Chapter 3

Inspection

Objectives

You will now begin a study of the Inspection portion of an official examination of vehicle and axle-load scales. After studying this chapter, you should be able to:

1. Identify and describe the items of scale design, installation, and operation that must be checked during the inspection, including:

    - Zero-Load Balance as Found
    - Marking
    - Indicating and Recording Elements
    - Installation
    - Weighing and Load-Receiving Elements
    - Approaches
    - Maintenance, Use, and Environmental Factors
    - Assistance

2. Describe Handbook 44 requirements relating to these items that are applicable in field examinations.

3. Explain the meaning of the following terms:

    Certificate of Conformance
    damping
    direct sale
    multiple of a scale
    overregistration and underregistration
    parallax
    performance requirements
    primary indicating or recording elements
    recorded representation
    scale divisions, number of (n)
    type
    type evaluation
    user requirement

These terms are printed in **bold type** when first introduced.

General Considerations

This chapter will describe the Inspection portion of an official field examination of vehicle and axle-load scales, following the organization of the EPOs (reproduced in their entirety in Appendix B). First, however, you should be aware of several general considerations, which may determine how you approach a particular inspection.

Handbook 44 (Scales Code, paragraph S.5.1.) specifies that scales manufactured after January 1, 1986, that are to be used for commercial purposes, shall be marked with an accuracy class designation as follows: I, II, III, III L, or IIII. The accuracy class is designated by the manufacturer, based upon guidelines established in the Scales Code; the guidelines are based upon the weighing applications of various scales. This topic will be covered in greater detail later.

The scales covered by this module, vehicle and axle-load scales, will fall into accuracy class III L. In this module, and in Handbook 44, you will find certain criteria that apply to scales marked III L, and certain criteria for scales not marked III L. The references to scales not marked III L apply to scales manufactured before 1986, which bear no accuracy class marking. It is important to be alert to this distinction.

In the Inspection portion of the official examination, you will determine the scale's compliance with specifications and other requirements pertaining to design, installation, and operation. The extent and emphasis of your inspection will depend on a number of factors relating to the specific device being tested and the circumstances under which it is being tested. Some of the more important factors are:

- your familiarity with the device,
- the age and service history of the device,
- whether or not the device is of a type that has been type evaluated, and
- whether or not a complaint has been received.

Naturally, your previous experience with the particular device will impact on the inspection process. If you are checking a device for the first time, you may want to perform an extensive inspection that includes a careful check of all applicable requirements in Handbook 44, including those concerned with design and installation. If you are checking a device with which you are familiar, one that has been in service for some time, you may not need to spend much time on design and installation requirements; however, you will want to look for such things as fraudulent use or abuse of the equipment, and inappropriate applications of the device.

The age and service history of the device are important because a number of requirements in Handbook 44 are nonretroactive as of a certain date. As a result, you will find that applicable requirements sometimes vary with the age of the device. Nonretroactive requirements are enforceable after the effective date for:

- devices manufactured within a State after the effective date;
- both new and used devices brought into the State after the effective date; and
- devices that have been used in non-commercial applications and are being placed into commercial use after the effective date.

In this module, as in Handbook 44, nonretroactive requirements are printed in italic type to distinguish them from fully retroactive requirements, and the effective date is also given. Note that some nonretroactive requirements become retroactive as of a specified date. This is also indicated, where applicable.

In most cases, the scales you will be testing will be of a type that has been evaluated under the National Type Evaluation Program (NTEP). NTEP is a cooperative program among the National Conference on Weights and Measures (NCWM), the States, the National Institute of Standards and Technology (NIST), and representatives of scale manufacturers and users for determining conformance of a weighing and measuring device "**type**" or "model" with the relevant provisions of Handbook 44. Manufacturers voluntarily submit models of their devices for evaluation under the NTEP program. An NTEP-authorized State or Federal laboratory conducts the evaluation.

When a device is found to meet all applicable technical requirements, the NCWM issues a **Certificate of Conformance (CC)** for that device. In some very limited cases, a provisional Certificate of Conformance may be issued, making final approval contingent upon specified modifications. The Certificate provides details of the evaluation results and device characteristics necessary for use in commerce. Some States require that new weighing and measuring devices receive a Certificate of Conformance before they may be placed in commercial service.

Before testing a new type of device, you should determine if a model of the device has been type evaluated; and, if it has, you should review the device's Certificate of Conformance to determine which features have been evaluated. The NCWM posts all NTEP CCs on its website at www.ncwm.net to help you determine if a particular device has been evaluated. CCs are also available from the manufacturer of the weighing or measuring device. If you are not familiar with NTEP CCs, your instructor will explain their organization and content to you.

During the **type evaluation** process, extensive tests are performed in laboratory and/or field settings to determine if a particular device model meets all applicable requirements in Handbook 44. Some of these tests are difficult to perform in the field; consequently, the existence of a Certificate of Conformance can make your job easier — during a field inspection, you may not need to extensively examine certain design criteria on a type evaluated device. But remember that type evaluation means that a model of a device has been examined, not each device; therefore, you should still review all applicable requirements when inspecting a new device. The review may simply consist of a brief visual check of an item.

In addition, it should be kept in mind that many scale system components, such as load cells, are type evaluated. This may be an important consideration if replacement parts have been installed: if your determination regarding the extent of inspection is based upon type evaluation, you should also consider the type evaluation status of any replacement parts or modifications. Specific policy regarding replacement parts is set forth in NCWM Publication 14, "NTEP Administrative Policy" and in the NTEP Technical Checklists comprising Publication 14.

Devices are designed with specific applications in mind. Some devices are designed for a narrow range of applications, whereas others have a multitude of features to satisfy many different applications. Not all features are suitable for all applications. A Certificate of Conformance will state the intended application of a device type, list its selectable and non-selectable features, and describe the suitability of the equipment and features for specific applications. (See the section on **Marking** in this chapter for more information on Certificates of Conformance.) If you encounter a new or unusual device or feature on a device in an unusual application, it should be thoroughly tested to determine its appropriateness and to assure that it does not facilitate fraud.

Another factor that affects the nature and extent of the Inspection portion of your examination is the existence of a complaint about a particular device or the practices of a device owner or operator. You may want to perform a more extensive inspection than usual if your office has received complaints about a device or business.

Because of the above factors and others, it was difficult to select one inspection approach to teach in this module. The approach taken has been to assume that a routine inspection is being carried out on a device for which a Certificate of Conformance has been issued.

EPO No. 13 and EPO No. 13-E list major items to check during the Inspection. The sequence in which these items are checked is not critical. For the purposes of this module, we will discuss each item in the order it is listed in the EPO. Your instructor will tell you if your jurisdiction follows a different sequence.

Zero-Load Balance As Found

The first item to be inspected is the condition of zero-load balance of a scale, that is, the balance condition with no load on the deck. Handbook 44 requires that all scales be designed with a means to indicate a zero-balance condition, and that automatic-indicating scales have a means to indicate an out-of-balance condition that is either above or below zero balance. In addition, scales must have a means of adjusting the zero-load balance so that the scale is balanced and indicates this condition when there is no load applied.

To inspect the scale for compliance, all load-counterbalance elements of the scale, such as poises or unit weights, should be set to zero, and the scale should indicate a zero balance condition.

If a scale is in an out-of-zero balance condition, you should ask the operator to zero the scale. If the operator does not know how to zero the scale, the owner (manager) should be requested to do so. Possible reasons for the out-of-balance condition are:

- the operator has not used the scale that day,
- debris has accumulated on the scale,
- the operator may not know how to balance the scale, tare was taken on the last weighing and not removed, or
- carelessness.

S.1.1. Zero Indication.

(a) On a scale equipped with indicating or recording elements, provision shall be made to either indicate or record a zero-balance condition.

(b) On an automatic-indicating scale or balance indicator, provision shall be made to indicate or record an out of-balance condition on both sides of zero.

(c) A zero-balance condition may be indicated by other than a continuous digital zero indication, provided that an effective automatic means is provided to inhibit a weighing operation or to return to a continuous digital indication when the scale is in an out-of-balance condition. (Added 1987)

(Amended 1987 and 1993)

S.2.1.1. 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.

NIST Handbook 44, Scales Code, Paragraphs S.1.1. and S.2.1.1.

In accordance with the Scales Code (paragraph UR.4.1.), it is the owner's responsibility to be sure that the scale is set at zero at all times during use.

UR.4.1. Balance Condition. - The zero load adjustment of a scale shall be maintained so that, with no load on the load receiving element and with all load counterbalancing elements of the scale (such as poises, drop weights, or counterbalance weights) set to zero, the scale shall indicate or record a zero balance condition. A scale not equipped to indicate or record a zero load balance shall be maintained in balance under any no load condition.

NIST Handbook 44, Scales Code, Paragraph U.R.4.1.

An out-of-balance condition should be noted on the report issued to the owner (manager) in order that a history can be maintained. If an out-of-balance condition is found regularly, it may be necessary to resort to other enforcement action (a "warning letter," scale condemnation, or, in extreme cases, prosecution) to convince the operator or owner that it is his or her responsibility to maintain the scale in zero balance.

Scales used in **direct sales** that have manual zero-setting mechanisms, such as balance balls, must be so designed that the mechanism is either enclosed in a cabinet or only operable by a separate tool, such as a screwdriver. This requirement is intended to prevent fraud by making it difficult for the owner or operator to move the scale ahead of zero when making a weighing and then return the scale to zero as the load is removed from the deck. Requiring the use of a tool, for example, makes a zero adjustment obvious, and the excuse of an accidental action is eliminated.

S.2.1.2. Scales used in Direct Sales. - A manual zero setting mechanism (except on a digital scale with an analog zero adjustment mechanism with a range of not greater than one scale division) shall be operable or accessible only by a tool outside of and entirely separate from this mechanism, or it shall be enclosed in a cabinet. Except on Class I or II scales, a balance ball shall either meet this requirement or not itself be rotatable.

A semiautomatic zero setting mechanism shall be operable or accessible only by a tool outside of and separate from this mechanism or it shall be enclosed in a cabinet, or it shall be operable only when the indication is stable within:

(a) plus or minus 3 scale divisions for scales of more than 2000 kg (5000 lb) capacity in service prior to January 1, 1981, and for all axle load, railway track, and vehicle scales; or

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

NIST Handbook 44, Scales Code, Paragraph S.2.1.2.

If the scale is equipped with a semi-automatic zero-setting mechanism (push-button zero), it will be tested to determine if it operates only when the indication is stable within plus or minus 3 scale divisions. Details for performing this test will be covered in Chapter 6. A semi-automatic zero-setting mechanism that resets the scale to zero when the scale is not stable to within 3 scale divisions must meet the same requirements as a manual zero-setting mechanism: it must be enclosed in a cabinet or be operable or accessible only by means of a tool.

Many vehicle and axle-load scales with a weighbeam have a balance ball. The balance ball is usually pinned so that it cannot rotate, but can only move back and forth on a screw, which must be turned with a screwdriver. This meets the requirements of S.2.1.2.

Electronic scales not intended to be used in direct sales applications may be equipped with a combined zero/tare function key, provided that the device is marked as described in Handbook 44 Scales Code paragraph S.2.1.6.

S.2.1.6. Combined Zero-Tare ("0/T") Key. - Scales not intended to be used in direct sales applications may be equipped with a combined zero and tare function key, provided that the device is clearly marked as to how the key functions. The device must also be clearly marked on or adjacent to the weight display with the statement "Not for Direct Sales."
(Added 1998)

NIST Handbook 44, Scales Code, Paragraph S.2.1.6.

Weighbeam Scales

The weighbeam of a scale must be in a horizontal position when the balance condition is indicated. This assures that the indicator will have equal distance for oscillation around the zero point.

S.1.5.1. Normal Balance Position. - The normal balance position of the weighbeam of a beam scale shall be horizontal.

