.20: S.1.11.2.(b) (1/1/90).

A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.
Code Reference: 2.20: S.1.11.2.

Audit trails shall use the format set forth in Table S.1.11. Categories of Device and Methods of Sealing.

Code Reference: 2.20: S.1.11.2 (c) (1/1/95), Table S.1.11. (1/1/95).

4.11.2. A metrologically-significant software change is a sealable event.

Code Reference: 1.10: G-S.9.

4.11.3. Physical Means of Security.

4.11.3.1. Security Seals. Check for the presence of security seals on the device. A security seal shall be affixed to any adjustment mechanism designed to be sealed. Document missing seals on the official report and apply new ones as needed.

Code Reference: 1.10: G-UR.4.5.

4.11.3.2. Accessibility to Security Seals. When applicable, the adjusting mechanism shall be readily accessible for the purpose of affixing a security seal. The device shall be installed or located such that access is provided to permit inspecting and applying security seals.

Code Reference: 1.10: G-UR.2.3.

4.11.4. Parameters Accessed Via Removable Digital Storage.

For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device**, such as a secure digital (SD) card, USB flash drive, etc., security shall be provided for those parameters using either:

(1) an event logger in the device; or

(2) a physical seal that must be broken in order to remove the digital storage device from the device (or system).

** This applies only to removable digital storage devices that must remain in the device or system for it to be operational.

Code Reference: 1.10: G-S.8.2., 2.20: S.1.11., Table S.1.11. (1/1/95).

4.11.5. Sealable Automatic Zero-Tracking Mechanism on Class III L Devices.

Code Reference: 2.20: S.2.1.3.3. (1/1/01).

4.11.6. Audit Trails, General.

4.11.6.1. Audit Trail Information. If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. Note that on some systems an electronic copy of the event log may also be available; however, the system must still be able to provide a hard copy. Examine these records for any signs of misuse of adjustments.

Code Reference: 1.10: G-S.8. (1/1/90), 2.20: S.1.11.1., S.1.11.2.(c) (1/1/95), Table S.1.11. (1/1/95).

4.11.6.2. Single Provision for Sealing Multiple Elements. For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified.

Code Reference: 1.10: G-S.8.1. (1/1/10).

4.11.7. Event Logger.

If security is provided using an event logger, the event logger shall include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter.

The event logger information must be available on demand through the device or through another on-site device at the time of inspection.

In addition to providing a printed copy of the information, the information may be made available electronically.

The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1000 records are required. (Note: Does not require 1000 changes to be stored for each parameter.)

Code Reference: 1.10: G-S.8. (1/1/90), 2.20: S.1.11., Table S.1.11. (1/1/95).

5. Pretest Determinations.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

When a specific code requirement is applicable to a certain type of weighing device that kind of device is identified by a single letter designation. The specific "Code Reference:" is immediately followed on the next line by the statement "Code Applies to:" and the appropriate letter designation for each device type. A key to identify the meaning of each device-type letter designation appears at the beginning of each inspection and test section of the EPO.

Key to the letter designation used to identity the type of weighing device(s) the "Code Applies to:" are as follows:

E = Electronic digital scales

WIM = Weigh-in-Motion vehicle scales

5.1. Tolerances – General.

5.1.1. Acceptance/Maintenance Tolerances.

Code Reference: 1.10: G-T.1., G-T.2.

5.1.2. Application.

Code Reference: 1.10: G-T.3., 2.20: T.N.2.1., T.N.2.3., T.N.2.4.

5.1.3. Intermediate Values.

Code Reference: 1.10: G-T.4.

5.2. Tolerance Values

5.2.1. Determine the Number of Verification Scale Intervals (n).

Using the following formula determine the number of verification scale intervals (n):

$$n = \frac{Scale\ Capacity}{Value\ of\ the\ Verification\ Scale\ Interval\ (e)}$$

5.2.2. Tolerance Associated with the Standard.

5.2.2.1. Tolerance on Tests When Type 2 Transfer Standards Are Used.

Code Reference: 1.10: G-T.5.

When Type 2 transfer standards are used to conduct accuracy tests, adjust the tolerances as described in General Code paragraph G-T.5. Tolerances on Tests When Type 2 Transfer Standards Are Used.

5.2.3. Unmarked Scales – Tolerance Values.

5.2.3.1. Unmarked Scales – All.

Code Reference: 2.20: T.1.1., Table T.1.1., T.1.2.

- Multiple Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.1.
- Single Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.2.
- Single Indicating Element, Multiple Indications.
  Code Reference: 2.20: T.N.4.3.
- Repeatability.
  Code Reference: 2.20: T.N.5.
- Discrimination.
  Code Reference: 2.20: T.N.7.2.
- Operating Temperature.
  Code Reference: 2.20: T.N.8.1.4. (Nonretroactive 1/1/81).
- Radio Frequency Interference and other interferences.
  Code Reference: 2.20: T.N.9.

5.2.3.2. Unmarked Scales With "n" Equal to 5000 or Less.

Code Reference: 2.20: T.1.1.

- Tolerance Application.
  Code Reference: 2.20: T.N.2.
- General Tolerances.
  Code Reference: 2.20: T.N.2.1.
- Subsequent Verification Examinations.
  Code Reference: 2.20: T.N.2.3.
- Multiple-Range and Multi-Interval Scales.
  Code Reference: 2.20: T.N.2.4.
- Ratio Tests (scales equipped with commercial weights).
  Code Reference: 2.20: T.N.2.5.

- Tolerance Values.
  Code Reference: 2.20: T.N.3., T.N.3.1. Table 6, T.N.3.2.

5.2.3.3. Unmarked Scales With "n" Greater Than 5000.
Code Reference: 2.20: Table T.1.1.

- Tolerances – General.
  Code Reference: 2.20: T.1., Table T.1.1.
- Ratio Tests (scales equipped with commercial weights).
  Code Reference: 2.20: T.N.2.5.

5.2.4. Marked Scales – Tolerance Values.

5.2.4.1. Scales Marked with an Accuracy Class Designation, Design.
Code Reference: 2.20: T.N.1.1.

- Accuracy Classes.
  Code Reference: 2.20: T.N.1.2.
- Verification Scale Interval.
  Code Reference: 2.20: T.N.1.3.
- General Tolerances.
  Code Reference: 2.20: T.N.2.1.
- Subsequent Verification Examinations.
  Code Reference: 2.20: T.N.2.3.
- Multiple-Range and Multi-Interval Scales.
  Code Reference: 2.20: T.N.2.4.
- Ratio tests (scales equipped with commercial weights).
  Code Reference: 2.20: T.N.2.5.
- Maintenance Tolerance Values.
  Code Reference: 2.20: T.N.3.1. [Table 6].
- Acceptance Tolerance Values.
  Code Reference: 2.20: T.N.3.2.
- Multiple Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.1.
- Single Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.2.
- Single Indicating Element, Multiple Indications.
  Code Reference: 2.20: T.N.4.3.
- Shift or Section Test (Agreement of Indications).
  Code Reference: 2.20: T.N.4.4.
- Repeatability.
  Code Reference: 2.20: T.N.5.

- Discrimination.
  Code Reference: 2.20: T.N.7.2.
- Operating Temperature.
  Code Reference: 2.20: T.N.8.1.4.
- Radio Frequency Interference and other interferences.
  Code Reference: 2.20: T.N.9.

5.3. Accuracy of Field Standards.

Code Reference: 2.20: N.2.

SAFETY REMINDER!!!

- **Be sure that the reference vehicle is not loaded beyond its legal weight capacity.**
- **Keep an appropriate distance during the loading and unloading of the reference vehicle(s).**
- **Make sure that loads on the reference vehicle(s) are safely secured.**

5.3.1. Reference Scale.

For verification of WIM vehicle scales' reference vehicles (See EPO 13 Appendix D. "Verification of the Weigh-in-Motion Scale Reference Vehicles").

Code Reference: 2.20: N.7.1.

Code Applies to: WIM only**.**

5.3.1.1. Dimension.

Code Reference: 2.20: N.7.1.1.

Code Applies to: WIM only.

5.3.1.2. Location.

The reference scale should be located near the weigh-in-motion vehicle scale to minimize the effect of vehicle fuel consumption. The reference scale and the weigh-in-motion vehicle scale may be the same scale.

When using the scale under test as the reference scale, it must be used in static weighing mode to determine the weight of the test vehicle(s).

Code Reference: 2.20: N.7.1.2.

Code Applies to: WIM only.

5.3.1.3. Timing.

Code Reference: 2.20: N.7.1.3.

Code Applies to: WIM only.

5.3.1.4. Qualification.

The reference scale shall comply with the principles in NIST Handbook 44 Appendix A, Fundamental Considerations, paragraph 3.2. Tolerances for Standards (See EPO 13 Appendix D. "Verification of the Weigh-in-Motion Scale Reference Vehicles").

Code Reference: 2.20: N.7.1.4.

Code Applies to: WIM only.

5.3.2. Reference Vehicle.

For verification of WIM vehicle scale (See EPO 13 Appendix D. "Verification of the Weigh-in-Motion Scale Reference Vehicles").

Code Reference: 2.20: N.7.2.

Code Applies to: WIM only.

5.3.2.1. Weight Conditions.

Reference vehicle(s) shall be selected to provide at least a high weight condition (> 90 % of the scale capacity or > 90 % of the maximum capacity of the vehicle, whichever is less) and a low weight condition (empty vehicle). Different types of vehicles may be used.

Code Reference: 2.20: N.7.2.1.

Code Applies to: WIM only.

5.3.2.2. Load Position.

Code Reference: 2.20: N.7.2.2.

Code Applies to: WIM only.

5.3.2.3. Static Weight.

The weight of the reference vehicle must be determined, including the load (if applicable) and the driver who is driving the vehicle during the dynamic tests (See Appendix D. "Verification of the Weigh-in-Motion Scale Reference Vehicles").

Code Reference: 2.20: N.7.2.3.

Code Applies to: WIM only.

5.3.2.3.1. Rounding.

Code Reference: 2.20: N.7.2.3.1.

Code Applies to: WIM only.

5.3.2.3.2. Re-Weighing.

Re-weighing the reference vehicle may be necessary between test runs or after the test, especially if fuel consumption or a change of driver plays a role.

Assuming that the fuel consumption of a truck varies between 6 and 8 miles per gallon, and that one gallon of diesel weighs 7.1 lb, the weight loss of the reference vehicle due to fuel consumption will then be approximately 1 lb per mile driven.

Code Reference: 2.20: N.7.2.3.2.

Code Applies to: WIM only.

5.4. Minimum Test Weights and Test Loads.

Code Reference: 2.20: N.3., Table 4.

6. Test Notes.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

When a specific code requirement is applicable to a certain type of weighing device that kind of device is identified by a single letter designation. The specific "Code Reference:" is immediately followed on the next line by the statement "Code Applies to:" and the appropriate letter designation for each device type. A key to identify the meaning of each device-type letter designation appears at the beginning of each inspection and test section of the EPO.

Key to the letter designation used to identity the type of weighing device(s) the "Code Applies to:" are as follows:

E = Electronic digital scales

WIM = Weigh-in-Motion vehicle scales

6.1. Test Methods. Permissible test methods for verifying compliance of commercial weighing and measuring systems with the provisions of NIST Handbook (HB) 44 include, but are not limited to, test methods and apparatus that have been approved by the Director as outlined in HB 44 Appendix A – Fundamental Considerations.

Code Reference: 1.10: G-N.3., Appendix A – Fundamental Considerations.

6.2. Zero-Load Balance and Level Condition. Check for maintenance of the zero-load balance and level condition. Establish a correct zero-load balance and level condition prior to beginning the test.

Code Reference: 2.20: UR.4.1., UR.4.2.

6.3. Repeatability. Check repeatability of indications throughout the test.

6.3.1. Repeatability of Indications.

Code Reference: 1.10: G-S.5.4., 2.20: T.N.5.

6.4. Agreement of Indications. Check for agreement of indications throughout the test.

Code Reference: 1.10: G-S.5.2.2., 2.20: T.N.4.

6.4.1. Multiple Digital Indications and Representations.

Code Reference: 2.20: T.N.4.1.

6.4.2. Single Indicating/Recording Element with Component Parts.

Code Reference: 2.20: T.N.4.2.

6.5. Return to Zero-Load Balance. Recheck the zero-load balance each time the test load is removed.

6.5.1. Zero-Load Balance Change.

Code Reference: 2.20: N.1.9.

6.5.2. Abnormal Performance.

Code Reference: 1.10: G-UR.4.2.

6.6. Recorded Representations.

6.6.1. Availability of Recorded Representation. Verify that any options available for obtaining a recorded representation are appropriate. For systems specifically required by a section of the Scales Code to issue a recorded representation, the recorded representation shall be made available to the customer in hard copy form unless otherwise specified by the customer. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability of issuing an electronic receipt, the customer may also be given the option of receiving the recorded representation electronically (e.g., via cell phone, computer, etc.) in lieu of or in addition to a hard copy.

Code Reference: 1.10: G-S.5.6.

6.7. Steps After Each Test Load – Recorded Representations. If the scale is equipped with a printer, print a ticket or label at each test load. Verify the following:

6.7.1. Digital Indication and Representations, Agreement and Display. Check that any recorded representations for weight, unit price, and total sale agree with their associated corresponding values that are displayed and are appropriately displayed.

Code Reference: 1.10: G-S.5.2.2., G-S.5.6.

6.7.2. Motion Detection. Check the effectiveness of motion detection. (See EPO 13 Appendix C. "Test for Motion Detection").

Code Reference: 2.20: S.2.5.1.(a).

6.7.3. Value of the Indicated and Recorded Scale Division. Verify that the value of the scale division as recorded on the recorded representation is the same as the division value indicated.

Code Reference: 2.20: UR.1.3. (1/1/86).

6.8. Zone of Uncertainty and Width of Zero, Electronic Scales Only. If, during the conduct of the test, the performance of the device is questionable with respect to the zone of uncertainty or the width of zero (see test procedure below), adequate tests should be conducted to determine compliance.

Code Reference: 2.20: N.1.5. (1/1/86), N.1.5.1., S.1.1.1.(a), S.1.1.1.(b) (1/1/25), S.1.1.1.(c) (1/1/93).

6.9. Other Operational Features, Electronic Scales Only. If the device is equipped with operational features such as programmable tare and/or unit prices, multiplier keys, sales accumulation, manual weight entries, price retention, two scales with one printer, etc., check proper operation and appropriateness.

Code Reference: 1.10: G-UR.4.1., G-UR.4.2., 2.20: S.4.3., S.1.12. (1/1/93 and 1/1/05), UR.3.10.

6.10. WIM Vehicle Scales Test Speeds.

Code Reference: 2.20: N.7.3.

Code Applies to: WIM only.

6.10.1. Range.

Code Reference: 2.20: N.7.3.1.

Code Applies to: WIM only.

6.11. WIM Vehicle Scales Identification of Faults.

Apart from the dynamic tests, the proper response to fault conditions should be verified for the scale under test.

Code Reference: 2.20: S.1.14.1., UR.3.14.

Code Applies to: WIM only.

6.12. WIM Vehicle Scale Information to be Recorded.

Code Reference: 2.20: S.1.14.2.

Code Applies to: WIM only.

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Drive cautiously when maneuvering test vehicles.**
- **Be aware of maneuvering test vehicles when observing dynamic tests.**

7. Test.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

When a specific code requirement is applicable to a certain type of weighing device that kind of device is identified by a single letter designation. The specific "Code Reference:" is immediately followed on the next line by the statement "Code Applies to:" and the appropriate letter designation for each device type. A key to identify the meaning of each device-type letter designation appears at the beginning of each inspection and test section of the EPO.

Key to the letter designation used to identity the type of weighing device(s) the "Code Applies to:" are as follows:

E = Electronic digital scales

WIM = Weigh-in-Motion vehicle scales

SAFETY REMINDER!!!

- **Wear Safety Shoes!**
- **Use Proper Lifting Techniques!**

7.1. Discrimination Test, At or Near Zero Load. If environmental conditions can be controlled, conduct a Discrimination Test at or near zero load.

Code Reference: 2.20: N.1.5. (1/1/86) N.1.5.1.

7.2. Automatic Zero-Tracking Mechanism. Test for proper design of automatic zero-tracking mechanism, if the scale is so equipped. (See EPO 13 - Appendix C. "Test for Motion Detection").

Code Reference: 2.20: S.2.1.3.1.(b) or S.2.1.3.2.(a).

Under normal operating conditions the maximum load that can be "rezeroed" when placed on or removed from the platform all at once, shall be 3.0 scale division for scales manufactured on or after January 1, 1981.

7.2.1. Tare Clearing. Check proper design of tare auto-clear, if scale is so equipped.

Code Reference: 2.20: S.2.3. (1/1/83).

NOTE: On a vehicle scale, this requires a complete weighing transaction that includes the gross weight determination, input of tare, and net weight calculation.

7.2.2. Semi-Automatic Zero-Tracking Mechanism. If scale is equipped with a semi-automatic zero-tracking mechanism, test effectiveness of motion detection. See EPO 13 - Appendix C. "Test for Motion Detection".

Code Reference: 2.20: S.2.1.2.(a).

7.2.3. Zero-Load Balance and Level Condition. Check for maintenance of the zero-load balance and level condition. Establish correct zero-load balance and level conditions prior to beginning the test.

Code Reference: 1.10: G-UR.4.2., 2.20: N.1.9., UR.4.1., UR.4.2.

7.2.4. Increasing-Load and Shift (Section) Test.

Code Reference: 2.20: N.1.1., N.1.3.3.

7.2.4.1. Minimum Shift Test:

Conduct at least one shift test with a minimum test load of 12.5 percent of scale capacity anywhere on the load receiving element using the prescribed test patterns and maximum test loads specified below.

Code Reference: 2.20: N.1.3.3.1.(a).

7.2.4.1.1. Prescribed Test Pattern.

An area of 1.2 meters (4 feet) in length and 3.0 meters (10 feet) in width or the width of the scale platform, whichever is less. When loading the scale for testing, one side of the test pattern shall be loaded to no more than one-half of the concentrated load capacity before loading the other side. An example of a possible test pattern is shown in Figure 1. "Prescribed Shift Test Pattern".

Code Reference: 2.20: N.1.3.3.1.(b).

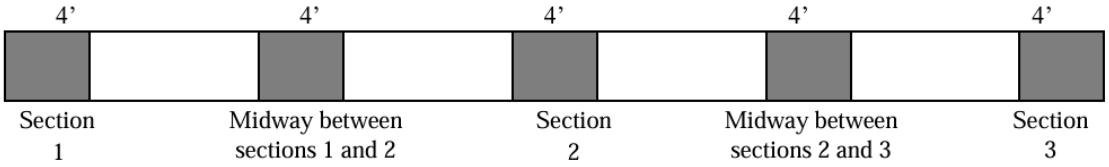


Figure 1. Prescribed Shift Test Pattern

7.2.4.1.2. Loading.

Code Reference: 2.20: N.1.3.3.1.(c).

For test patterns less than 1.2 meters (4 feet) in length:
Determine the maximum loading using the formula:

$$(Wheelbase\ of\ Test\ Cart\ or\ Length\ of\ Test\ Load\ \div 48\ in)\ \times 0.9\ \times CLC$$

For test patterns that exceed 1.2 meters (4 feet):
The maximum test load applied shall not exceed CLC × the largest "r" factor in Table UR.3.2.1. Span Maximum Load for the length of the area covered by the test load.

Test Load:
The maximum test load applied to the prescribed test pattern shall not exceed the concentrated load capacity (or for scales manufactured prior to January 1, 1989, the rated section capacity).

7.2.4.1.3. Multiple Pattern Loading.

To test to the nominal capacity, multiple patterns may be simultaneously loaded in a manner consistent with the method of use.

Code Reference: 2.20: N.1.3.3.1.(d).

7.2.4.1.4. Other Designs.

Special design scales and those that are wider than 3.7 meters (12 feet) shall be tested in a manner consistent with the method of use but following the principles described above in 7.2.4.1.1. through 7.2.4.1.3. in accordance with NIST Handbook Scales Code paragraph N.1.3.3.1. Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales.

Code Reference: 2.20: N.1.3.3.1.(e).

NOTE 1: When testing scales manufactured prior to January 1, 1989, caution should be exercised when loading test weights equivalent to the rated section capacity onto areas between sections.

NOTE 2: When loading the first section to be tested, it is recommended that observations be made at each increment of test weight application.

7.2.4.1.5. Prescribed Test Patterns and Test Loads for Combination Vehicle/Livestock Scales with More Than Two Sections.

Code Reference: 2.20: N.1.3.3.2.