NIST Handbook 44, Scales Code, Paragraph S.1.5.1.

On a beam scale with trig loop, a balance condition must be in the center of the trig loop. On a beam scale with a balance indicator, a balance condition is indicated by the tip of the indicator pointing to the zero position.

Dial Scales

A dial scale is in zero-load balance when the indicator points to the zero graduation, the line or marking associated with the numeral "zero" on the dial. Any other position would indicate that the scale is out of balance at zero load. If the scale has a printer, it must print "zero" with no load on the platform, and it must be in agreement with any other indicator. A dial indicator may have a screw adjustment for zero that requires using a screwdriver or similar tool. This arrangement, too, meets Handbook 44 requirements.

Electronic Digital Indicating Scales

You will find a variety of mechanisms used to zero vehicle and axle-load scales with electronic digital indicators. On some scales, you will find a knob that is turned to zero the scale (the knob must be enclosed to satisfy S.2.1.2.). On other scales, a similar device is operated with a screwdriver. A push-button may perform the same function. Because of the "rounding" involved in generating digital signals, described in Chapter 1, the zero-balance indication of an electronic digital indicator can represent a condition that is out of balance by as much as plus or minus one-half of a scale division. Handbook 44 permits uncertainty only to that degree. Some digital indicators are equipped with a "center of zero" feature that provides greater sensitivity for the zero-balance indication. For these devices, the uncertainty is limited to one-quarter of a scale division. In addition, a digital indicating device must either automatically maintain a center of zero condition to +/- ¼ scale division or less or have an auxiliary or supplemental center-of-zero indication as specified in paragraph S.1.1.1.

S.1.1.1. Digital Indicating Elements.

(a) A digital zero indication shall represent a balance condition that is within ±½ the value of the scale division.

(b) A digital indicating device shall either automatically maintain a "center-of-zero" condition to ±¼ scale *division or less, or have an auxiliary or supplemental "center-of-zero" indicator that defines a zero-balance condition to ±¼ of a scale division or less.*
[Nonretroactive as of January 1, 1993]
(Amended 1992)

NIST Handbook 44, Scales Code, Paragraph S.1.1.1.

In addition, the scale indicator may have an electronic circuit, called an **automatic zero-setting mechanism** (**AZSM**), that automatically zeroes the scale under certain conditions. A special requirement applies to this type of device.

> ***S.2.1.3. Scales Equipped with an Automatic Zero-Setting Mechanism. —*** *Under normal operating conditions, the maximum load that can be "rezeroed," when either placed on or removed from the platform all at once, shall be:*
>
> * * *
>
> *(b) For vehicle, axle-load, and railway track scales: 3.0 scale divisions.*
> *[Nonretroactive and enforceable as of January 1, 1981.]*

NIST Handbook 44, Scales Code, Paragraph S.2.1.3.

If the scale has an AZSM, the mechanism must not rezero the scale if a load of more than 3 scale divisions is placed on or removed from the deck. The procedure for testing this feature will be described in Chapter 6.

Finally, the General Code includes a requirement in paragraph G-S.5.2.2.(d) that is intended to assure that a digital zero-load indication is unambiguous. This requirement also applies to recorded representations.

> **G-S.5.2.2. Digital Indication and Representation. —** Digital elements shall be so designed that:
>
> *(d) A digital zero indication includes the display of a zero for all places that are displayed to the right of the decimal point and at least one place to the left. When no decimal values are displayed, a zero shall be displayed for each place of the displayed scale division. [Nonretroactive as of January 1, 1986.]*

NIST Handbook 44, General Code, Paragraph G-S.5.2.2. (d)

Vehicle and axle-load scales with electronic digital indicators generally have scale divisions of no less than 10 lb and no more than 50 lb. Therefore, a digital indicator that displays in terms of pounds must show zeroes for at least the first two digits at the right of the display (one for each place of the displayed scale division), as illustrated by the upper drawing in Figure 3-1. On the other hand, a vehicle or axle-load scale with a scale division value of 0.01 ton would require a zero indication of at least two zeroes to the right of the decimal point plus one zero to the left, as shown in the lower drawing in Figure 3-1.

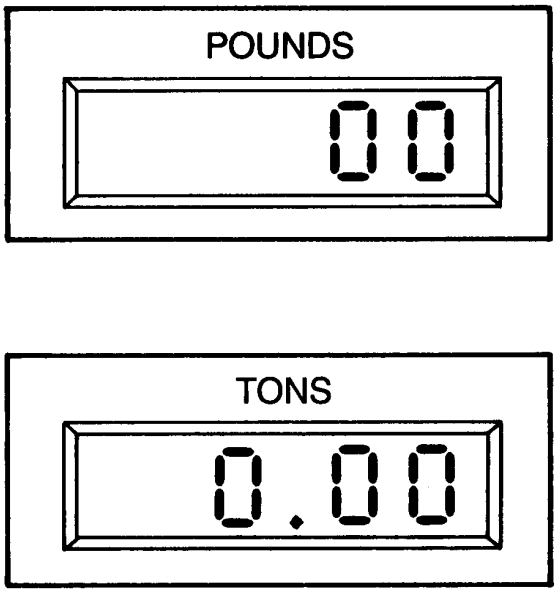

Figure 3-1. Digital Zero Indication

Marking

Basic information that identifies a weighing device is often needed by device users, service personnel, and weights and measures officials for maintenance, adjustment, and testing purposes. This basic information includes items relating to the origin, type, capacities, application, limitations, and special features or parameters of the device. Handbook 44 requires that specific information be permanently marked on devices, so that it is available when needed.

Many scale systems, including vehicle and axle-load scales, consist of several components, which may have been manufactured at different times or even by different manufacturers, and which may also be physically separate. To the degree that these components are distinct, Handbook 44 requires that they be marked separately with relevant identifying information. Five distinct "categories" are identified in the Scales Code:

- weighing, load-receiving, and indicating element in the same housing or covered on the same CC – applies to systems in which the weighing and indicating elements are housed within a single enclosure. Since the weighing elements of vehicle and axle-load scales are separate from the indicating element, this category is not applicable.

- indicating element not permanently attached to weighing and load-receiving element or covered by a separate CC – applies to indicating elements that are not permanently attached to a weighing element. For vehicle and axle-load scales, this could be a weighbeam, dial, or electronic digital indicator.

- weighing and load receiving element not permanently attached to indicating element or covered by a separate CC – applies to combined weighing and load-receiving elements that are not permanently attached to an indicating element. Vehicle and axle-load scales fall into this category.

- load cell with CC – applies to load cells which have been evaluated and received a Certificate of Conformance (CC) under NTEP after the Nonretroactive dates noted in Table S.6.3.b.

- other equipment or device – applies to equipment that is necessary to the weighing system but having no metrological effect, e.g., auxiliary remote display, keyboard, etc.

The components and items of information that must be marked upon them are specified in paragraphs G-S.1. of the General Code and S.6.3. of the Scales Code. Tables S.6.3.a. and S.6.3.b summarize all requirements by component. These tables have been reproduced at the end of this chapter. Refer to them as you read the following description of marking requirements.

In summary, each individual component of a vehicle or axle-load scale included in one of these five categories of Table S.6.3.a. must be marked with the items listed for that category. Thus, a system must have separate markings on the indicating element and the load-receiving/weighing elements, and on other equipment or devices and load cells with CCs if so equipped. The specific items of information that must be marked are described below, under the respective categories.

One other important general consideration relating to the inspection of required markings is that many of the requirements are nonretroactive, and have different effective dates. This can be confusing. However, note that Table S.6.3.b gives the effective dates; the EPOs also show the effective date for each requirement.

S.6.3. Scales, Main Elements, and Components of Scales or Weighing Systems. - Scales, main elements of scales when not contained in a single enclosure for the entire scale, load cells for which Certificates of Conformance (CC) have been issued under the National Type Evaluation Program, and other equipment necessary to a weighing system, but having no metrological effect on the weighing system, shall be marked as specified in Table S.6.3.a. and explained in the accompanying notes (Table S.6.3.b.)
(Added 1990)

NIST Handbook 44, Scales Code, Paragraph S.6.3.

Table S.6.3.a.
Marking Requirements

To Be Marked With ⇓	Weighing Equipment				
	Weighing, load-receiving, and indicating element in same housing or covered on the same CC[1]	Indicating element not permanently attached to weighing and load-receiving element or covered by a separate CC	Weighing and load-receiving element not permanently attached to indicating element or covered by a separate CC	Load cell with CC (11)	Other equipment or device (10)
Manufacturer's ID (1)	x	x	x	x	x
Model Designation and Prefix (1)	x	x	x	x	x
Serial Number and Prefix (2)	x	x	x	x	x (16)
Certificate of Conformance Number (CC) (23)	x	x	x	x	x (23)
Accuracy Class (17)	x	x (8)	x (19)	x	
Nominal Capacity (3)(18)(20)	x	x	x		
Value of Scale Division, "d" (3)	x	x			
Value of "e" (4)	x	x			
Temperature Limits (5)	x	x	x	x	
Concentrated Load Capacity (CLC) (12)(20)(22)		x	x (9)		
Special Application (13)	x	x	x		
Maximum Number of Scale Divisions (n_{max}) (6)		x (8)	x (19)	x	
Minimum Verification Scale Division (e_{min})			x (19)		
"S" or "M" (7)				x	
Direction of Loading (15)				x	
Minimum Dead Load				x	
Maximum Capacity				x	
Safe Load Limit				x	
Load Cell Verification Interval (v_{min}) (21)				x	
Section Capacity (14)(20)(22)		x	x		

Note: For applicable notes, see Table S.6.3.b.
[1]Weighing/load receiving elements and indicators which are in the same housing or which are permanently attached will generally appear on the same CC. If not in the same housing, elements shall be hard wired together or sealed with a physical seal or an electronic link. This requirement does not apply to peripheral equipment that has no input or effect on device calibrations or configurations.

(Added 1990) (Amended 1992, 1999, 2000, 2001 and 2002) (Footnote 1 Added 2001)

Table S.6.3.b., Notes For Table S.6.3.a.

1. Manufacturer's identification and model designation and *model designation prefix*.*
   **[Nonretroactive as of January 1, 2003*]
   (See also G-S.1.) *[Prefix lettering may be initial capitals, all capitals or all lower case]*
   (Amended 2000)

2. *Serial number [Nonretroactive as of January 1, 1968] and prefix [Nonretroactive as of January 1, 1986].* (See also G-S.1.)