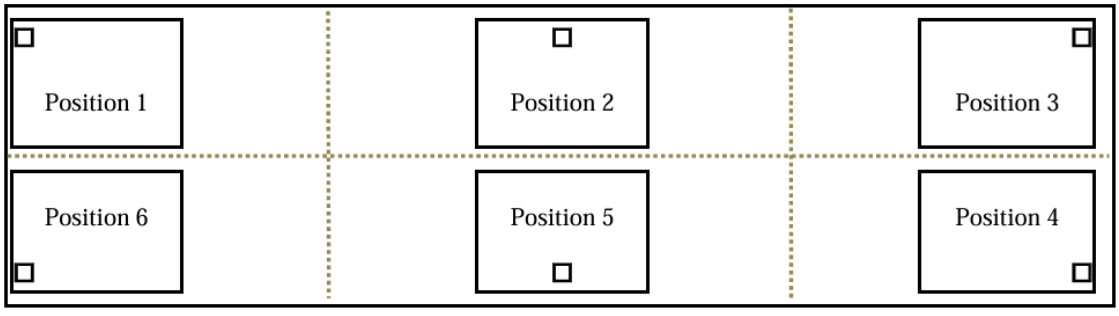


Figure 2. Prescribed Test Patterns for Combination Application Scales with More Than Two Sections

7.2.4.1.6. Prescribed Test Pattern.

A minimum test load of 5 000 kg (10 000 lb) or one-half of the rated section capacity or CLC, whichever is less, shall be placed, as nearly as possible, successively over each main

load support as shown above. Two section livestock scales shall also be tested consistent with N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers.

7.2.5. Decreasing-Load Test. Automatic indicating only, at one-half of maximum test load.

Code Reference: 2.20: N.1.2., N.1.2.2.

7.2.5.1. Zero-Load Balance Change. Remove the test load and verify the zero-load balance does not change by more than the minimum applicable tolerance.

Code Reference: 1.10: G-UR.4.2., 2.20: N.1.9.

7.2.6. Strain-Load or Substitution Test.

7.2.6.1. Strain-Load Tests – Follow the procedures in Appendix B. "Strain-Load and Substitution Load Methods of Testing and Strain-Load Testing Using Error Weights" for EPO 13.

7.2.6.2. Tolerances apply only to the test weights or substitution test load.

7.2.6.3. Test on at least two sections. Position vehicle or some other object, material, etc. of unknown weight on one end of the load-receiving element of the scale. Use error weights to determine the reference point within the displayed division before adding test weights.

7.2.6.4. Substitution Test – Follow the procedures in Appendix B. "Strain-Load and Substitution Load Methods of Testing and Strain-Load Testing Using Error Weights" for EPO 13.

7.2.6.5. Tolerances are applied to the substitution test load.

Code Reference: 2.20: N.1.11., N.1.12., N.3., T.N.3.11., T.N.3.12.

7.2.7. Discrimination Test, Maximum Capacity (Automatic Indicating Scales). If environmental conditions can be controlled, conduct a Discrimination Test at or near maximum capacity.

Code Reference: 2.20: N.1.5. (1/1/86), N.1.5.1.

A test load equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 2.0 d.

Code Reference: 2.20: T.N.7.2.

7.2.8. Radio Frequency Interference (RFI)/Electromagnetic Interference (EMI).

Conduct test at or near capacity when RFI/EMI transmission sources are present or if a problem is suspected.

Code Reference: 1.10: G-N.2., G-UR.1.2., G UR.3.2., G-UR.4.2., 2.20: N.1.6., T.N.9.

NOTE: Procedures developed by the Scale Manufacturers Association (SMA) were adopted during the 1978 63rd National Council on Weights and Measures Annual Meeting as part of the Specifications and Tolerances Committee Final Report on Agenda Item 303-9 Electromagnetic Interference. SMA intended the published procedural document as an educational tool for manufacturers, distributors, inspectors, and customers. The procedures retitled *Scale Manufacturers Association Standard RFI/EMI Field Test Procedures for Electronic Scales* were revised in 2008 and are available on the SMA website at: https//scalemanufacturers.org/uploads/standard_rfiemi_field _test_proceduresfor_electronic_scales_november2008_93a122b86b.pdf.

7.2.9. Over-Capacity Indication. If practical test for over-capacity indication.

Code Reference: 2.20: S.1.7.(a), S.1.7.(b) (1/1/93).

7.2.10. Discrimination Test, Maximum Capacity. Except for Class I or II scales in which e = d and is less than 5 mg, if environmental conditions can be controlled, conduct a Discrimination Test at maximum capacity.

Code Reference: 2.20: N.1.5. (1/1/86), N.1.5.1.

A test load equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 2.0 d.

Code Reference: 2.20: T.N.7.2.

7.2.11. Zero-Load Balance Change. Remove the test load and verify the zero-load balance does not change by more than the minimum applicable tolerance.

Code Reference: 2.20: N.1.9., G-UR.4.2.

7.3. WIM Vehicle Scales Static Tests.

7.3.1. WIM Vehicle Scales Applicable Static Tests.

Scale test procedures defined in NIST HB 44 Scales Code N.1. Test Procedures shall be applied to WIM vehicle scales when tested statically.

Code Reference: 2.20: N.1., N.7.4.

Code Applies to: E and WIM.

7.4. WIM Vehicle Scales Dynamic Tests.

7.4.1. Vehicles.

Code Reference: 2.20: N.7.5.1.

Code Applies to: WIM only.

7.4.2. Weighments.

Code Reference: 2.20: N.7.5.2.

Code Applies to: WIM only.

7.4.3. Vehicle Position.

Code Reference: 2.20: N.7.5.3.

Code Applies to: WIM only.

7.4.4. Travel Directions.

Code Reference: 2.20: N.7.5.4.

Code Applies to: WIM only.

7.4.5. Results.

Code Reference: 2.20: N.7.5.5.

Code Applies to: WIM only.

7.5. WIM Vehicle Scale Fault Indications.

If applicable the WIM vehicle scale shall identify the following fault conditions to the customer and operator:

(a) Vehicle speed was below the minimum or above the maximum speed as specified by the manufacturer.

(b) A change in vehicle speed greater than that specified by the manufacturer was detected.

(c) Vehicle direction of travel was not valid for the installation.

(d) The amount of time all vehicle axles were simultaneously on the scale was below the minimum data acquisition time.

(e) Vehicle path of travel was outside the lateral side edges of the load-receiving element.

Code Reference: 2.20: S.1.14., UR.3.14.

Code Applies to: WIM only.

8. Post-Test Tasks – Electronic Digital Indicating and Weigh-in-Motion Vehicle Scales.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

When a specific code requirement is applicable to a certain type of weighing device that kind of device is identified by a single letter designation. The specific "Code Reference:" is immediately followed on the next line by the statement "Code Applies to:" and the appropriate letter designation for each device type. A key to identify the meaning of each device-type letter designation appears at the beginning of each inspection and test section of the EPO.

Key to the letter designation used to identity the type of weighing device(s) the "Code Applies to:" are as follows:

E = Electronic digital scales
WIM = Weigh-in-Motion vehicle scales

8.1. Security Means.

Adequate provision shall be made for applying a physical security seal and/or providing other approved means of security such as a data change audit trail.

Code Reference: 1.10: G-S.8. (1/1/90), G-S.8.1. (1/1/10), 2.20: S.1.11. (portions Nonretroactive), Table S.1.11. (1/1/95).

For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device, security shall be provided for those parameters as specified in G-S.8.2. Devices and Systems Adjusted Using Removable Digital Storage Devices.

Code Reference: 1.10: G-S.8.2., 2.20: S.1.11.1.

For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified.

Code Reference: 1.10: G-S.8.1. (1/1/10).

A metrologically-significant software change is a sealable event.

Code Reference: 1.10: G-S.9.

8.1.1. Audit Trail Information. If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. Note that on some systems

an electronic copy of the event log may also be available; however, the system must still be able to provide a hard copy. Examine these records for any signs of misuse of adjustments.

Code Reference: 1.10: G-S.8. (1/1/90), 2.20: S.1.11.1., S.1.11.2.(c) (1/1/95), Table S.1.11. (1/1/95).

8.1.2. Security Seal. Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed.

Code Reference: 1.10: G-UR.4.5.

8.2. Review/Analyze Results. After all equipment at a location has been tested, review the results to determine compliance with requirements for equipment maintenance and use of adjustments.

Code Reference: 1.10: G-UR.4.1., G-UR.4.3.

8.3. Record Compliance Action and Explain Results. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

SAFETY REMINDER!!!

- **Secure all test equipment when transporting it to next location.**

Part II – Mechanical-Analog Indicating.

9. Scope.

It is recommended this outline be followed as minimum criteria for examining vehicle and axle-load scales applications. EPO No. 13 is divided into two parts: Part I – Electronic Digital Indicating and Part II – Mechanical-Analog Indicating. Part I applies to vehicle and axle-load scales (load receiving elements) equipped with electronic digital indicators and to weigh-in-motion (WIM) vehicle scales. This portion of the EPO, Part II applies to vehicle and axle-load scales equipped with weighbeams and/or mechanical dials.

10. Inspection.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

10.1. Accessibility and Assistance in Inspecting, Testing, and Sealing.

Device must be readily accessible for purposes of testing. Assistance shall be provided by the firm if needed.

Code Reference: 1.10: G-UR.2.3., G-UR.4.4., 2.20: UR.2.5.

10.2. Zero-Load Balance and Level Condition.

Check the zero-load balance and level conditions as found. If the device is not indicating a zero-balance and/or level condition, the user should be made aware of these requirements and a warning issued if necessary.

Code Reference: 1.10: G-UR.3.1, 2.20: UR.4.1., UR.4.2.

10.2.1. Zero Indication.

10.2.1.1. Zero Indication – General.

- Indicate or record zero-balance condition.
  Code Reference: 2.20: S.1.1.(a).
- Automatic-indicating scale or balance indicator shall indicate or record an out-of-balance condition on both sides of zero.
  Code Reference: 2.20: S.1.1.(b).

10.2.1.2. Zero Load Adjustment. General. - A scale shall be equipped with means by which the zero-load balance may be adjusted. Any loose material used for this purpose shall be enclosed so that it cannot shift in position and alter the balance condition of the scale. Except for an initial zero-setting mechanism, an automatic zero adjustment outside the limits specified in S.2.1.3. Scales Equipped with an Automatic Zero-Tracking Mechanism is prohibited.

Code Reference: 2.20: S.2.1., S.2.1.1.