3. The nominal capacity *and value of the scale division shall be shown together (e.g., 50 000 x 5 kg, 100 000 x 10 lb, 15 x 0.005 kg , or 30 x 0.01 lb) adjacent to the weight display when the nominal capacity and value of the scale division are not immediately apparent. Each scale division value or weight unit shall be marked on multiple range or multi-interval scales. [Nonretroactive as of January 1, 1983]*

4. *Required only if different from "d." [Nonretroactive as of January 1, 1986]*

5. *Required only on Class III, III L, and IIII devices if the temperature range on the NTEP CC is narrower than and within -10 °C to 40 °C (14 °F to 104 °F). [Nonretroactive as of January 1, 1986]*

6. *This value may be stated on load cells in units of 1000; e.g., n: 10 is 10 000 divisions. [Nonretroactive as of January 1, 1988]*

7. *Denotes compliance for single or multiple load cell applications. It is acceptable to use a load cell with the "S" or Single Cell designation in multiple load cell applications as long as all other parameters meet applicable requirements. A load cell with the "M" or Multiple Cell designation can be used only in multiple load cell applications.[Nonretroactive as of January 1, 1988]*
   (Amended 1999)

8. *An indicating element not permanently attached to a weighing element shall be clearly and permanently marked with the accuracy Class of I, II, III, III L, or IIII, as appropriate, and the maximum number of scale divisions, n_{max} , for which the indicator complies with the applicable requirement. Indicating elements that qualify for use in both Class III and III L applications may be marked III/III L and shall be marked with the maximum number of scale divisions for which the device complies with the applicable requirements for each accuracy class. [Nonretroactive as of January 1, 1988]*

9. *For vehicle and axle-load scales only. The CLC shall be added to the load-receiving element of any such scale not previously marked at the time of modification. [Nonretroactive as of January 1, 1989]*
   (Amended 2002)

10. Necessary to the weighing system but having no metrological effect, e.g., auxiliary remote display, keyboard, etc.

11. *The markings may be either on the load cell or in an accompanying document; except that, if an accompanying document is provided, the serial number shall appear both on the load cell and in the document. [Nonretroactive as of January 1, 1988] The manufacturer's name or trademark, the model designation, and identifying symbols for the model and serial numbers as required by paragraph G.-S.1. shall also be marked both on the load cell and in any accompanying document. [Nonretroactive as of January 1, 1991]*

12. Required on the indicating element *and the load-receiving element* of vehicle and axle-load scales. *Such marking shall be identified as "concentrated load capacity" or by the abbreviation "CLC."**
    *[*Nonretroactive as of January 1, 1989]*
    (Amended 2002)

13. *A scale designed for a special application rather than general use shall be conspicuously marked with suitable words visible to the operator and customer restricting its use to that application, e.g., postal scale, prepack scale, weight*

Table S.6.3.b., Notes For Table S.6.3.a.

classifier, etc. When a scale is installed with an operational counting feature, the scale shall be marked on both the operator and customer side with the statement "The counting feature is not legal for trade." [*Nonretroactive as of January 1, 1986]*
(Amended 1994)

14. *Required on livestock* and railway track scales. When marked on vehicle and axle-load scales manufactured before January 1, 1989, it may be used as the CLC. For livestock scales manufactured between January 1, 1989 and January 1, 2003, required markings may be either CLC or section capacity. [*Nonretroactive as of January 1, 2003.*
(Amended 2002)

15. *Required if the direction of loading the load cell is not obvious. [Nonretroactive as of January 1, 1988]*

16. *Serial number [Nonretroactive as of January 1, 1968] and prefix [Nonretroactive as of January 1, 1986]*. (See also G-S.1.) Modules without "intelligence" on a modular system (e.g., printer, keyboard module, cash drawer, and secondary display in a point-of-sale system) are not required to have serial numbers.

17. *The accuracy Class of a device shall be marked on the device with the appropriate designation as I, II, III, III L, or IIII. [Nonretroactive as of January 1, 1986]*

18. The nominal capacity shall be conspicuously marked as follows:

    (a) on any scale equipped with unit weights or weight ranges;
    (b) on any scale with which counterpoise or equal-arm weights are intended to be used;
    (c) on any automatic-indicating or recording scale so constructed that the capacity of the indicating or recording element, or elements, is not immediately apparent;
    (d) on any scale with a nominal capacity less than the sum of the reading elements; and
    *(e) on the load-receiving element (weigh-bridge) of vehicle, axle-load, and livestock scales.**
    *[*Nonretroactive as of January 1, 1989]*
    (Amended 1992)

19. *[Nonretroactive as of January, 1, 1988]* (Amended 1992)

20. *Combination vehicle/railway track scales must be marked with both the nominal capacity and CLC for vehicle weighing and the nominal capacity and section capacity for railway weighing. All other requirements relating to these markings will apply. [Nonretroactive as of January 1, 2000]*
(Added 1999)

21. The value of the load cell verification interval (v_{min}) must be stated in mass units. In addition to this information, a device may be marked with supplemental representations of v_{min}. *[Nonretroactive as of January 1, 2001]*
(Added 1999)

22. *Combination vehicle/livestock scales must be marked with both the CLC for vehicle weighing and the section capacity for livestock weighing. All other requirements relative to these markings will apply.*
[Nonretroactive as of January 1, 2003]
(Added 2002)

23. *Required only if a CC has been issued for the device or equipment.*
[Nonretroactive as of January 1, 2003]
(G-S.1. Identification (f) Added 2001)

Basic Identification Information

Paragraph G-S.1. of the General Code requires that all devices be marked to identify the manufacturer or distributor. In addition, devices manufactured or placed in service for the first time within the State after January 1, 1968, must have a nonrepetitive serial number, which identifies a device uniquely.

G-S.1. Identification. - All equipment, except weights and separate parts necessary to the measurement process but not having any metrological effect, shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the manufacturer or distributor;

(b) a model designation that positively identifies the pattern or design of the device;

(c) *the model designation shall be prefaced by the term "Model," "Type," or "Pattern." These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.). The abbreviation for the word "Model" shall be "Mod" or "Mod."*
[Nonretroactive January 1, 2003]
(Added 2000) (Amended 2001)

[Note: Prefix lettering may be initial capitals, all capitals or all lower case.]

(d) except for equipment with no moving or electronic component parts and not built-for-purpose, software-based devices, a nonrepetitive serial number;
[Nonretroactive as of January 1, 1968]

(e) for not built-for-purpose, software-based devices the current software designation;

(f) the serial number shall be prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required serial number; and
[Nonretroactive as of January 1, 1986]

(g) the serial number shall be prefaced by the words "Serial Number" or an abbreviation of that term. Abbreviations for the word "Serial" shall, as a minimum, begin with the letter "S," and abbreviations for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., S/N, SN, Ser. No, and S No.).
[Nonretroactive as of January 1, 2001]

(h) For devices that have an NTEP Certificate of Conformance (CC) Number or a corresponding CC addendum number, the NTEP CC shall be prefaced by the terms "NTEP CC," "CC," or "Approval." These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.)
[Nonretroactive as of January 1, 2003]

The required information shall be so located that it is readily observable without the necessity of the disassembly of a part requiring the use of any means separate from the device.
(Amended 1985, 1991, 1999,2000, and 2003)

G-UR.2.1.1. Visibility of Identification. — Equipment shall be installed in such a manner that all required markings are readily observable.

Added 1978

NIST Handbook 44, General Code, Paragraphs G-S.1. and G-UR.2.1.1.

According to G-S.1., the required markings must be observable without disassembly that requires a tool. This requirement is intended to insure that they are readily accessible. This requirement is supported by another paragraph in the General Code (G-UR.2.1.1.), which states that devices must be installed in such a way that required markings are readily observable. However, the Scales Code contains an exception to these requirements for some scales, including most vehicle and axle-load scales. See the discussion of paragraph 3.6.2. below for more information.

The information specified in G-S.1. must appear on the components or groups of components shown in Table S.6.3.a, except that auxiliary devices that do not have intelligence — that is, do not have processing capability — and have no metrological effect, such as a secondary weight display, and not built-for purpose, software-based devices are not required to have a marked serial number. This is set forth in Item 16 in Table S.6.3.b., and, in the case of not built for purpose devices, in G-S.1.1. (see below). In addition, note that Item 11 states that required information for load cells may be presented in an accompanying document, except that the information specified in G-S.1. must be marked both on the load cell and in the accompanying document.

Not Built-For-Purpose Devices, Software-Based

Electronic vehicle scale weighing systems are generally comprised of a weighing/load receiving element interfaced with an electronic indicator. Many systems today use, in place of an electronic indicator dedicated to and designed specifically for weighing operations, a computer system with a CRT display. These systems typically use generic, "off the shelf" computer hardware (central processing unit, computer display, and other peripheral equipment) along with software that is specifically developed for use in weighing applications.

NIST Handbook 44 General Code paragraph G-S.1.1. applies to these types of software-based devices that were not built solely for use either as a stand-alone weighing system or as an accessory to a weighing or measuring system. These are referred to as "not built-for-purpose, software-based" devices, and a definition for these devices appears in Appendix D of Handbook 44.

Paragraph G-S.1.1. defines how the information required by G-S.1. is to be marked or displayed by the system. Options are provided for marking certain G-S.1. information on the device or displaying the information either continuously or through a "help" menu on the device. Some G-S.1. information such as the manufacturer or distributor and the model designation must be continuously displayed or marked on the device.

For software-based systems, the functionality of the system and its compliance with the performance and operational requirements of Handbook 44 are controlled by the software used in the system. In these systems, a serial number is not relevant to positively identifying the device and its capability to function as a weighing device under Handbook 44. Consequently, a serial number is not required on "not built-for-purpose, software-based devices." Instead, the manufacturer of the software must display on the screen, the version of software used in the system. This information can be used by the inspector to clearly identify the manufacturer that is responsible for the weighing operation and functionality of the system. The requirement for marking or displaying the software designation also provides an effective way to determine if a computer system is using a specific version of software that has been evaluated as part of an NTEP evaluation.

Note that the manufacturer of the computer hardware (central processing unit, computer display screen, and other peripheral equipment) may also mark the hardware with identification and serial number information.

-S.1.1. Not Built–For–Purpose Devices, Software-Based. - *For not built–for–purpose, software based devices, the following shall apply:*

(a) the manufacturer or distributor and the model designation shall be continuously displayed or marked on the device (see note below), or

(b) the Certificate of Conformance (CC) Number shall be continuously displayed or marked on the device (see note below), or

(c) all required information in G-S.1. Identification. (a), (b), (c), (e), and (h) shall be continuously displayed. Alternatively, a clearly identified view only System Identification, G-S.1. Identification, or Weights and Measures Identification shall be accessible through the "Help" menu. Required information includes that information necessary to identify that the software in the device is the same type that was evaluated.

Note: Clear instructions for accessing the remaining required G-S.1. information shall be listed on the CC. Required information includes that information necessary to identify that the software in the device is the same type that was evaluated.
[Nonretroactive as of January 1, 2004]

[Added 2003]

Definition, Handbook 44 Appendix D:

built-for-purpose device. Any main device or element which was manufactured with the intent that it be used as, or part of, a weighing or measuring device or system.

NIST Handbook 44, Scales Code, Paragraph S.6.3.

Remanufactured Devices

In addition to the information specified in G-S.1., remanufactured devices and remanufactured main elements must be clearly and permanently marked with certain identification information regarding the remanufacturer or the distributor of the equipment. These requirements are outlined in General Code Paragraph G-S.1.2. Definitions for terminology used in conjunction with remanufactured equipment can be found in Appendix D of NIST Handbook 44.

G-S.1.2. Remanufactured Devices and Remanufactured Main Elements. - All remanufactured devices and remanufactured main elements shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the last remanufacturer or distributor;

(b) the remanufacturer's or distributor's model designation if different than the original model designation.

[Nonretroactive as of January 1, 2002]
(Added 2001)

Note: Definitions for "manufactured device," "repaired device," and "repaired element" are also included (along with definitions for "remanufactured device" and "remanufactured element") in Appendix D, Definitions.

NIST Handbook 44, General Code, Paragraph G-S.1.2.

Indicating Element Not Permanently Attached to Weighing and Load-receiving Element or Covered by a Separate CC

The following notes on the various types of markings (other than the basic identification requirements of G-S.1.) required for separate indicating elements are intended to supplement the information in Table S.6.3.b. Marking requirements that apply to weighing/load-receiving elements will be described in the next section.

- **accuracy class —** indicating elements not permanently attached to a weighing element must be clearly and permanently marked with an accuracy class of I, II, III, III L, or IIII, as appropriate. This requirement is nonretroactive as of January 1, 1988. Vehicle and axle-load scales should be marked class III L. Note, however, that a separate indicating element may be marked for more than one class (for example, III/III L). If the indicator has a different number of scale divisions for the different classes marked, the maximum number of scale divisions must be marked for each class.

- **nominal capacity —** as designated by the manufacturer. However, the maximum nominal capacity is limited by the concentrated load capacity, as specified in S.6.1. Note that the nominal capacity *and scale division value must be marked together (e.g., 100,000 x 10 lb) immediately next to the weight display, unless these values are clear from the display*. [Nonretroactive as of January 1, 1983]

S.6.1. Nominal Capacity; Vehicle and Axle-Load Scales. - *For all vehicle, axle-load, scales, the marked nominal capacity shall not exceed the concentrated load capacity (CLC) times the quantity of the number of sections in the scale minus 0.5.*

As a formula, this is stated as: $\text{nominal capacity} \leq \text{CLC} \times (N - 0.5)$
where N = the number of sections in the scale.
(See N.1.3.4. and T.N.3.1.)
[Nonretroactive as of January 1, 1989]

[**Note:** When the device is used in a combination railway track and vehicle weighing application, the above formula shall apply only to the vehicle scale application.]
(Added 1988) (Amended 1999 and 2002)

NIST Handbook 44, Scales Code, Paragraph S.6.1.

- **value of scale division (d) —** The value of the smallest graduated interval on an indicating device with graduations, or the smallest weight increment that is displayed on a digital indicator.

- **value of "e" —** The verification scale division, for indicating elements that are capable of indicating smaller divisions than those displayed (see definition in Appendix A for examples). For vehicle and axle-load scales, the value of "e" and the value of "d" are generally identical. Note that if "d" and "e" are the same, "e" need not be marked.

- **temperature limits —** Range of temperatures over which the device is designed to operate. For vehicle and axle-load scales, these limits need only be marked if outside the range of 14 to 104 °F (-10 to 40 °C). (See note 5 of Table S.6.3.b.)

- **concentrated load capacity (CLC) —** A capacity rating of a vehicle, axle-load scale, or livestock scale specified by the manufacturer, defining the maximum load concentration for which the weighbridge is designed. In the case of vehicle and axle-load scales, it is the maximum axle-load concentration (for a group of two axles with a centerline spaced 4 feet apart and an axle width of 8 feet) for which the weighbridge is designed as specified by the manufacturer. The concentrated load capacity rating is for both test and use.

- **special application —** See examples in Note 13. Generally not applicable to vehicle and axle-load scales.

- **maximum number of scale divisions (n_{max}) —** Must not exceed limits specified in Table 3 (for scales marked with an accuracy class); Handbook 44 does not specify limits for scales that are not marked with an accuracy class.

- **section capacity —** The greatest live load that may be divided equally on the load pivots or load cells of a section without inducing stresses in any member in excess of the working stresses allowed for the load cells and materials involved. The section capacity was required to be marked on the indicating element of all vehicle scales manufactured prior to 1989. Table S.6.3.a now requires that the indicating element and the load-receiving element of vehicle and axle-load scales be marked with the CLC rather than the section capacity. For scales manufactured prior to 1989, the section capacity

may be use as the CLC during testing.

Weighing and Load-Receiving Element Not Permanently Attached to Indicating Element or Covered by a Separate CC

Many of the marking requirements pertaining to indicating elements not permanently attached to a weighing or load receiving element also apply to devices in this category. For example, as shown in Table S.6.3.a the combined weighing/load-receiving elements of a vehicle or axle-load scale must also be marked to show the basic identification specified in G-S.1. (manufacturer's ID, model designation, and serial number).

In addition, the following markings are required for devices in this category, as described in Table S.6.3.a. and in the accompanying notes in Table S.6.3.b.

- **accuracy class –** This requirement is nonretroactive as of January 1, 1988 for devices in this category.

- **nominal capacity –** This requirement is nonretroactive as of January 1, 1989 for devices in this category, and the information must be marked on the load-receiving element (weighbridge) of the scale. See footnote 20 of Table S.6.3.b. for marking of combination vehicle/railroad track scales.

- **temperature limits –** The application of this requirement is the same for indicating elements described above.

- **concentrated load capacity –** The application of marking requirements are the same for indicating elements described above with one additional requirement - the CLC must be added to the load-receiving element of a scale not previously marked at time of modification. See above notes and footnote 9, Table S.6.3.b.

- **special application –** The application of this requirement is the same for indicating elements described above.

- **maximum number of scale divisions (n_{max}) –** This requirement is nonretroactive as of January 1, 1988 for devices in this category.

- **minimum verification scale division (e_{min}) -** The e_{min} is the smallest scale division for which a weighing element complies with the influence factor requirements in the Scales Code of Handbook 44. This value must be less than or equal to the "e" or "d" value marked on the indicating element. This requirement is Nonretroactive as of January 1, 1988. A comparison among the various division/interval markings found on scales or their components is shown in Figure 3-2.

The required markings may be located on the weighing element or on the load-receiving element, depending on how the scale has been installed. On some vehicle and axle-load scales — especially pit installations — the surface of the scale platform is the only portion of the weighing and load-receiving elements that is above ground. Because this surface is continuously exposed to traffic and the elements, conformance with the requirements of G-S.1. that require markings be permanent and observable without disassembly requiring a tool is not practicable. Paragraph S.6.2. of the Scales Code includes an exemption from the latter requirement, provided that the information is easily accessible.

Marking	Symbol	Location	Definition
Value of the scale division	d	On scale or on separate indicating element	The value of the displayed scale division.
Verification scale division	e	On scale or on separate indicating element	The value by which the tolerance values and the accuracy class applicable to the scale are determined. "e" may be less than or equal to "d." If "e" is equal to "d," it does not have to be marked.
Minimum verification scale	e_{min}	On separate weighing/load-receiving element	The smallest scale division for which a weighing element complies with the influence factor requirements in Handbook 44, including temperature effect on zero. Similar to v_{min} marking on load cells.
Load cell verification	v_{min}	On load cell	The smallest value for which a load cell interval complies with the temperature effect on zero requirements in Handbook 44.

Figure 3-2. Division/Interval Markings on Scales and Components

S.6.2. Location of Marking Information. — Scales that are not permanently attached to an indicating element, and for which the load-receiving element is the only part of the weighing/load-receiving element visible after installation, may have the marking information required in G-S.1. of the General Code and S.6. of the Scales Code located in an area that is accessible only through the use of a tool; provided that the information is easily accessible (e.g., the information may appear on the junction box under an access plate). The identification information for these scales shall be located on the weighbridge (load-receiving element) near the point where the signal leaves the weighing element or beneath the nearest access cover. (Added 1989)

NIST Handbook 44, Scales Code, Paragraph S.6.2.

For example, it would be permitted to put the information on a junction box under the access plate that would have to be unfastened using a screwdriver. The paragraph requires that the identification information be located on the weighbridge near the point where the signal leaves the weighing element or beneath the nearest access cover. For scales with a lever system, some manufacturers put the markings on a ring inside the manhole cover nearest the transverse lever. On an electronic scale, the markings might be under an access cover or adjacent to the junction box at which the cables carrying signals from the load cells are connected.

Other Equipment or Device

Auxiliary elements, such as a printer or a computer incorporated in the weighing system, are only required to be marked with the basic identification specified in G-S.1.

Load Cell with CC

In addition to the basic identifications specified in G-S.1., load cells manufactured after January 1, 1988, that have received an NTEP Certificate of Conformance must also be marked to show the accuracy class and the temperature limits as well as the following. These requirements are nonretroactive as of January 1, 1988, except where noted otherwise.

- **maximum number of scale divisions (n_{max}) -** This value may be stated on load cells in units of 1000; e.g., n: 10 is 10,000 divisions.

- **"S" or "M" -** indication of whether a load cell has received approval for **S**ingle or **M**ultiple load cell applications..

- **certificate of conformance number (CC) -** *Nonretroactive as of January 1, 2003.*

- **direction of loading** — required if the direction of loading of the cell is not obvious (see Table S.6.3.b., Note 15).

- **minimum dead load** — the minimum weight that will produce a zero output signal when applied to a load cell. Not used in field examinations of electronic vehicle and axle-load scales.

- **maximum capacity** — the capacity of the load cell

- **safe load limit** — the maximum weight that can be applied to a single load cell. Not used in field examinations of vehicle and axle-load scales.

- **load cell verification interval (v_{min})** — the minimum scale division for which the load cell was designed. Must be less than or equal to the verification scale division (e) of the indicator. Used to determine the appropriateness of a load cell for its application, as explained later in this chapter.

Note that in accordance with Table S.6.3.b. (Note 11), required markings may be provided either on a load cell itself or in a separate document, provided that the unique serial number of the load cell appears both on the document and on the load cell (nonretroactive as of January 1, 1988). In addition, the manufacturer's name or trademark, the model designation, and identifying symbol for the serial number also must appear both on the load cell and in any accompanying document (nonretroactive as of January 1, 1991). Consider, for example, the load cell identification plate shown in Figure 3-3.

The identification plate in Figure 3-3 includes the following required markings (read from the top down; however, note that the order of presentation is not specified, and varies from one model to another):

- model number (629R-R10-50K-30P5); in this example, the model number includes the capacity (50K, or 50,000 lb), which is also marked separately
- accuracy Class (IIIL), n_{max} (10, representing 10,000), and multiple application (M)
- v_{min} (4.8 lbs)
- maximum capacity (50K lbs)
- serial number (12345)
- manufacturer's name (Load Cells, Inc.)

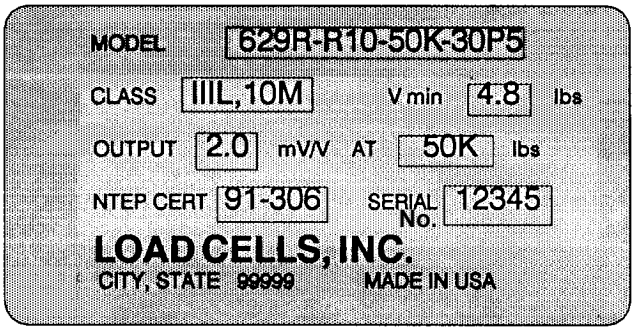

Figure 3-3. Sample Load Cell Identification Plate

The plate shown in Figure 3-3 also includes the output of the cell, which is not required by Handbook 44, but which may prove helpful. This plate does not include all of the following required markings, including:

- direction of loading (not required if obvious)
- temperature limits (required only if other than that specified in T.N.8.1.1.)
- minimum dead load
- safe load limit

These markings, as applicable, would have to be marked on the device or in an accompanying document. Note that the manufacturers name or trademark and model designation and the applicable identifying symbols for model and serial numbers must be marked on the load cell and, for cells manufactured after January 1, 1991, in any accompanying document.

Additional Marking Requirements

In addition to the markings required by G-S.1. and S.6.3., the General Code has additional requirements relating to marking of controls and features and readability and permanence of markings and instructions.

G-S.6. Marking Operational Controls, Indications, and Features. - All operational controls, indications, and features, including switches, lights, displays, push buttons, and other means, shall be clearly and definitely identified. The use of approved pictograms or symbols shall be acceptable. [Nonretroactive as of January 1, 1977]
(Amended 1978 and 1995)

G-S.7. Lettering. — All required markings and instructions shall be distinct and easily readable and shall be of such character that they will not tend to become obliterated or illegible.

NIST Handbook 44, General Code, Paragraphs G-S.6. and G-S.7.

Markings and lettering are considered permanent if they will withstand wear and cleaning. Lettering is not permanent if it can be removed by scraping the marking with a fingernail or if it would easily fade or be washed away during cleaning. The markings may be placed on an identification plate or a label. Be sure that the plate or label is permanently attached to the device. An identification plate secured with rivets would be acceptable; however, a plate secured with removable screws would not. A pressure-sensitive label or badge is acceptable if it can not be removed without being destroyed or distorted in appearance so that it cannot be reused and would show obvious evidence that the badge was removed. For example, if attempts to remove the badge results in tears, permanent and extensive wrinkling, or repeated exposure of the word "VOID", the permanence of the badge would be considered acceptable. For devices evaluated under NTEP, specific tests are conducted to ensure the permanence of badges and of required markings and lettering.