10.2.2. Level Condition.

Code Reference: 2.20: UR.4.2.

10.3. Selection and Suitability.

10.3.1. Suitability, General.

Code Reference: 1.10: G-UR.1.1., G-UR.1.2., 2.20: UR.1.

10.3.2. Special Designs.

Code Reference: 2.20: UR.3.6.

10.3.3. Adjustable Components.

Code Reference: 2.20: S.1.10.

10.3.4. Design of Weighing Devices, Accuracy Class.

Code Reference: 2.20: S.5.*

10.3.4.1. Designation of Accuracy Class.

Code Reference: 2.20: S.5.1. (1/1/86), UR.1.1.

10.3.4.2. Parameters for Accuracy Class.

Code Reference: 2.20: S.5.2. (1/1/86).

10.3.4.3. Typical Class for Weighing Applications.

Code Reference: 2.20: UR.1.1., Table 7a. and Table 7b.

10.3.5. Recommended Minimum Load.
Code Reference: 2.20: UR.3.1.

10.3.6. Minimum Load on a Vehicle Scale.
Code Reference: 2.20: UR.3.8.

10.3.7. Maximum Load.
Code Reference: 2.20: UR.3.2.

10.3.8. Environment.

10.3.8.1. Suitable for the environment in which it is used.
Code Reference: 1.10: G-UR.1.2.

10.3.8.2. Protection from Environmental Factors.
Code Reference: 2.20: UR.2.3.

10.3.9. Permanence.
Code Reference: 1.10: G-S.3.

10.4. Installation.

10.4.1. In Accordance with Manufacturer's Instructions.
Code Reference: 1.10: G-UR.2.1.

10.4.2. Indicating and Recording Elements.
Code Reference: 1.10: G-UR.2.2.

SAFETY REMINDER!!!

- **Check to be sure the scale supports are adequate to support the scale and test weights equal to the capacity of the scale!**

10.4.3. Foundation, Supports, and Clearance – Soundness of the scale's support structure and clearance of its parts from any impedance.
Code Reference: 2.20: UR.2.1., UR.2.4.

10.4.4. Approaches.
Code Reference: 2.20: UR.2.6.

10.4.4.1. Vehicle Scales.
Code Reference: 2.20: UR.2.6.1.

10.4.4.2. Axle-Load Scales.
Code Reference: 2.20: UR.2.6.2.

10.4.5. Visibility of Identification – Installation to ensure ready visibility of markings.
Code Reference: 1.10: G-UR.2.1.1.

10.4.6. Position of Equipment.
Code Reference: 1.10: G-UR.3.3.

10.5. Use.

10.5.1. Facilitation of Fraud.
Code Reference: 1.10: G-S.2.

10.5.2. Method of Operation.
Code Reference: 1.10: G-UR.3.1.

10.5.3. Special Designs.
Scales designed and marked for special applications shall not be used for other than the intended purpose.
Code Reference: 1.10: G-UR.3.1., 2.20: UR.3.6.

10.5.4. Operation with Associated and Nonassociated Equipment.
Code Reference: 1.10: G-UR.3.2.

10.5.5. Recommended Minimum Load.
Code Reference: 2.20: UR.3.1.

10.5.6. Minimum Load on a Vehicle Scale.
Code Reference: 2.20: UR.3.8.

10.5.7. Maximum Load.
Code Reference: 2.20: UR.3.2.

10.5.8. Single Draft Vehicle Weighing.
Code Reference: 2.20: UR.3.3.

10.5.9. Weighing of Axle Loads and Axle-Group Loads.
Code Reference: 2.20: UR.3.4.

10.6. Maintenance.

10.6.1. Maintenance of Equipment, General.
Code Reference: 1.10: G-UR.4., G-UR.4.1.

10.6.2. Abnormal Performance.
Code Reference: 1.10: G-UR.4.2.

10.6.3. Scale Modification.
Code Reference: 2.20: UR.4.3.

10.6.4. Use of Adjustments.
Code Reference: 1.10: G-UR.4.3.

10.6.5. Check for the presence security seals on any component designed to be sealed.
Code Reference: 1.10: G-UR.4.5.

10.7. Design of Weighing Device.

10.7.1. Designation of Accuracy Class.
Code Reference: 2.20: S.5.1. (1/1/86), UR.1.1.

10.7.2. Parameters for Accuracy Class.
Code Reference: 2.20: S.5.2. (1/1/86).

10.7.3. Multi-Interval and Multiple Range.
Code Reference: 2.20: S.5.3.

Relationship of the minimum load cell verification interval (v_{min}) to the value of the scale interval (e).
Code Reference: 2.20: S.5.4. (1/1/94).

Relationship of the verification scale interval (e) of a weighing/load-receiving element to the value of the scale division (d). Except for dynamic monorail scales and weight classifiers, the value of "e" must be equal to "d" on Class III, III L, and IIII scales.
Code Reference: 2.20: S.1.2.2.2.

10.8. Markings.

10.8.1. Markings – Overview.

10.8.1.1. Identification.
Code Reference: 1.10: G-S.1., G-S.1.2.

10.8.1.2. Size and character; designation and marking of subordinate values.
Code Reference: 1.10: G-S.5.2.3.

10.8.1.3. Values.
Code Reference: 1.10: G-S.5.2.4.

10.8.1.4. Permanence of Markings.
Code Reference: 1.10: G-S.5.2.5.

10.8.1.5. Accuracy Class.
Code Reference: 2.20: S.5.

10.8.1.6. Location.
Code Reference: 2.20: S.6.2.

10.8.1.7. Specific Scales' Code Markings.
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

10.8.1.8. Special Design.
Code Reference: 2.20: Table S.6.3.a. and Table S.6.3.b. (1/1/86), UR.3.6.

Scales designed for special application appropriately marked to restrict its use (e.g., postal scale, prepack scale, weight classifier).

Code Reference: Table S.6.3.b. Note 13 (Nonretroactive 1/1/86).

10.8.2. Marking Requirements – All Devices.

10.8.2.1. General.

Code Reference: 2.20: S.6.

10.8.2.2. Identification.

Code Reference: 1.10: G-S.1.

10.8.2.2.1. Name, Initials, or Trademark of Manufacturer or Distributor.

Code Reference: 1.10: G-S.1.(a) Retroactive.

10.8.2.2.2. Model Identifier.

Code Reference: 1.10: G-S.1.(b) Retroactive.

Model Identifier Prefix and acceptable abbreviation for “Model” and “Number.”

Code Reference: 1.10: G-S.1.(b)(1) (1/1/03).

10.8.2.2.3. Nonrepetitive Serial Number.

Code Reference: 1.10: G-S.1.(c) (1/1/68).

Serial Number Prefix.

Code Reference: 1.10: G-S.1.(c)(1) (1/1/86).

Acceptable abbreviations for “Serial” and “Number.”

Code Reference: 1.10: G-S.1.(c)(2) (1/1/01).

10.8.2.2.4. As of 2004 the current software version or revision identifier for not-built-for-purpose software-based devices and as of 2022 the current software version or revision identifier for all software-based devices.

Code Reference: 1.10: G-S.1.(d) (1/1/04), G-S.1.(d) (1/1/22).

Software Version or Identifier.

Code Reference: 1.10: G-S.1.(d).

(1) Preface identifying it as such.
Code Reference: 1.10: G-S.1.(d)(1)*i*. (1/1/07).

(2) Continuously displayed or accessible via display.
Code Reference: 1.10: G-S.1.(d)(1)*ii*. (1/1/22).

(3) Acceptable abbreviations for “Version,” “Number,” and “Revision."
Code Reference: 1.10: G-S.1.(d)(2) (1/1/07).

10.8.2.2.5. NTEP CC Number for Devices with NTEP CC.

Code Reference: 1.10: G-S.1.(e) (1/1/03).

Preface by the terms “NTEP CC,” “CC,” or “Approval” followed by either the word or an acceptable abbreviation of “number.”

Code Reference: 1.10: G-S.1.(e) (1/1/03).

10.8.2.3. Devices or Main Elements Remanufactured as of January 1, 2002.
Code Reference: 1.10: G-S.1.2. (1/1/02).

Name, initials, or trademark of last remanufacturer or distributor.
Code Reference: 1.10: G-S.1.2.(a) (1/1/02).

Model designation if different from original model designation.
Code Reference: 1.10: G-S.1.2.(b) (1/1/02).

10.8.2.4. Operational Controls, Indications, and Features.
Code Reference: 1.10: G-S.6. (1/1/77).

10.8.2.5. Lettering.
Code Reference: 1.10: G-S.7.

10.8.2.6. Visibility of Identification – installation to ensure ready visibility of markings.
Code Reference: 1.10: G-UR.2.1.1.

10.8.2.7. Interchange or Reversal of Parts.
Code Reference: 1.10: G-S.4.

10.8.3. Marking Requirements – Weighing, load-receiving, and indicating element in same housing or covered on the same CC (in addition to marking requirements for all devices).
Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

10.8.3.1. Accuracy Class.
Code Reference: Table S.6.3.b. Note 17 (Nonretroactive 1/1/86).

10.8.3.2. Nominal Capacity.
Code Reference: Table S.6.3.b. Note 3 Retroactive and Note 18 Retroactive.

Where the value of "e" is equal to the value of "d," the nominal capacity shall be shown together with the value of the scale division "d" or the verification scale interval "e."
Code Reference: 2.20: Table S.6.3.b. Note 3 (Nonretroactive 1/1/83).

For any scale that has no "d", the nominal capacity shall be shown together with the verification scale interval "e."
Code Reference: Table S.6.3.b. Note 4(a) (Nonretroactive 1/1/86).

For any scale where "e" does not equal "d," the nominal capacity shall be shown together with the value of the scale division "d" and the verification scale interval "e."
Code Reference: 2.20: Table S.6.3.b. Note 4(b) (Nonretroactive 1/1/86).

10.8.3.3. Temperature Limits.
Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).
Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

10.8.4. Marking Requirements – Indicating element not permanently attached or covered on separate CC (in addition to marking for all devices).

Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

10.8.4.1. Accuracy Class.

Code Reference: 2.20: Table S.6.3.b. Note 8 (Nonretroactive 1/1/88).

10.8.4.2. Nominal Capacity.

Code Reference: 2.20: Table S.6.3.b. Note 3 Retroactive and Note 18 Retroactive.

Where the value of "e" is equal to the value of "d," the nominal capacity shall be shown together with the value of the scale division "d" or the verification scale interval "e."