Recording and Verification of Markings

Because of the number and complexity of these marking requirements, it is good practice to work with a checklist, like the ones included in the EPOs. It is also a good idea to make a record of the marked items, which will help you or another inspector determine at a subsequent inspection whether parts have been replaced and whether the replacements are appropriate. First identify the components, then locate the markings and verify them for completeness, accessibility, permanence, and readability.

If a scale system or component has been type-evaluated under NTEP, markings found on the equipment should be compared to those shown on the CC to determine that the device has the same capacities and parameters as the model that was actually tested. (Instances have been found in which a manufacturer has changed the listed capacities or parameters of the model after the CC was issued.)

Consider the sample CC in Figures 3-4A and 3-4B, which was issued for a "family" of load cells. (A single CC is often issued for a number of devices of similar design and operating parameters that are produced by a manufacturer, in this case, bending beam type load cells with capacities ranging from 37,500 to 75,000 lb.) The required markings that can be verified by comparing this CC with the actual markings on the load cell are:

- **manufacturer —** printed in the box in the "Submitted by" box on the upper right of the first page of the CC.

- **model number —** printed in the "For" box on the upper left of page 1. Note that when a CC

covers a family of devices, as in this case, the model number printed on the device may include additional numbers to designate the specific model. For example, a cell belonging to the model family covered by the sample CC might bear the number "12345-100K," with the additional numbers followed by the letter "K" indicating the capacity of that particular model (100,000 lb).

- **accuracy class —** printed in the "For" box. Note that components of vehicle and axle-load scales may be marked with a dual accuracy class (III/III L) if they comply with Handbook 44 requirements for both. In that case different values for n_{max} (the maximum number of scale divisions) relating to each class should also be marked.

- **single or multiple application —** also in the "For" box. Load cells approved for single cell applications (usually marked "S" on the load cell) may also be used in multiple cell applications, but that cells approved for multiple cell application (usually marked "M") may not be used in single cell applications.

- **n_{max} —** also in the "For" box. In this example, 10,000 is the maximum number of scale divisions.

- **temperature range —** shown in the "Standard Features and Options" box. Note that the temperature range in the sample CC corresponds to the range specified in T.N.8.1.1. (and note 5 in Table S.6.3.b.), and that the load cell would therefore not be required to be marked with this particular item.

- **v_{min} —** the minimum verification scale division for the various capacities in this load cell family are presented in tabular form on page 1 of the CC. This appropriate value should be determined based upon the specific model being tested and then compared with the v_{min} marked on the load cell.

- **minimum dead load —** is also displayed for each capacity on page 1.

National Conference on Weights and Measures
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Certificate Number

Certificate Number: 04-XXXA3
Page 1 of 2

Device or Family Description

National Type Evaluation Program
Certificate of Conformance
for Weighing and Measuring Devices

Manufacturer Information

For:
Load Cell
Bending Beam
Model Family: 12345 Series (see below)
n_{max}: Multiple Cells: 10 000
Capacity: 37 500 lb to 75 000

Submitted by:
Load Cell Company
123 Main Street
Anywhere, USA 12345
Tel: (111) 555-1212
Fax: (111) 555-1213
Contact:

Standard Features and Options

Model	Capacity (lb)	v_{min} (lb)	Minimum Dead Load (lb)
WBT-37.5 K	37 500	3.75	500
WBT-50.0 K	50 000	5.00	600
WBT-60.0 K	60 000	5.00	600
WBT-75.0 K	75 000	7.00	1000

Load Application Methods:

Radiused link applies load onto circular contoured knob on end of beam
Column member applies load to vertical threaded hole in end of beam

Features of Specific Models

Temperature Range: -10 to 40 °C (14 to 104 °F)

Features and Options

This device was evaluated under the National Type Evaluation Program (NTEP) and was found to comply with the applicable technical requirements of Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices." Evaluation results and device characteristics necessary for inspection and use in commerce are on the following pages.

Chairman, NCWM, Inc.

Chairman, National Type Evaluation Program Committee

Issue date:

Note: The National Conference on Weights and Measures does not "approve", "recommend", or "endorse" any proprietary product or material, either as a or as single item a class or group. Results shall not be used in advertising or sales promotion to indicate explicit or implicit endorsement of the product or material by the NCWM.

Figure 3-4A. Page 1 of a Sample NTEP Certificate of Conformance for a Load Cell

Load Cell Company
Bending Beam Load Cell
Model: 12345 Series

Application: The load cells may be used in Class III L scales for multiple cell applications consistent with the model designations, number of scale divisions, and parameters specified in this certificate. Load cells of a given accuracy class may be used in applications with lower accuracy class requirements provided the number of scale divisions, the v_{min} values, and temperature range are suitable for the application. The manufacturer may market the load cell with fewer divisions (n_{max}) and with larger v_{min} values than those listed on the certificate. However, the load cells must be marked with the appropriate n_{max} and v_{min} for which the load cell may be used.

Identification: A pressure sensitive identification badge containing the manufacture's name, model designation, and serial number is located on the load cell. All other required information, if not marked on the load cell, must be on an accompanying document including the serial number of the load cell.

Test Conditions: This Certificate supersedes Certificate of Conformance Number 04-XXXA2 and is issued without additional testing to include a vertical threaded hole in the end of the beam for load application. The CC holder supplied technical information and performance data. This load application was also evaluated in a vehicle scale under NTEP CC 04-YYY. Previous test conditions are listed below as reference.

Certificate of Conformance Number 04-XXXA2: This Certificate supersedes Certificate of Conformance Number 04-XXXA1 and is issued without additional testing to include the Model 12345-60.0K, 60 000-lb capacity load cells.

Certificate of Conformance Number 04-XXXA1: This addendum was issued to change the v_{min} of the Model 12345-75.0K load cell from 7.50 lb to 7.00 lb. The certificate was previously changed to include the 50 000-lb capacity load cell in the 12345 Model Family. Testing of the two 37 500-lb load cells indicated below was performed in addition to the testing performed at the time that Certificate of Conformance Number 04-XXXP was issued. Results of the additional testing indicate it is appropriate to include the 50 000-lb load cell in this certificate.

Certificate of Conformance Number 04-XXX: This Certificate superseded Certificates of Conformance Numbers 04-XXXP and 04-XXXPA and was issued to upgrade the status of the certificates from provisional to full.

Certificate of Conformance Number 04-XXXPA: This Certificate superseded Certificate of Conformance Number 04-XXXP and was issued to include the Model 12345-50.0K, 50 000-lb capacity load cells. Two 37 500-lb capacity load cells were tested at NIST using dead weights as the reference standard. The data were analyzed for multiple load cell applications. The cells were tested over a temperature range of -10 °C to 40 °C. Three tests were run on each cell at each temperature. The temperature effect on zero was measured and a time dependence (creep) test was performed. The barometric pressure test was waived due to the insensitivity of the load cell design to changes in barometric pressure.

Certificate of Conformance Number 04-XXXP: Two 37 500-lb capacity load cells were tested at the manufacturer's laboratory using dead weights as the reference standard. The data were analyzed for multiple load cell applications. The cells were tested over a temperature range of -10 °C to 40 °C. Three tests were run on each cell at each temperature. The temperature effect on zero was measured and a time dependence (creep) test was performed. The barometric pressure test was waived due to the insensitivity of the load cell design to changes in barometric pressure.

The results of the evaluations indicate the load cell complies with applicable requirements of NIST Handbook 44.

Type Evaluation Criteria Used: NIST Handbook 44, 2004 Edition

Tested By: NIST Force Group, NIST Office of Weights and Measures

Information Reviewed By: NTEPDirector

Figure 3-4B. Page 2 of a Sample NTEP Certificate of Conformance for a Load Cell

In the case of multiple scales used together to perform single-draft weighings, each individual element must be marked as it would be if used in a single system. However, elements that perform for the system as a whole must be marked with aggregate capacities. For example, if a single indicator is used to total the registrations of the separate weighing elements, its nominal capacity and n_{max} must be based upon the total capacity of the system and, at the same time, must meet the requirements for III L scales in Handbook 44.

Thus, if the individual elements have capacities of 100,000 lb, 100,000 lb, and 60,000 lb and scale divisions of 20 lb, the nominal capacity marked on the totalizing indicator can be greater than any of the individual units but could not be equal to the sum of the individual capacities, because the number of scale divisions would not meet Handbook 44 requirements for the maximum number of scale divisions permitted on Class III L scales:

$$100{,}000 + 100{,}000 + 60{,}000 = 260{,}000 \text{ lb}$$

$$260{,}000/20 = 13{,}000 \text{ scale divisions}$$

An appropriate nominal capacity for this scale system would be 200,000 pounds, because the number of scale divisions would meet Class III L requirements:

$$200{,}000 \div 20 = 10{,}000 \text{ scale divisions}$$

The totalizing indicator would also have to meet all other applicable requirements. For example, it could not indicate values in excess of 105 percent of the marked nominal capacity of the system.

Determining the Suitability of System Components

As explained in the last section, marking requirements apply to the separate major components of a vehicle or axle-load scale: the indicating element, the weighing/load-receiving elements and, if the system is so equipped, to load cells and/or other devices. Some vehicle and axle-load scales are custom built for a specific set of service requirements from separate components, and some scale systems currently in service have been modified since their original installation. As a result, the fact that the marking of a particular component is correct and that the model has received an NTEP Certificate of Conformance does not guarantee that the component is suitable for the specific installation. You should, therefore, determine the suitability of the components used in the system before proceeding to the inspection of individual components. Note, however, that it is only possible to make this determination for components that are marked.

In general, each of the capacities and parameters of the scale system as a whole is limited by the corresponding feature of the individual component of the system that is most limited. For example, if the temperature ranges of the indicating element and the load cells are different, the system as a whole is only suitable for use within the narrowest temperature range.

Similarly, the number of scale divisions for the scale must be less than or equal to the maximum number of scale divisions n_{max} for the indicator or the load cells, whichever is less; for example, if the indicator has an n_{max} of 10,000 and the load cells have an n_{max} of 5,000, then the scale may be used for up to 5,000 divisions.

The marked Accuracy Class of all components should also be checked. For vehicle and axle-load scales, components marked for Class III or III L, or those marked for dual application (III/III L) are suitable. Remember that scale components marked for Accuracy Class III may also be used in Class III L applications, but that components marked Class III L may not be used in Class III applications.

It is especially important to verify the suitability of load cells used in fully electronic and electromechanical scales. The EPO for vehicle and axle-load scales equipped with electronic digital indicators (No. 13-E) specifies several determinations that are applicable to load cells with NTEP CCs. These determinations are listed under the "Markings" section of the EPO.

In addition to checking the n_{max} marked on the load cells to determine the appropriate number of scale divisions for the scale system and determining that the Accuracy Class is appropriate to the application, as described above, two additional verifications are specified:

- appropriate use in single versus multiple load cell application, and
- conformance for field examination purposes with a requirement relating to temperature effect on zero-load balance.

Load cells with CCs must be marked to indicate whether the cell is designed for single- or multiple-applications. Load cells approved for single use (usually bearing an "S" marking) may also be employed in multiple cell applications. However, cells marked for multiple use (usually with the letter "M") cannot be used in single cell applications (for example, in an electromechanical system that incorporates a single load cell).

In accordance with T.N.8.1.3., on Class III L devices, including vehicle and axle-load scales, zero-load indication may not vary by more than 3 scale divisions for every change in temperature of 9 °F (5 °C).

T.N.8.1.3. Temperature Effect on Zero-Load Balance. - The zero-load indication shall not vary by more than:

(a) three divisions per 5 °C (9 °F) change in temperature for Class III L devices; or

(b) one division per 5 °C (9 °F) change in temperature for all other devices.
(Amended 1990)

NIST Handbook 44, Scales Code, Paragraph T.N.8.1.3.

It is not possible to test for conformance with requirements relating to the effect of temperature on zero-load balance (T.N.8.1.3.) in the field. However, as stated in EPO 13-E, a load cell may be considered to meet this requirement for the purpose of a field examination if its marked v_{min} does not exceed a calculated value as specified in NIST Handbook 44 Scales Code paragraph S.5.4. and summarized below. Note that the requirements in paragraph S.5.4. do not apply to complete scales and weighing elements which satisfy certain criteria as specified in S.5.4.

- for fully electronic systems employing more than one load cell, the v_{min} may not exceed the scale division (d) divided by the square root of the number of cells employed (N):

$$v_{min} \leq \frac{d}{\sqrt{N}}$$

A table including calculated values for a number of d and N values is provided at the end of EPO 13-E (Appendix A).

- for electromechanical scales (lever systems employing a single load cell), the marked v_{min} may not exceed the scale division divided by the scale multiple (which can be determined from the ratios marked on the levers):

$$v_{min} \leq \frac{d}{\text{Scale multiple}}$$

Examples of both calculations are provided following the table in Appendix A of the EPO. Note that the calculated limit for v_{min} will vary for the same model cell when installed in scale systems with a different number of sections or a different scale multiple. This verification thus relates to the suitability of the load cell being examined (with respect to temperature change on zero-load balance) for use in the specific system in which it has been installed.

S.5.4. Relationship of Load Cell Verification Interval Value to the Scale Division. - *The relationship of the value for the load cell verification scale interval, v_{min}, to the scale division, d, for a specific scale installation shall be:*

(a) where N is the number of load cells in the scale for scales without lever systems: $v_{min} \leq \frac{d}{\sqrt{N}}$

and,

(b) for scales with lever systems: $v_{min} \leq \frac{d}{\sqrt{N \text{ x (scale multiple)}}}$

[Nonretroactive as of January 1, 1994]

[Note: When the value of the scale division, d, is different than the verification scale division, e, for the scale, the value of e must be used in the formulae above]

This requirement does not apply to complete scales and weighing elements which satisfy the following criteria:

(1) The device has been evaluated for compliance with T.N.8.1. Temperature under the National Type Evaluation Program (NTEP);

(2) The device has received an NTEP Certificate of Conformance; and

(3) The device must be equipped with an automatic zero-setting mechanism which cannot be made inoperative in the normal weighing mode. (A test mode which permits the disabling of the automatic zero-setting mechanism is permissible, provided the scale cannot function normally while in this mode.)
(Added 1993) (Amended 1996)

NIST Handbook 44, Scales Code, Paragraph T.N.8.1.3.

Indicating And Recording Elements

Accuracy Class Designations

Effective January 1, 1986, all scales must be designated with an accuracy class as specified in NIST Handbook 44 Scales Code paragraph S.5.1. Scales Code paragraph S.5.2. requires that the accuracy class of a weighing device be designated by the manufacturer and that the device comply with the parameters specified for the corresponding accuracy class as shown in Table 3.

S.5.1. Designation of Accuracy Class. - *Weighing devices are divided into accuracy classes and shall be designated as I, II, III, III L, or IIII.*
[Nonretroactive as of January 1, 1986]

S.5.2. Parameters for Accuracy Class. - *The accuracy class of a weighing device is designated by the manufacturer and shall comply with parameters shown in Table 3.*
[Nonretroactive as of January 1, 1986]

NIST Handbook 44, Scales Code, Paragraphs S.5.1. and S.5.2.

Table 3 *Parameters for Accuracy Classes*			
Class	***Value of the verification scale division (d or e[1])***	***Number of scale[4] divisions (n)***	
		Minimum	***Maximum***
SI Units			
I	*equal to or greater than 1 mg*	*50 000*	*--*
II	*1 to 50 mg, inclusive*	*100*	*100 000*
	equal to or greater than 100 mg	*5 000*	*100 000*
III[2]	*0.1 to 2 g, inclusive*	*100*	*10 000*
	equal to or greater than 5 g	*500*	*10 000*
III L[3]	*equal to or greater than 2 kg*	*2 000*	*10 000*
IIII	*equal to or greater than 5 g*	*100*	*1 200*
INCH-POUND Units			
III	*0.0002 lb to 0.005 lb, inclusive*	*100*	*10 000*
	0.005 oz to 0.125 oz, inclusive	*100*	*10 000*
	equal to or greater than 0.01 lb	*500*	*10 000*
	equal to or greater than 0.25 oz	*500*	*10 000*
III L[3]	*equal to or greater than 5 lb*	*2 000*	*10 000*
IIII	*greater than 0.01 lb*	*100*	*1 200*
	greater than 0.25 oz	*100*	*1 200*

[1]For Class I and II devices equipped with auxiliary reading means (i.e., a rider, a vernier, or a least significant decimal differentiated by size, shape, or color), the value of the verification scale division "e" is the value of the scale division immediately preceding the auxiliary means.

[2] A scale marked "For prescription weighing only" may have a scale division not less than 0.01 g. (Added 1986)

[3] The value of a scale division for crane and hopper (other than grain hopper) scales shall be not less than 0.2 kg (0.5 lb). The minimum number of scale divisions shall be not less than 1 000.

[4]On a multiple range or multi-interval scale the number of divisions for each range independently shall not exceed the maximum specified for the accuracy class. The number of scale divisions, n, for each weighing range is determined by dividing the scale capacity for each range by the verification scale division, e, for each range. On a scale system with multiple load receiving elements and multiple indications, each element considered shall not independently exceed the maximum specified for the accuracy class. If the system has a summing indicator, the n_{max} for the summed indication shall not exceed the maximum specified for the accuracy class.

[Nonretroactive as of January 1, 1986.] (Amended 1986, 1987, 1997, 1998, and 1999) (Footnote 4 Added 1997)

NIST Handbook 44, Scales Code, Table 3

Scale Division: Value (d) and Number (n)

The Scales Code requires that for all scales manufactured after January 1, 1986, the value of scale division units must be either 1, 2, or 5, a decimal multiple or submultiple of 1, 2, or 5, or a binary submultiple of a specific unit (e.g., ½ ounce, ¼ pound). That is, on vehicle or axle-load scales, the scale divisions in pound units may be 10 lb, 20 lb, or 50 lb, but not 30 lb or 40 lb. This requirement is based on an international requirement that was adopted to insure the use of sequences of numbers with which people are most familiar and promote logic in the tolerance structure.

In addition, all digital-indicating scales (except postal scales) manufactured after January 1, 1989, are required to indicate weight values using only a single unit of measure; for example, a digital vehicle scale may not indicate in both pounds and ounces. Selection of different weight units from an external key or switch is permitted, however. The Scales Code also prohibits the digital representation of common fractions such as 1/2 or 1/4.

S.1.2. Value of Scale Division Units. - *Except for batching scales and weighing systems used exclusively for weighing in predetermined amounts, the value of a scale division "d" expressed in a unit of weight shall be equal to:*

(a) 1, 2, or 5; or

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

(c) a binary submultiple of a specific unit of weight.

Examples: scale divisions may be 0.01, 0.02, 0.05; 0.1, 0.2, or 0.5; 1, 2, or 5; 10, 20, 50, or 100; or, scale divisions may be 1/2, 1/4, 1/8, 1/16, etc.
[Nonretroactive as of January 1, 1986]

S.1.2.1. Weight Units. - Except for postal scales, a digital-indicating scale shall indicate weight values using only a single unit of measure. Weight values shall be presented in a decimal format with the value of the scale division expressed as 1, 2, or 5, or a decimal multiple or submultiple of 1, 2, or 5.
[Nonretroactive as of January 1, 1989]
(Added 1987)

NIST Handbook 44, Scales Code, Paragraphs S.1.2. and S.1.2.1.

All scales must meet the basic requirement of suitability for their application. Among other characteristics, the size and number of scale divisions determine the suitability of a scale for a particular application.

The Scales Code limits either the size or the number of scale divisions that may be employed. The applicable requirement depends upon whether or not the scale is marked with an accuracy class.

If the scale was manufactured before January 1, 1986, it will not be marked with an accuracy class. In this case, a maximum scale division size is specified in Table 7b of the Scales Code, which is referenced in paragraph UR.1.1.(b).

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

[1] Purchasers and users of scales such as railway track, hopper, and vehicle scales should be aware of possible additional requirements for the design and installation of such devices.
(Footnote Added 1995)

NIST Handbook 44, Scales Code, Paragraph UR.1.

Table 7b.
Applicable to Devices not Marked With a Class Designation

Scale Type or Design	Maximum Value of d
Retail Food Scales, 50-lb capacity and less	1 ounce
Animal Scales	1 pound
Grain Hopper Scales Capacity up to and incl. 50 000 lb Capacity over 50 000 lb	 10 pounds (not greater than 0.05 % of capacity) 20 pounds
Crane Scales	not greater than 0.2 % of capacity
Vehicle and Axle-Load Scales Used in Combination Capacity up to and including 200 000 lb Capacity over 200 000 lb	 20 pounds 50 pounds
Railway Track Scales With weighbeam Automatic indicating	 20 pounds 100 pounds
Scales with capacities greater than 500 lb except otherwise specified	0.1 % capacity (but not greater than 50 lb)
Wheel-Load Weighers	0.25 % capacity (but not greater than 50 lb)
Note: For scales not specified in this table, G-UR.1.1. and UR.1. apply. (Added 1985) (Amended 1989)	

NIST Handbook 44, Scales Code, Table 7b

According to this table, for a vehicle scale or for axle-load scales used in combination that were manufactured before January 1, 1986 (and, therefore, not marked accuracy class III L), the value of the scale division may not be greater than 20 lb if the capacity of the scale is 200,000 lb or less. For scales with capacity over 200,000 lb, the value of the scale division may not be greater than 50 lb.

In all likelihood, nearly all axle-load scales (used alone or in combination) and many vehicle scales that you encounter will have capacities of 200,000 lb (100 tons) or less and will have scale divisions not greater than 20 lb. You may, however, encounter a few old axle-load scales that are being used alone for enforcement

purposes; these scales should be subject to the requirement for "Scales with capacities greater than 500 lb except otherwise specified" in Table 7b and thus could have scale division values larger than 20 lb.

Scales manufactured on or after January 1, 1986, to be used for vehicle or axle-load weighing will be marked III L. For these scales there is no maximum size for the scale division, but the scale must meet the requirements of an accuracy class III L scale: no fewer than 2,000 scale divisions and no more than 10,000 scale divisions, with a minimum scale division of 5 lb. This requirement is set forth in Table 3, which is referenced in paragraph S.5.2.

To determine the number of scale divisions (n) on a scale, you need to know the value of the scale division (d) and the scale capacity.

The value of the scale division (the smallest subdivision of the scale for analog devices or the difference between two consecutively indicated values for digital devices) is required to be marked on the device. It frequently appears as part of the capacity statement, e.g., 200,000 × 20 lb (d = 20 lb).

To determine the number of scale divisions, divide scale capacity by the scale division value,

$$n = \frac{\text{scale capacity}}{\text{scale division value}} = \frac{200{,}000}{20} = 10{,}000 \text{ divisions}$$

The formula for determining the number of scale divisions that is given in Handbook 44 indicates that the scale capacity should be divided by the "verification scale division (e)," which is the value by which the tolerance values and accuracy class for a device are determined. The verification scale division (e) may be different from the displayed scale division (d); however, they are usually the same in the case of vehicle and axle-load scales.

In the above example, n corresponds to the maximum number of scale divisions permitted for a Class III L scale. A scale with this capacity could have as few as 2,000 divisions, but the divisions would have to be 100 lb. Since vehicle and axle-load scales typically have scale divisions of 10 or 20 lb, this effectively limits their capacity to 100,000 and 200,000, respectively. Typical scale capacity values, scale division values, and number of scale divisions found on vehicle and axle-load scales now in use are as shown in Figure 3-5.