Code Reference: 2.20: Table S.6.3.b. Note 3 (Nonretroactive 1/1/83).

For any scale that has no "d," the nominal capacity shall be shown together with the verification scale interval "e."

Code Reference: 2.20: Table S.6.3.b. Note 4(a) (Nonretroactive 1/1/86).

For any scale where "e" does not equal "d," the nominal capacity shall be shown together with the value of the scale division "d" and the verification scale interval "e."

Code Reference: 2.20: Table S.6.3.b. Note 4(b) (Nonretroactive 1/1/86).

10.8.4.3. Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).

Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

10.8.4.4. Maximum Number of Verification Scale Intervals (n_{max}).

Code Reference: 2.20: Table S.6.3.b. Note 6 (Nonretroactive 1/1/88).

10.8.5. Marking Requirements – Weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices).

Code Reference: 2.20: S.6.3., Table S.6.3.a. and Table S.6.3.b.

10.8.5.1. Accuracy Class.

Code Reference: 2.20: Table S.6.3.b. Note 19 (Nonretroactive 1/1/88).

10.8.5.2. Nominal Capacity.

Code Reference: 2.20: Table S.6.3.b. Note 3 Retroactive and Note 18 Retroactive.

10.8.5.3. Temperature limits if narrower than and within – 10 °C to 40 °C (14 °F to 104 °F).

Code Reference: 2.20: Table S.6.3.b. Note 5 (Nonretroactive 1/1/86).

10.8.5.4. Maximum Number of Verification Scale Intervals (n_{max}).

Code Reference: 2.20: Table S.6.3.b. Note 19 (Nonretroactive 1/1/88).

10.8.5.5. Minimum verification scale division for which device complies with the requirements (e_{min} or d).

Code Reference: 2.20: Table S.6.3.b. Note 19 (Nonretroactive 1/1/88).

10.9. Indicating and Recording Elements.

10.9.1. Appropriateness of Design.

10.9.1.1. Accuracy Class.
Code Reference: 2.20: S.5.

10.9.1.2. Indicating and Recording Elements, General Design.
Code Reference: 1.10: G-S.5.1.

10.9.1.3. Capacity Indication, Weight Ranges, and Unit Weights.
Code Reference: 2.20: S.1.7.

10.9.1.4. Recommended Minimum Load.
Code Reference: 2.20: UR.3.1.

10.9.1.5. Maximum Load.
Code Reference: 2.20: UR.3.2.

10.9.2. Value of Scale Division and/or Interval.

10.9.2.1. Value – General.
Code Reference: 1.10: G-S.5.3., G-S.5.3.1., 2.20: UR.1.1.(b).

10.9.2.2. Value of Scale Units.
Code Reference: 2.20: S.1.2.* (1/1/86).

10.9.2.3. Except for dynamic monorail scales and weight classifiers, the value of "e" must be equal to "d" on Class III, III L, and IIII scales.
Code Reference: 2.20: S.1.2.2.2.*

10.9.2.4. Recorded scale division shall be the same as the value of indicated division, except for Class I scales.
Code Reference: 2.20: UR.1.3. (1/1/86), UR.1.3.1.(a).

10.9.2.5. Multi-Interval and Multiple-Range Scales.
Code Reference: 2.20: S.5.3.

10.9.3. Graduations.
Code Reference: 2.20: S.1.3.

10.9.4. Indicators.
Code Reference: 2.20: S.1.4.

10.9.5. Value of Tare Division.
Code Reference: 2.20: S.2.3. (1/1/83).

10.9.6. Tare Mechanism.
Code Reference: 2.20: S.2.3.

10.9.7. Repeatability.
Code Reference: 1.10: G-S.5.4.

10.9.8. Recorded Representations.

10.9.8.1. Recorded Representations, General.
Code Reference: 1.10: G-S.5.6., 2.20: UR.1.3. (1/1/86).

10.9.8.2. Indicated and Recorded Representation, Abbreviations of Units.
Code Reference: 1.10: G-S.5.6.1.

- Equipment manufactured on or after January 1, 2008.
  Code Reference: 1.10: G-S.5.6.1.(a).
- Equipment manufactured prior to January 1, 2008.
  Code Reference: 1.10: G-S.5.6.1.(b).

10.9.9. Damping Means.
Code Reference: 2.20: S.2.5.

10.9.10. Adjustable Components.
Code Reference: 2.20: S.1.10.

10.10. Weighing Elements.

10.10.1. Antifriction Means.
Code Reference: 2.20: S.4.1.

10.10.2. Adjustable Components.
Code Reference: 2.20: S.1.10., S.4.2.

10.10.3. Multiple Load-Receiving Elements.
Code Reference: 2.20: S.4.3.

10.11. Provision for Sealing. The Provision for Sealing requirements outlined below are provided in entirety to include the full scope of requirements applicable to sealable parameters for vehicle and axle-load scale applications.

10.11.1. Sealing, General.
A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism.
Code Reference: 1.10: G-S.8. (1/1/90).

A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.
Code Reference: 1.10: G-S.8., 2.20: S.1.11.2.

Except for devices and systems adjusted using a removable digital storage device and Class I scales, the following provisions for sealing apply:

Code Reference: 2.20: S.1.11.2.

Provision shall be made for applying a security seal in a manner that requires the security seal to be broken before an adjustment can be made to any component affecting the performance of an electronic device.

Code Reference: 2.20: S.1.11.2.(a) (1/1/79).

A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism.

Code Reference: 2.20: S.1.11.2.(b) (1/1/90).

A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.

Code Reference: 2.20: S.1.11.2.

Audit trails shall use the format set forth in Table S.1.11. Categories of Device and Methods of Sealing.

Code Reference: 2.20: S.1.11.2 (c) (1/1/95), Table S.1.11. (1/1/95).

10.11.2. A metrologically-significant software change is a sealable event.

Code Reference: 1.10: G-S.9.

10.11.3. Physical Means of Security.

10.11.3.1. Security Seals. Check for the presence of security seals on the device. A security seal shall be affixed to any adjustment mechanism designed to be sealed. Document missing seals on the official report and apply new ones as needed.

Code Reference: 1.10: G-UR.4.5.

10.11.3.2. Accessibility to Security Seals. When applicable, the adjusting mechanism shall be readily accessible for the purpose of affixing a security seal. The device shall be installed or located such that access is provided to permit inspecting and applying security seals.

Code Reference: 1.10: G-UR.2.3.

10.11.4. Parameters Accessed Via Removable Digital Storage.

For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device**, such as a secure digital (SD) card, USB flash drive, etc., security shall be provided for those parameters using either:

(1) an event logger in the device; or

(2) a physical seal that must be broken in order to remove the digital storage device from the device (or system).

** This applies only to removable digital storage devices that must remain in the device or system for it to be operational.

Code Reference: 1.10: G-S.8.2., 2.20: S.1.11., Table S.1.11. (1/1/95).

10.11.5. Sealable Automatic Zero-Tracking Mechanism on Class III L Devices.

Code Reference: 2.20: S.2.1.3.3. (1/1/01).

10.11.6. Audit Trails, General.

10.11.6.1. Audit Trail Information. If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. Note that on some systems an electronic copy of the event log may also be available; however, the system must still be able to provide a hard copy. Examine these records for any signs of misuse of adjustments.

Code Reference: 1.10: G-S.8. (1/1/90), 2.20: S.1.11.1., S.1.11.2.(c) (1/1/95), Table S.1.11. (1/1/95).

10.11.6.2. Single Provision for Sealing Multiple Elements. For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified.

Code Reference: 1.10: G-S.8.1. (1/1/10).

10.11.7. Event Logger.

If security is provided using an event logger, the event logger shall include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter.

The event logger information must be available on demand through the device or through another on-site device at the time of inspection.

In addition to providing a printed copy of the information, the information may be made available electronically.

The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1000 records are required. (Note: Does not require 1000 changes to be stored for each parameter.)

Code Reference: 1.10: G-S.8. (1/1/90), 2.20: S.1.11., Table S.1.11. (1/1/95).

11. Pretest Determinations.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

11.1. Tolerances – General.

11.1.1. Acceptance/Maintenance Tolerances.

Code Reference: 1.10: G-T.1., G-T.2.

11.1.2. Application.

Code Reference: 1.10: G-T.3., 2.20: T.N.2.1., T.N.2.3., T.N.2.4.

11.1.3. Intermediate Values.

Code Reference: 1.10: G-T.4.

11.2. Tolerance Values.

11.2.1. Determine the Number of Verification Scale Intervals (n).

Using the following formula determine the number of verification scale intervals (n):

$$n = \frac{Scale\ Capacity}{Value\ of\ the\ Verification\ Scale\ Interval\ (e)}$$

11.2.2. Tolerance Associated with the Standard.

11.2.2.1. Tolerance on Tests When Type 2 Transfer Standards Are Used.

Code Reference: 1.10: G-T.5.

When Type 2 transfer standards are used to conduct accuracy tests, adjust the tolerances as described in General Code paragraph G-T.5. Tolerances on Tests When Type 2 Transfer Standards Are Used.

11.2.3. Unmarked Scales – Tolerance Values.

Note: Many NIST Handbook (HB) 44 Scales Code "T.N." tolerances apply to unmarked vehicle scales. See NIST HB 44 Table T.1.1. Tolerances for Unmarked Scales for a list of "T.N." paragraphs applicable to unmarked scales.

11.2.3.1. Unmarked Scales – All.

Code Reference: 2.20: T.1.1., Table T.1.1.

- Multiple Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.1.
- Single Indicating or Recording elements.
  Code Reference: 2.20: T.N.4.2.
- Single Indicating Element, Multiple Indications.
  Code Reference: 2.20: T.N.4.3.
- Repeatability.
  Code Reference: 2.20: T.N.5.
- Discrimination.
  Code Reference: 2.20: T.N.7.2.
- Operating Temperature.
  Code Reference: 2.20: T.N.8.1.4. (Nonretroactive 1/1/81).
- Radio Frequency Interference and other interferences.
  Code Reference: 2.20: T.N.9.

11.2.3.2. Unmarked Vehicle, Axle-Load, Livestock, Railway Track (Weighing Statically), Crane, and Hopper (Other than Grain Hopper) Scales.

Code Reference: 2.20: T.1.1.