Type	Capacity (pounds)	Scale Division Value	Number of Scale Divisions
Vehicle scale	40 000	10	4 000
	50 000	10	5 000
	60 000	10	6 000
	100 000	10	10 000
	40 000	20	2 000
	50 000	20	2 500
	60 000	20	3 000
	100 000	20	5 000
	120 000	20	6 000
	150 000	20	7 500
	160 000	20	8 000
	200 000	20	10 000
Axle-load scale	40 000	20	2 000
	60 000	20	3 000

Figure 3-5. Typical Scale Capacities, Scale Division Values, and Number of Scale Divisions for Vehicle and Axle-Load Scales

An important question of interpretation arises with respect to the application of the limitations on the number of scale divisions in S.5.2. and Table 3 to multiple-weighing systems, that is, systems in which a number of independent weighing devices are interfaced with a totalizing indicating element and are used to perform single-draft weighings of vehicles. Consider three axle-load scales with the following capacities: 100,000 × 20 lb, 100,000 × 20 lb, and 60,000 × 20 lb. When used simultaneously for single draft weighing, their separate weight registrations are summed by a single indicator. If considered as separate scales, they would each meet the requirements for n in Table 3, since they have 5,000, 5,000, and 3,000 divisions, respectively. However, if considered as a single scale, with a capacity of 260,000 lb and a total of 13,000 scale divisions, the system would exceed the maximum n for Class III L scales.

In 1990, the NCWM adopted a statement supporting the interpretation that multiple weighing devices used together must be considered to be a single system, and that Handbook 44 requirements must be met by each scale separately and by the system as a whole. A detailed discussion of this interpretation and its implications for other design and marking requirements, and for the application of tolerances, can be found in Item 320-11of the "Report of the 75th National Conference on Weights and Measures." This topic will be discussed further in this module under the various applicable requirements.

Multi-Interval and Multiple Range Devices

Some weighing devices may be used for multiple purposes. For example, a combination vehicle and railway track scale is used to weigh both highway vehicles and railroad cars. In order to ensure a suitable scale division size and to meet minimum load and suitability requirements for both weighing applications, a multi-interval scale will often be used. A multi-interval scale is one in which a single weighing range is divided into partial weighing ranges, each with a different scale interval. The weighing range and

corresponding division are determined automatically according to the load applied to the scale. For example, a combination vehicle/railway track scale may have the following intervals:

Weighing Range (Capacity)	"e" = verification scale division	n = number of divisions
0 - 100 000 lb	-	5000
100 000 - 200 000 lb	50	4000
200 000 - 400 000 lb	100	4000

The number of divisions, n, for each weighing range is determined by dividing the scale capacity for each range by the verification scale division, e, for each range. Paragraph S.5.3. requires that the value of "e" be equal to the value of "d" for multi-interval and multiple range scales.

S.5.3. Multi-Interval and Multiple Range Scales, Division Value. - On a multi-interval scale and multiple range scale, the value of "e" shall be equal to the value of "d." [1]
(Added 1986) (Amended 1995)

[1] See Footnote 1 to Table 3 Parameters for Accuracy Classes.

NIST Handbook 44, Scales Code, Paragraph S.5.3.

A similar type of scale is a manual multi-interval scale. This is a device in which the capacity and the value of the scale division is changed by manual operation. Each manually-selected capacity and scale division (weighing range) is considered to be an individual scale and evaluated accordingly.

Another variation is a multiple-range scale. This instrument has two or more weighing ranges with different maximum capacities and different scale intervals for the same load-receiving element. However, each range extends from zero to its maximum capacity. The weighing ranges maybe either manually or automatically selected. Each weighing range is considered to be an individual scale and evaluated accordingly.

Rounding

As said earlier, digital values, whether on an electronic indicator or generated by a printer, will be a rounded value. The General Code requires that indicated or recorded values must represent the registered weight to the nearest minimum graduation. For scales, this means that the weight increment should be divided evenly between successive indicated or recorded increments.

G-S.5.2.2. Digital Indication and Representation. - Digital elements shall be so designed that:
…
(c) A digital value "rounds off" to the nearest minimum unit that can be indicated or recorded.

(Amended 1973 and 1985)

NIST, Handbook 44 General Code, Paragraph G-S.5.2.2.(c)

Consider, for example, a 200,000-lb capacity vehicle scale with an electronic digital indicator having 20-lb scale divisions. If a load of 120,505 lb is sensed by the weighing element, the indicator should register

120,500 lb, since that is the closest indication to the weight; if 10 pounds is added to the load, for a total of 120,515, the indicator should read 120,520. A printed ticket would have to represent the same values under these conditions. The indication and **recorded representation** would change at exactly the midpoint of the scale division, in this example, at 120,510 lb (within the limits of sensitivity of the device).

Note that this is analogous to the correct method for reading values on an analog device, as described in Handbook 44 (Appendix A, Fundamental Considerations, section 10.3). This is obviously the most equitable method. If values were always rounded to the next (higher) value, the seller could charge for product not delivered up to a full scale division, and would never be selling less than the registered amount; if values were rounded to the previous (lower) value, the buyer would benefit in the same way. Since actual quantities of product delivered often fall more or less randomly between indicated amounts, rounding to the nearer value should balance out over a number of transactions, and the rounding in each transaction will be small enough that neither party is materially affected.

Manual Weight Entries

Some electronic scales are equipped with a feature that permits the operator to manually enter a weight value through a keyboard. As specified in NIST Handbook 44 Scales Code paragraph S.1.12., a device shall accept an entry of a manual weight value only when the scale is at gross load zero and the scale indication is at zero in the gross weight display mode. This helps to ensure that that the manual weight value does not appear to be a result of a normal weighing operation. For devices equipped with a printer capable of printing manual weight values, the manual weight value must be identified and defined by specific terms as specified in paragraph S.1.12. A related user requirement, paragraph UR.3.9., only permits the use of manual weight entries under very specific conditions. For vehicle scales, manual weight entries are only permitted when the system generates a weight ticket to correct an erroneous value.

S.1.12. Manual Gross Weight Entries. - *A device shall accept an entry of a manual weight value only when the scale is at gross load zero and the scale indication is zero in the gross weights display mode. Recorded manual weight entries, except those on labels generated for packages of standard weights, shall identify the weight value as a manual weight entry by one of the following terms: "Manual Weight," "Manual Wt," or "MAN WT." The use of a symbol to identify multiple manual weight entries on a single document is permitted, provided that the symbol is defined on the same page on which the manual weight entries appear and the definition of the symbol is automatically printed by the recording element as part of the document.*
[Nonretroactive as of January 1, 1993]
(Added 1992)

UR.3.9. Use of Manual Gross Weight Entries. - Manual gross weight entries are permitted for use in the following applications only: (1) when credit is given for a weighed item on point-of-sale systems interfaced with scales; (2) when a device or system generates labels for standard weight packages; (3) when postal scales or weight classifiers generate manifests for packages to be picked up at a later time; or (4) when livestock and vehicle scale systems generate weight tickets to correct erroneous tickets.
(Added 1992) (Amended 2000)

NIST Handbook 44, Scales Code, Paragraphs S.1.12. and UR.3.9.

Tare Division Value and Tare Mechanism

A nonretroactive requirement, effective as of January 1, 1983, specifies that the tare division on a scale must be equal to the scale division. For example, if the value of the scale division is 20 lb, the value of the tare division must be 20 lb.

This same paragraph (S.2.3) also includes requirements that apply to the tare mechanism. The function of a tare mechanism is to subtract the weight of the empty vehicle from the total or gross load. However, operation of the tare mechanism may not in any case cause a scale to display a weight value that is more than the actual weight of the product. You must, therefore, determine that tare operates only in the direction of **underregistration** with respect to zero. This portion of the requirement is fully retroactive, and applies to both mechanical and digital scale systems.

S.2.3. Tare. - *On any scale (except a monorail scale equipped with digital indications), the value of the tare division shall be equal to the value of the scale division.** The tare mechanism shall operate only in a backward direction (that is, in a direction of underregistration) with respect to the zero-load balance condition of the scale. *A device designed to automatically clear any tare value shall also be designed to prevent the automatic clearing of tare until a complete transaction has been indicated.**

*[Note: On a computing scale, this requires the input of a unit price, the display of the unit price, and a computed positive total price at a readable equilibrium. Other devices require a complete weighing operation, including tare, net, and gross weight determination]**

*[*Nonretroactive as of January 1, 1983]*
(Amended 1985)

NIST Handbook 44, Scales Code, Paragraph S.2.3.

In direct sale situations, the customer must be able to verify the amount of tare during the transaction. Some scales with electronic digital indicators are designed to automatically clear the tare value at the end of a transaction. For scales with this capability that are subject to this portion of the requirement (nonretroactive as of January 1, 1983), the design must prevent the automatic clearing of tare until a complete transaction has been indicated. The complete transaction might include tare, net, and gross weight determination. If the scale you are examining is used for direct sales, you must verify that an appropriate tare mechanism is used.

The performance of the tare mechanism will be verified as a part of the Test portion of the scale examination, and will be covered in Chapter 6 of this module.

Appropriateness of Design

General

Many of the requirements relating to the appropriateness of indicating and recording elements are set forth in the section G-S.5. of the General Code, and apply to all commercial weighing measuring devices (except those specifically excluded). The most basic requirement states that indicating and recording elements must be "appropriate in design and adequate in amount," and that primary indications and recorded representations must be clear, definite, accurate, and readable under normal conditions of service.

G-S.5.1. General. - All weighing and measuring devices shall be provided with indicating or recording

elements appropriate in design and adequate in amount. Primary indications and recorded representations shall be clear, definite, accurate, and easily read under any conditions of normal operation of the device.

NIST Handbook 44 General Code, Paragraph G-S.5.1.

Primary indicating and recording elements are those that are used as the basis for a commercial transaction. In the case of vehicle and axle-load scales, this would include the indicator and a printer that produces the record of the transaction (if the system is so equipped), and any remote indicators if they are used by the operator to determine the vehicle weight or the weight basis for charges. In multiple scale applications, all indicating and recording elements for all scales used to weigh single vehicles are considered to be primary elements of a single system.

Inspect indicating and recording elements identified as primary to verify that they are appropriate in design, adequate in amount, and easy to read under normal operating conditions. Be particularly alert when there have been replacements or modifications.

The general requirement in G-S.5. for analog indicators simply states that graduations and a suitable indicator must be provided.

G-S.5.2.1. Analog Indication and Representation. - Graduations and a suitable indicator shall be provided in connection with indications designed to advance continuously.

NIST Handbook 44, General Code, Paragraph G-S.5.2.1.

Requirements for digital indications and recorded representations are somewhat more detailed, and recognize the necessity of reconciling all indications within a weighing system.

G-S.5.2.2. Digital Indication and Representation. - Digital elements shall be so designed that:

(a) All digital values of like value in a system agree with one another.

(b) A digital value coincides with its associated analog value to the nearest minimum graduation.

(c) A digital value "rounds off" to the nearest minimum unit that can be indicated or recorded.

(d) A digital zero indication includes the display of a zero for all places that are displayed to the right of the decimal point and at least one place to the left. When no decimal values are displayed, a zero shall be displayed for each place of the displayed scale division.
[Nonretroactive as of January 1, 1986.]
(Amended 1973 and 1985)

NIST Handbook 44, General Code, Paragraph G-S.5.2.2.

To summarize these requirements in terms of scales:

- All digital values within the system must agree with one another. This means, for example, that the weight displayed on an electronic digital indicator, on a ticket printer used with that indicator and on a remote display that is part of the same system must agree exactly.