- Tolerance Application.
  Code Reference: 2.20: T.N.2.
- General Tolerances.
  Code Reference: 2.20: T.N.2.1.
- Subsequent Verification Examinations.
  Code Reference: 2.20: T.N.2.3.
- Multiple-Range and Multi-Interval Scales.
  Code Reference: 2.20: T.N.2.4.
- Ratio Tests (scales equipped with commercial weights).
  Code Reference: 2.20: T.N.2.5.
- Tolerance Values.
  Code Reference: 2.20: T.N.3., T.N.3.1. Table 6, T.N.3.2.

11.2.4. Marked Scales – Tolerance Values.

11.2.4.1. Scales Marked with an Accuracy Class Designation, Design.

Code Reference: 2.20: T.N.1.1.

- Accuracy Classes.
  Code Reference: 2.20: T.N.1.2.
- Verification Scale Interval.
  Code Reference: 2.20: T.N.1.3.
- General Tolerances.
  Code Reference: 2.20: T.N.2.1.
- Subsequent Verification Examinations.
  Code Reference: 2.20: T.N.2.3.
- Multiple-Range and Multi-Interval Scales.
  Code Reference: 2.20: T.N.2.4.
- Ratio Tests (scales equipped with commercial weights).
  Code Reference: 2.20: T.N.2.5.
- Maintenance Tolerance Values.
  Code Reference: 2.20: T.N.3.1. [Table 6].
- Acceptance Tolerance Values.
  Code Reference: 2.20: T.N.3.2.
- Multiple Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.1.
- Single Indicating or Recording Elements.
  Code Reference: 2.20: T.N.4.2.
- Single Indicating Element, Multiple Indications.
  Code Reference: 2.20: T.N.4.3.

- Shift or Section Test (Agreement of Indications).
  Code Reference: 2.20: T.N.4.4.
- Repeatability.
  Code Reference: 2.20: T.N.5.
- Discrimination.
  Code Reference: 2.20: T.N.7.2.
- Operating Temperature.
  Code Reference: 2.20: T.N.8.1.4.
- Radio Frequency Interference and other interferences.
  Code Reference: 2.20: T.N.9.

11.3. Accuracy of Field Standards.
Code Reference: 2.20: N.2.

11.4. Minimum Test Weights and Test Loads.
Code Reference: 2.20: N.3., Table 4.

11.5. Maximum Test Load.
Determine the maximum test load to be applied during test: a test load not to exceed marked Concentrated Load Capacity (or for scales manufactured prior to January 1, 1989, the marked Section Capacity) may be applied to any section or between any two sections. A test load of 100 percent of capacity may be distributed over the entire platform.
Code Reference: 2.20: N.1.3.3.1., UR.3.2.

SAFETY REMINDER!!!

- **Carefully inspect electrical supply lines, cables, chains, hydraulic lines, etc., on test equipment for wear or damage (e.g., electric weight carts, lifting equipment, etc.)!**
- **Protect test equipment cables, power cables, hydraulic lines, etc., from damage during use!**
- **Correct potentially hazardous conditions before use (e.g., obstacles, water, or other slippery conditions)!**

12. Test Notes.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as safety shoes to prevent possible injury from falling weights and slipping on slick surfaces and a hard hat to prevent injury from overhead hazards!**

12.1. Test Methods. Permissible test methods for verifying compliance of commercial weighing and measuring systems with the provisions of NIST Handbook (HB) 44 include, but are not limited to, test methods and apparatus that have been approved by the Director as outlined in HB 44 Appendix A – Fundamental Considerations.

Code Reference: 1.10: G-N.3., Appendix A – Fundamental Considerations.

12.2. Zero-Load Balance and Level Condition. Check for maintenance of the zero-load balance and level condition. Establish a correct zero-load balance and level condition prior to beginning the test.

Code Reference: 2.20: UR.4.1., UR.4.2.

12.3. Repeatability. Check repeatability of indications throughout the test.

12.3.1. Repeatability of Indications.

Code Reference: 1.10: G-S.5.4., 2.20: T.N.5.

12.4. Agreement of Indications. Check for agreement of indications throughout the test.

Code Reference: 1.10: G-S.5.2.2., 2.20: T.N.4.

12.4.1. Multiple Digital Indications and Representations.

Code Reference: 2.20: T.N.4.1.

12.4.2. Single Indicating/Recording Element with Component Parts.

Code Reference: 2.20: T.N.4.2.

12.4.3. Single Indicating Element, Multiple Indications.

Code Reference: 2.20: T.N.4.3.

12.5. Return to Zero-Load Balance. Recheck the zero-load balance each time the test load is removed.

12.5.1. Zero-Load Balance Change.

Code Reference: 2.20: N.1.9.

12.5.2. Abnormal Performance.

Code Reference: 1.10: G-UR.4.2.

12.6. Recorded Representations.

12.6.1. Availability of Recorded Representation.

Verify that any options available for obtaining a recorded representation are appropriate. For systems specifically required by a section of the Scales Code to issue a recorded representation, the recorded representation shall be made available to the customer in hard copy form unless otherwise specified by the customer. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability of issuing an electronic receipt, the customer may also be given the option of receiving the recorded representation electronically (e.g., via cell phone, computer, etc.) in lieu of or in addition to a hard copy.

Code Reference: 1.10: G-S.5.6.

12.7. Steps After Each Test Load – Recorded Representations. If the scale is equipped with a printer, print a ticket or label at each test load. Verify the following:

12.7.1. Indication and Representations, Agreement and Display. Check that any recorded representations agree with their associated corresponding values that are displayed and are appropriately displayed.

Code Reference: 1.10: G-S.5.2.2., G-S.5.6.

12.7.2. Value of the Indicated and Recorded Scale Division. Verify that the value of the scale division as recorded on the recorded representation is the same as the division value indicated.

Code Reference: 2.20: UR.1.3. (1/1/86).

13. Test for Mechanical Scales.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY REMINDER!!!

- **Wear Safety Shoes!**
- **Use Proper Lifting Techniques!**

13.1. Sensitivity Test At Zero Load. Conduct the Sensitivity Test at zero load for weighbeams and balance indicators only.

Code Reference: 2.20: N.1.4., T.2., T.2.1., T.2.7., T.N.6.*

13.2. Zero-Load Balance and Level Condition. Check for maintenance of the zero-load balance and level condition. Establish correct zero-load balance and level conditions prior to beginning the test.

Code Reference: 1.10: G-UR.4.2., 2.20: N.1.9., UR.4.1., UR.4.2.

13.3. Discrimination Test, At or Near Zero Load (Automatic Indicating Scales). Dials and balance indicators with graduations having a specific value only) if environmental conditions can be controlled, conduct a Discrimination Test at or near zero load.

Code Reference: 2.20: N.1.5. (1/1/86).

A test loads equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 1.0 d.

Code Reference: 2.20: T.N.7.1.

13.4. Increasing-Load and Shift (Section) Test.

Code Reference: 2.20: N.1.1., N.1.3.

13.4.1. Beam and Dial Scales.

- If beam scale, test at not less than two points on each weighbeam.
- If automatic indicating scale, test at not less than three points on reading face, including all possible quarters of the reading-face capacity. Test all unit weights possible.

13.4.2. Minimum Shift Test:

- Conduct at least one shift test with a minimum test load of 12.5 percent of scale capacity anywhere on the load receiving element using the prescribed test patterns and maximum test loads specified below.

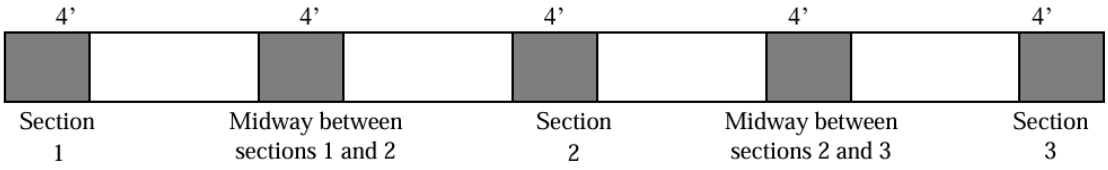
  Code Reference: 2.20: N.1.3.3.1.(a).

13.4.3. Shift Test.

13.4.3.1. Prescribed Test Pattern.

An area of 1.2 meters (4 feet) in length and 3.0 meters (10 feet) in width or the width of the scale platform, whichever is less. When loading the scale for testing, one side of the test pattern shall be loaded to no more than one-half of the concentrated load capacity before loading the other side. An example of a possible test pattern is shown in the following diagram (Figure 1 from 7.2.4.1.1. Prescribed Shift Test Pattern).

Code Reference: 2.20: N.1.3.3.1.(b).



13.4.3.2. Loading.

Code Reference: 2.20: N.1.3.3.1.(c).

For test patterns less than 1.2 meters (4 feet) in length:

Determine the maximum loading using the formula:

$$(Wheelbase\ of\ Test\ Cart\ or\ Length\ of\ Test\ Load\ \div 48\ in)\ \times 0.9\ \times CLC$$

For test patterns that exceed 1.2 meters (4 feet):
The maximum test load applied shall not exceed CLC × the largest "r" factor in Table UR.3.2.1. Span Maximum Load for the length of the area covered by the test load.

Test Load:
The maximum test load applied to the prescribed test pattern shall not exceed the concentrated load capacity (or for scales manufactured prior to January 1, 1989, the rated section capacity).

13.4.3.3. Multiple Pattern Loading.

To test to the nominal capacity, multiple patterns may be simultaneously loaded in a manner consistent with the method of use.

Code Reference: 2.20: N.1.3.3.1.(d).

13.4.3.4. Other Designs.

Special design scales and those that are wider than 3.7 meters (12 feet) shall be tested in a manner consistent with the method of use but following the principles described above in 13.1.4.3.1. through 13.1.4.3.3. in accordance with NIST Handbook Scales Code paragraph N.1.3.3.1. Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales.

Code Reference: 2.20: N.1.3.3.1.(e).

NOTE 1: When testing scales manufactured prior to January 1, 1989, caution should be exercised when loading test weights equivalent to the rated section capacity onto areas between sections.

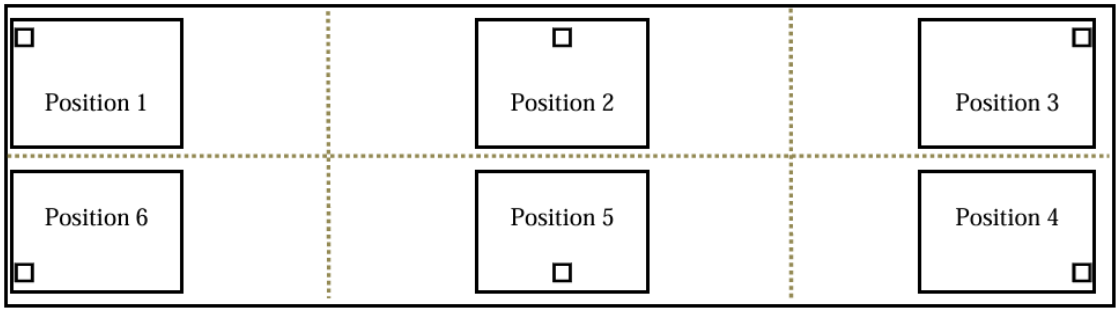
NOTE 2: When loading the first section to be tested, it is recommended that observations be made at each increment of test weight application.

13.4.4. Prescribed Test Patterns and Test Loads for Combination Vehicle/Livestock Scales with More Than Two Sections.

Code Reference: 2.20: N.1.3.3.2.

13.4.4.1. Prescribed Test Pattern.

A minimum test load of 5 000 kg (10 000 lb) or one-half of the rated section capacity or CLC, whichever is less, shall be placed, as nearly as possible, successively over each main load support as shown below (Figure 2 from 7.2.4.1.5. Prescribed Test Pattern for Combination Application Scales with More Than Two Sections). Two section livestock scales shall also be tested consistent with N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers.



□ = Load Bearing Point

13.5. Decreasing-Load Test. Automatic indicating only, at one-half of maximum test load. For dials, test at no less than one-half dial face capacity.

Code Reference: 2.20: N.1.2., N.1.2.2.

13.6. Strain Load Increasing-Load and Shift (Section) Test.

Strain-Load Tests – Follow the procedures in Appendix B. "Strain-Load and Substitution Load Methods of Testing and Strain-Load Testing Using Error Weights" for EPO 13. Tolerances apply only to the test weights or substitution test load.

Substitution Test – Follow the procedures in Appendix B. "Strain-Load and Substitution Load Methods of Testing and Strain-Load Testing Using Error Weights" for EPO 13. Tolerances are applied to the substitution test load.

Code Reference: 2.20: N.1.11., N.1.12., N.3., T.N.3.11., T.N.3.12.

13.7. Sensitivity Test At Maximum Load. Conduct the Sensitivity Test at maximum test load for weighbeams and balance indicators only.

Code Reference: 2.20: N.1.4., T.2., T.2.1., T.2.7, T.N.6.*

13.8. Discrimination Test, Maximum Capacity (Automatic Indicating Scales). Dials and balance indicators with graduations having a specific value only if environmental conditions can be controlled, conduct a Discrimination Test at or near maximum capacity.

Code Reference: 2.20: N.1.5. (1/1/86).

A test load equivalent to 1.4 d shall cause a change in the indicated or recorded value of at least 1.0 d.

Code Reference: 2.20: T.N.7.1.

13.9. Zero-Load Balance Change. Remove the test load and verify the zero-load balance does not change by more than the minimum applicable tolerance.

Code Reference: 1.10: G-UR.4.2., 2.20: N.1.9.

13.10. Remove error weights and establish correct zero-load balance.

14. Post-Test Tasks for Mechanical Scales.

NOTE: Code references used throughout the document are drawn from NIST Handbook (HB) 44 General Code (Section 1.10) and Scales Code (Section 2.20). The relevant code section(s) is cited by its numerical designation and the applicable requirement(s) from that code section is identified by letter-number designation only. The code section and paragraph designation(s) are then shown immediately after the corresponding line item or task listed in the procedure. For example, NIST HB 44 General Code (Section 1.10) is designated as "1.10:" followed by the paragraph designation(s) relevant to the line item. Nonretroactive requirements are followed by the applicable date in parentheses.

14.1. Security Means.

Adequate provision shall be made for applying a physical security seal and/or providing other approved means of security such as a data change audit trail.

Code Reference: 1.10: G-S.8. (1/1/90), G-S.8.1. (1/1/10), 2.20: S.1.11. (portions Nonretroactive), Table S.1.11. (1/1/95).

For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified.

Code Reference: 1.10: G-S.8.1. (1/1/10).

14.1.1. Security Seal. Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed.

Code Reference: 1.10: G-UR.4.5.

14.2. Review/Analyze Results. After all equipment at a location has been tested, review the results to determine compliance with requirements for equipment maintenance and use of adjustments.

Code Reference: 1.10: G-UR.4.1., G-UR.4.3.

14.3. Record Compliance Action and Explain Results. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

SAFETY REMINDER!!!

- **Secure all test equipment when transporting it to next location.**

Appendix A. Maximum Values of the Scale Load Cell(s)

Establish the maximum permissible value for each load cell in vehicle and axle-load scales equipped with multiple load cells. In accordance with NIST Handbook 44 Scales Code paragraph S.5.4. Relationship of Minimum Load Cell Verification Interval Value to the Verification Scale Interval - The relationship of the value for the minimum load cell verification scale interval, v_{min}, to the verification scale interval, e, for a scale using National Type Evaluation Program (NTEP) certified load cells shall comply with the following formulae (in the case of 1. electronic scales without lever systems and 2. for scales with lever systems); where N is the number of load cells in a single independent (not attached to adjacent elements and with its own A/D conversion circuitry and displayed weight) weighing/load-receiving element:

A.1. Full Electronic Scales.

For a full electronic scale the value of the minimum load cell verification interval, v_{min}, for the load cells must be less than or equal to the value of the verification scale interval, e, divided by the square root of the number of load cells, N, used in the scale as shown in the relationship in the formula:

$$V_{min} \leq \frac{e}{\sqrt{N}}$$

Example: For a vehicle scale with four sections (eight load cells) and a verification scale interval of 20 lb, the maximum value permitted for each load cell is 7.1 lb. The equation used to determine the maximum value for each load cell is shown below. If the value marked on the load cell is less than or equal to the value computed for the v_{min}, then the load cell is considered to comply with T.N.8.1.3. Temperature Effect on Zero-Load Balance.

$$V_{min} \leq \frac{20\ lb}{\sqrt{8}} \leq \frac{20\ lb}{2.83} \leq 7.07\ lb\ rounded\ to\ 7.1\ lb$$

Number of Load Cells	Verification Scale Interval (lb)						
	1	2	5	10	20	50	100
	Minimum v_{min} rating for each cell (lb)						
2	0.71	1.41	3.54	7.07	14.1	35	70
4	0.50	1.00	2.50	5.00	10.0	25	50
6	0.41	0.82	2.04	4.08	8.2	20.4	41
8	0.35	0.71	1.77	3.54	7.1	17.7	35
10	0.32	0.63	1.58	3.16	6.3	15.8	32
12	0.29	0.58	1.44	2.89	5.8	14.4	29
14	0.27	0.53	1.34	2.67	5.4	13.4	27

A.2. Mechanical Scales with Single Load Cell.

Example: Calculate the multiple of the lever system from the ratios marked on the levers. Suppose the multiple for a vehicle scale is 400:1 and that the scale has a verification scale interval (e) of 20 lb. Then the maximum value for the v_{min} of the load cell is 0.05 lb. The equation used in calculating the maximum value for v_{min} is shown below. If the load cell is marked with a v_{min} less than or equal to the calculated value, then the load cell is considered to comply with T.N.8.1.3.

$$V_{min} \leq \frac{e}{\sqrt{N} \times (Scale\ Multiple)}$$

$$V_{min} \leq \frac{20\ lb}{\sqrt{1} \times (400)} \leq \frac{20\ lb}{400} \leq 0.05\ lb$$

Appendix B. Strain-Load and Substitution Load Methods of Testing and Strain-Load Testing Using Error Weights

B.1. When the Test-Weight Load Is Inadequate.

During the test of a large-capacity scale where the total amount of test weights available is less than the "used" or maximum capacity of the scale under test, it is necessary for the inspector to resort to a substitution method of test (which may be referred to as a “build-up” or “step” test), or to the use of from one to several “strain” loads in addition to the available load of test weights. The substitution test is generally the preferred method when carefully carried out but will typically consume a considerably greater amount of time than the strain-load test method.

B.2. Tolerance Application to the Substitution Method and Strain-Load Tests.

There is an important difference between the substitution method and the strain-load method in the manner of applying the tolerances. In the substitution method, the entire load on the load-receiving element of the scale at the time of making any test observation is regarded as known load, and any observed error is an error on the total load on the scale. In the strain-load test method, observed errors are errors on the test-weight load only, since before each application of the test-weight load the strain load of unknown value has been balanced out; accordingly, the tolerances to be applied are to be selected according to the value of the test-weight load in each instance of an accuracy observation under the strain-load test method.

B.3. Substitution Method of Testing.

The principle of the substitution method of testing is the successive substitution for the test-weight load using a load of any available material, whereby a total known load of any number of times the value of the available test weights is gradually built up, resulting from the scale under examination being utilized for the determination of each substituted load. For example, assume a 40 000-pound vehicle scale must be tested with only 10 000 pounds of test weights. The test would be performed in the ordinary manner up to the point where the distributed load on the platform is 10 000-pounds – all of the available test weights. By means of small weights and/or the movement of a poise, if necessary, the scale would then be brought to a readily reproducible condition of balance, such as the exact coincidence between the indicator and some graduation, or a weighbeam that just fails to “bump” when released. Then the 10 000 pounds of test weights would be removed, great care being exercised not to disturb the scale mechanism in any way that would affect the balance condition, and any material available would be carefully added to the platform until the former condition of balance had been reproduced; assuming the scale under test to be capable of repeating its indications, it is apparent that there would now have been added to the platform just 10 000 pounds of material within that degree of accuracy determined by the ability of the scale to duplicate the original balance condition. In other words, there would now be available a 20 000-pound known load consisting of 10 000 pounds of test weights and 10 000 pounds of other material. If now any poise that had been moved were restored to its original position and any small weights that may have been utilized in establishing the reproducible balance condition were to be removed, the scale would be in just the same condition as though the test had just been started with 20 000 pounds of test weights and had proceeded to the point where 10 000 pounds of that amount had been used.

The test would then proceed as before until the platform load reached 20 000 pounds, when another substitution would be made in the same manner as has been outlined. [No more than three substitutions shall be used during substitution testing, after which the tolerances for strain load tests shall be applied to each set of tests (In accordance with NIST Handbook 44 Scales Code Table 4 Minimum Test Weights and Test Loads Footnote 2).

It may well be repeated that in making these substitutions the greatest care must be exercised each time weights are removed and material is added, to avoid disturbing the scale mechanism in any way that would affect the balance condition; similar care must likewise be used in establishing and duplicating the balance condition on which the substitution depends for its accuracy. Some error is inevitable at each substitution, and unless this error is held down to a minimum, the accumulated error after several substitutions may reach serious proportions.

Another caution that must be observed during a substitution test is never to change the adjustment of the regular balancing means of the scale during the progress of the test. When a temporary balancing operation is made necessary in order to establish a reproducible balance condition prior to removal of the test-weight load, the inspector must always restore the original conditions that prevailed when the scale was originally balanced at zero after the substitution is completed and before proceeding with the test; this cannot be done with precision if the adjustment of the regular balancing means has been changed, hence the instruction that these temporary balancing operations be performed by means of poise movement or weights added to platform or counterpoise hanger. When a full-capacity beam scale has an error of overregistration and is equipped with a notched fractional bar, it may be necessary to accomplish this temporary balancing by setting the fractional poise out one or more notches until the beam is balanced low, and then adding enough small weights to the platform to produce the desired balance; when an automatic-indicating scale has a similar error, enough small weights may be added to the platform to bring the indicator into coincidence with the next forward graduation so that a precise reading can be made.

B.4. Strain-Load Method of Testing.

This following summary of the procedure for use in the strain-load method for testing scales was excerpted from an August 2004 technical newsletter article A 009 *The Importance of Using Error Weights in Strain-Load Testing* available on the NIST OWM Newsletter Quarterly Archive at: www.nist.gov/pml/wmd/pubs/upload/A-009.pdf (or www.nist.gov/pml/wmd/pubs/newsletter-archives.cfm).

During the performance of a strain-load test of a scale, an unknown quantity of material or objects is applied to the load-receiving element of a scale to establish a reference load to which test weights are then added. The strain-load test is used to determine the accuracy of a portion of the total weighing range of a scale. Field personnel frequently utilize strain-load tests when testing large capacity scales so that accuracy can be verified in the weighing ranges where many of these scales are typically used. Strain-load tests are also frequently utilized when the amount of test weight available for testing is less than the minimum test loads required under Table 4 Minimum Test Weights and Test Loads of the Scales Code in NIST Handbook 44.

To properly perform a strain-load test, error weights should be used to determine a reference point for the unknown load prior to adding the test weights to complete the test. Failure to determine a specific reference point using error weights can cause unacceptable errors in the performance results of this particular test. NIST Office of Weights and Measures frequently receives inquiries regarding the use of error weights in testing scales. The paragraphs below describe procedures for conducting strain-load tests, including procedures for determining necessary reference points, on scales having digital and beam indications.

B.4.1. Using Error Weights When Testing a Digital Scale.

To perform the strain-load test on a scale having digital indications, error weights are used to establish, as a reference point, the center of the displayed division representing the unknown load. Once the center of the displayed division has been established, test weights can then be added and scale errors determined by direct reading of the indication.

The procedure for conducting a strain-load test on a scale having digital indications is as follows:

1. Apply 10 error weights, each having a value of 0.1 d, to the platform and zero the scale.
2. Apply the unknown load. Record the displayed value and identify it as the weight of the unknown load.
3. Remove error weights from the platform in 0.1 d increments until the indication just begins flashing to the next lower division.
4. In a separate location on the platform repeat the procedure with a second group of error weights by adding back all of the error weights that were just removed in the previous step.
5. Continue adding additional error weights to this second group in 0.1 d increments until the displayed indication just begins flashing to the next higher division.
6. Total the error weight in the second group and remove one-half of it from the platform. Doing so places the indication at the proper reference, i.e., in the center of the displayed division and properly establishes your reference point for the strain-load test.
7. Apply known test weights in predetermined increments or all at one time.
8. Add the weight of the unknown load (determined in step 2) to the value of the known test weights applied.
9. Scale error is determined by subtracting the summed value from step 8 from the displayed indication.

After performance results have been determined and recorded for all of the test weights, return weights equal to one division to the scale platform, remove the known test weights and the unknown load, and verify that the scale returns to zero.

B.4.2. Using Error Weights When Testing a Beam Scale.

During normal use of a beam scale, loads are weighed by balancing the weighbeam to within the smallest graduation employed on any of the weighbars. However, balancing a beam to within the smallest graduation on a weighbar seldom causes a true balance condition. Instead, scale users are normally placed in the position having to choosing the poise settings that most correctly balance a beam. Oftentimes, one setting will cause the beam to rise beyond true balance while the next higher setting will cause the beam to remain below true balance. When strain-load testing a scale having a beam indication, the beam must be precisely balanced with the unknown load applied to the platform before the test weights are added to complete the test. Error weights are used in conjunction with poise settings to precisely balance the weighbeam with the unknown load applied. Proper balancing of the beam using error weights establishes the needed reference for completing this test. The procedure for conducting a strain-load test on a beam scale is as follows:

1. At zero load, balance in an amount of error weight equal to the maximum tolerance value applicable to the total of all test weights that will be used in the strain-load testing of the scale.
2. Apply the unknown load and slide the poises on the various weighbars to positions that cause the beam to become balanced to within the closest minimum graduation on the weighbar having the smallest size graduation.
3. Precisely balance the beam by adding or removing error weights from the platform in increments of 0.1 d.
4. Total the amount of error weight on the platform and make note of it. The total amount of error weight and unknown load on the platform represents your reference point for the strain-load test.

5. Total the values of all poise settings and record the total on the inspection report, identifying the value as the weight of the unknown load.
6. Apply known test weights in predetermined increments or all at one time.
7. Add the reference weight of the unknown load to the value of the applied test weights and adjust the poises on the weighbars to equal the sum.
8. Properly balance the beam by adjusting the amount of error weight on the platform.
9. Determine the amount of error in the scale by totaling the amount of error weight on the platform and subtracting from it the amount used to balance the beam with the unknown load applied (reference amount from step 4).

After performance results have been determined and recorded for all of the test weights, remove the test weights and the unknown load from the platform. Verify that the scale returns to the initial zero-load balance by returning the amount of error weight initially added to the platform in step 1.

Appendix C. Test for Motion Detection

In accordance with NIST Handbook 44 Scales Code paragraph S.2.5.1. Digital Indicating Elements; Damping Means a digital electronic device must have a motion detection capability that prevents the device from zeroing (push-button zero) or taring (pushbutton tare) part of a load when the semi-automatic zero or tare key is activated at the same time that a load is added, changed, or removed from the scale.

A digital electronic scale equipped with a printer must have motion detection capability that prevents the scale from printing weight values before the weight display has stabilized within specified limits. This reduces the possibility of recording incorrect weight values. The limits for motion detection are:

1. plus or minus (±) 3 scale divisions for:
   a. axle-load,
   b. railway track,
   c. vehicle scales,
   d. combination vehicle/livestock scales,
   e. combination vehicle/railway track scales and
   f. hopper (other than grain hopper) scales with a capacity exceeding 22 000 kg (50 000 lb); and

2. plus or minus (±) 1 scale division for all other scales.

The following procedure is recommended to test the effectiveness of motion detection for printing, push-button zero, push-button tare, and storing a weight value in a memory register.

For higher capacity scales, apply or remove a load of greater than 15 divisions (15 d) while activating the following functions (e.g., pressing the applicable pushbutton, switch, etc.):

- semiautomatic (pushbutton) zero-setting,
- semiautomatic (pushbutton) tare,
- storing a gross, net or tare weight value, or
- printing a ticket, receipt, invoice, etc.

It is important to ensure that peak oscillations of greater than 15 d are induced. These tests can usually be performed as test weights are being placed on or removed from the weighing/load-receiving element.

Indicated, stored, and recorded weight values must be within 3 divisions (3 d) of the value obtained under static conditions for vehicle, axle-load, and railway track scales. All recorded values shall be within applicable tolerances.

Appendix D. Verification of the Weigh-in-Motion Scale Reference Vehicles

This appendix provides a procedure for determining the weight of reference vehicles used in testing the accuracy performance of a weigh-in-motion (WIM) vehicle scale. NIST Office of Weights and Measures notes the development of the procedure is practical in principle and work is being done to collect additional data on its use for WIM vehicle scale applications. The weight of reference vehicles is determined using a reference vehicle scale. The reference vehicle scale selected is of the same accuracy class as the WIM vehicle scale under test, i.e., accuracy Class III L. In order to achieve a sufficient level of accuracy on the weight of the reference vehicle(s), the calculable inaccuracy of the reference scale must be determined and accounted for in the final measurement data.

In this case the verification procedure in Appendix D uses the reference scale as a mass comparator, relating the weighing result(s) to calibrated test weights independent of the reference scale's own weighing result. In order to reach sufficient resolution the weight values in this procedure (i.e., O_x, O_1, and O_2) need to be obtained using the scale's indication to at least a five times (5x) higher resolution than its verification scale interval, or by using error weights (0.1 d) to bring the indications into the zone of uncertainty (see Note 3. below). The steps for this procedure are as follows:

Step 1 If the reference scale has not yet been exercised, run the reference vehicle two or three times over the scale.

Step 2 Zero the reference scale.

Step 3 Weigh the reference vehicle with the driver on the reference scale and record the weighing result. This is an estimation of the vehicle's weight and will be referred to as O_x.

Step 4 Remove the reference vehicle and set the reference scale to zero.

Step 5 Place calibrated test weights on the scale to a load, (S_1), close to, but not exceeding, O_x and register the weighing result. This result will be referred to as O_1.

Step 6 Place additional calibrated test weight on the scale so that the total load, (S_2), exceeds O_x and register the weighing result. This result will be referred to as O_2.

Step 7 Calculate the weight of the reference vehicle, X, through interpolation using the following formula:

$$X = S_1 + (O_x - O_1) \times \left(\frac{S_2 - S_1}{O_2 - O_1}\right)$$

NOTE 1: This procedure can be combined with the build-up test of the reference scale by taking O_x before starting the test and including loads S_1 and S_2 to the test sequence.

NOTE 2: When using calibrated test weights to load the reference vehicle, only the weight of the empty reference vehicle needs to be determined with this procedure. If a random load is used for the load reference vehicle, then the weights of both the empty and loaded reference vehicle(s) need to be determined using this procedure.

NOTE 3: If error weights are used to obtain a higher resolution of the measurements of (O_x, O_1, and O_2), then the following formula is used:

$$O_n = I + 0.5\ d - \Delta L$$

Where: I is the indication without error weights,

d is the scale division, and

ΔL is the total amount of weight added to bring the scale to its zone of uncertainty.