- Any displayed digital value must agree with an associated analog value to the nearest scale

division. For example, if the indicator on a mechanical dial scale stops between successive graduations, the value recorded on a printed ticket must be the same as the value of the graduation on the dial that is closest to the indicator.

- Digital indications and recorded representations must be rounded to the nearest minimum scale division. (This requirement was discussed under Rounding, above.)

- On vehicle and axle-load scales with digital indicating elements that do not display decimal values, a zero must be displayed for each digit in the displayed scale division. (This requirement was discussed under Zero-load Balance, above.)

Conformance with these requirements can only be determined when the scale is in operation. The Test Notes section of the EPOs instructs the inspector to check indications and recorded representations for agreement repeatedly.

Three additional requirements relate to the size and character, representation of values, and permanence of graduations, indications, and recorded representations.

G-S.5.2.3. Size and Character. - In any series of graduations, indications, or recorded representations, corresponding graduations and units shall be uniform in size and character. Graduations, indications, or recorded representations that are subordinate to, or of a lesser value than others with which they are associated, shall be appropriately portrayed or designated. [Made retroactive as of January 1, 1975.]

G-S.5.2.4. Values. - If graduations, indications, or recorded representations are intended to have specific values, these shall be adequately defined by a sufficient number of figures, words, symbols, or combinations thereof, uniformly placed with reference to the graduations, indications, or recorded representations and as close thereto as practicable, but not so positioned as to interfere with the accuracy of reading.

G-S.5.2.5. Permanence. - Graduations, indications, or recorded representations and their defining figures, words, and symbols shall be of such character that they will not tend easily to become obliterated or illegible.

NIST Handbook 44, General Code, Paragraphs G-S.5.2.3., G-S.5.2.4., and G-S.5.2.5.

These requirements are intended to help insure that the meaning and associated values of indications and recorded representations are clear to the user.

According to paragraph G-S.5.3., the values assigned to graduated intervals (the distance from the center of one graduation to the center of the succeeding graduation) must be uniform within any series of graduations.

G-S.5.3. Values of Graduated Intervals or Increments. - In any series of graduations, indications, or recorded representations, the values of the graduated intervals or increments shall be uniform throughout the series.

NIST Handbook 44, General Code, Paragraph G-S.5.3.

For example, on a dial scale with 20-lb and 100-lb graduations, the values of the graduated intervals could not change to 10-lb and 50-lb midway through the series of graduations. On an electronic scale with a scale division value of 10 lb, the scale could not suddenly begin indicating in 20-lb increments (unless the scale

was identified as being a multi-range scale — in that case, the scale division values could change at some point, but the would have to be uniform within the range specified on the device.)

A subparagraph of G-S.5.3. relates this requirement to devices that indicate or record in both inch-pound and metric units.

G-S.5.3.1. On Devices That Indicate or Record in More Than One Unit. - On devices designed to indicate or record in more than one unit of measurement, the values indicated and recorded shall be identified with an appropriate word, symbol, or abbreviation.
[Made retroactive 1990] (Amended 1978 and 1986)

NIST Handbook 44, General Code, Paragraph G-S.5.3.1.

It is a fundamental requirement of any weighing or measuring device that it be capable of repeating its indications and recorded representations. Failure to repeat the same indication for the same test load applied under the same conditions generally indicates a worn or malfunctioning component. The General Code states the basic requirement for repeatability.

Performance requirements and test procedures relating to repeatability will be described in Chapters 5 and 6.

G-S.5.4. Repeatability of Indications. - A device shall be capable of repeating, within prescribed tolerances, its indications and recorded representations. This requirement shall be met irrespective of repeated manipulation of any element of the device in a manner approximating normal usage (including displacement of the indicating elements to the full extent allowed by the construction of the device and repeated operation of a locking or relieving mechanism) and of the repeated performance of steps or operations that are embraced in the testing procedure.

NIST Handbook 44, General Code, Paragraph G-S.5.4.

Most vehicle and axle-load scales are not equipped with computing-type indicators. However, in applications in which a charge or fee is based upon the weight of the vehicle contents, some systems have a computer linked to the indicator, which computes the charges associated with the registered weight and drives a printer that makes a permanent record. Since these components provide the basis for the transaction, they are considered to be primary elements, subject to all applicable requirements. Specifically, the General Code includes a requirement relating to recorded money values or digital money value indications produced by a computing device.

For example, if a shipping company's fee schedule for transporting a commodity to a particular location is $8.87 per hundredweight (100 pounds) and the vehicle scale, after taking tare, registers a net weight of 38,690 lb, the total fee for the transaction, computed mathematically, would be $3,431.803 (38,690/100 x $8.87). The indication or recorded representation produced by the system would have to be $3,431.80.

G-S.5.5. Money Values, Mathematical Agreement. - Any recorded money value and any digital money-value indication on a computing-type weighing or measuring device used in retail trade shall be in mathematical agreement with its associated quantity representation or indication to the nearest 1 cent of money value. This does not apply to auxiliary digital indications intended for the operator's use only, when these indications are obtained from existing analog customer indications that meet this requirement. (Amended 1973)

NIST Handbook 44, General Code, Paragraph G-S.5.5.

Another paragraph in the General Code states that requirements applicable specifically to indicating and recording elements are also applicable to recorded representations, when they are appropriate. This paragraph also states, as mentioned above, that all recorded values must be printed digitally. It would not, for example, be permissible to print a representation of a dial face, with the printed arrow indicating the value corresponding to the value indicated on the scale.

G-S.5.6. Recorded Representations. - Insofar as they are appropriate, the requirements for indicating and recording elements shall also apply to recorded representations. All recorded values shall be printed digitally.
[Made retroactive 1990] (Amended 1975)

NIST Handbook 44, General Code, Paragraph G-S.5.6.

A final requirement in this section makes it clear that all of the requirements in Handbook 44 for indications and graduations apply to indications and graduations that are magnified by an optical system. For example, if a magnifier is used to make a dial indicator more easily readable, the distance between the end of the indicator graduations in the magnified image could be no more than 0.06 inch (S.1.4.4.)

G-S.5.7. Magnified Graduations and Indications. - All requirements for graduations and indications apply to a series of graduations and an indicator magnified by an optical system or as magnified and projected on a screen.

NIST Handbook 44, General Code, Paragraph G-S.5.7.

Weighbeams

Requirements relating to weighbeams are set forth in paragraph S.1.5. of the Scales Code. The various requirements under this paragraph will be discussed separately in this section, except for subparagraph S.1.5.5, which applies only to scales with nominal capacity of 30 lb or less, which is far below the capacity of vehicle and axle-load scales.

A weighbeam on a vehicle or axle-load scale must be properly constructed and must function properly. When at rest in the normal position, the weighbeam must be horizontal.

S.1.5.1. Normal Balance Position. - The normal balance position of the weighbeam of a beam scale shall be horizontal.

NIST Handbook 44, Scales Code, Paragraph S.1.5.1.

When in motion, the tip of the beam must travel equal distances above and below horizontal. A trig loop may be used to show a balanced condition, with the edges of the trig loop stopping the travel of the weighbeam tip. There may be other stops that limit travel of the weighbeam. In either of these cases, the distance the weighbeam travels between limiting stops must meet the minimums shown in Table 1.

S.1.5.2. Travel. - The weighbeam of a beam scale shall have equal travel above and below the horizontal. The total travel of the weighbeam of a beam scale in a trig loop or between other limiting stops near the weighbeam tip shall be not less than the minimum travel shown in Tables 1M and 1. When such limiting stops are not provided, the total travel at the weighbeam tip shall be not less than 8 percent of the distance from weighbeam fulcrum to the weighbeam tip.

NIST Handbook 44, Scales Code, Paragraph S.1.5.2.

Table 1 M. Minimum Travel of Weighbeam of Beam Scale Between Limiting Stops	
Distance from weighbeam fulcrum to limiting stops (centimeters)	Minimum travel between limiting stops (millimeters)
30 or less	10
30+ to 50, inclusive	13
50+ to 100, inclusive	18
Over 100	23

Table 1. Minimum Travel of Weighbeam of Beam Scale Between Limiting Stops	
Distance from weighbeam fulcrum to limiting stops (inches)	Minimum travel between limiting stops (inches)
12 or less	0.4
12+ to 20, inclusive	0.5
20+ to 40, inclusive	0.7
Over 40	0.9

NIST Handbook 44, Scales Code, Tables 1M. and 1.

If a weighbeam has no limiting stops or trig loop, the tip of the weighbeam must have freedom to travel at least 8 percent of the distance from the weighbeam fulcrum to the weighbeam tip. This minimum travel requirement assures that it is readily apparent whether the scale is balanced or out of balance when a reading is taken. Note that this minimum travel is considerably greater than that required in Table 1 for weighbeams equipped with trig loops.

Conformance with the requirements of S.1.5.2. is extremely important because it directly affects the **sensitivity** of the weighbeam, which is a non-automatic-indicating device and therefore depends upon operator judgment to determine the balance condition of the scale. Good sensitivity is required to obtain accurate weight values on a beam scale. As you will learn, specific **performance requirements** apply to sensitivity of both automatic- and non-automatic-indicating scales.

Because weighbeams are seldom submitted for type evaluation, travel should be checked on every weighbeam scale. (When type evaluations have been conducted on weighbeams, this is a common violation.)

Weighbeams may employ customary graduation lines or the poise locating notches may be used as graduations, with the center of the notch corresponding to the graduation line. In some cases, a combination of lines and notches may be used, with the notches representing subdivisions of the intervals between graduation lines. In any case, intervals must be uniform in size, shape, and arrangement. If notches are used as graduations, they must be clearly and accurately marked.

S.1.5.3. Subdivision. - A subdivided weighbeam bar shall be subdivided by scale division graduations, notches, or a combination of both. Graduations on a particular bar shall be of uniform width and perpendicular to the top edge of the bar. Notches on a particular bar shall be uniform in shape and dimensions and perpendicular to the face of the bar. When a combination of graduations and notches is employed, the graduations shall be positioned in relation to the notches to indicate notch values clearly and accurately.

NIST Handbook 44, Scales Code, Paragraph S.1.5.3.

The weighbeam must also be designed so that values are easily and accurately read. Even when a recorded representation can be made, as in the case of a type-registering weighbeam, it must be possible to verify this value from direct observation of the position of the poise on the beam.

S.1.5.4. Readability. - A subdivided weighbeam bar shall be so subdivided and marked, and a weighbeam poise shall be so constructed, that the weight corresponding to any normal poise position can easily and accurately be read directly from the beam, whether or not provision is made for the optional recording of representations of weight.

NIST Handbook 44, Scales Code, Paragraph S.1.5.4.

The graduation lines and numbers, usually etched on the beam, must be clear and distinct, and the index of the poise must be designed in such a way that the graduations are indicated unambiguously, even if the weighbeam is capable of producing a clear and unambiguous recorded representation.

Finally, a stop must be provided to prevent the poise from crossing the zero mark. This prevents a zero-balance adjustment that would have the effect of causing the scale to underregister because the poise was behind the zero graduation when the adjustment was made.

S.1.5.6. Poise Stop. - Except on a steelyard with no zero graduation, a shoulder or stop shall be provided on each weighbeam bar to prevent a poise from traveling and remaining back of the zero graduation.

NIST Handbook 44, Scales Code, Paragraph S.1.5.6.

Poises

As mentioned above, poises are used on scales equipped with a weighbeam. The poise counterbalances the load on the deck and provides a clear indication of the weight of the load. Because the calibration of the scale is based upon the poise weight, replacing the poise with one of a different weight would affect the accuracy of the device. This could be done deliberately to defraud the customer, especially if it were possible to replace the poise used to zero the scale with another of different weight during the transaction, or to remove or replace a part of the poise, such as the locking screw, which would change the weight of the poise. To prevent this, neither the poise nor any part of the poise can be readily removable. Hanging poises must swing freely so that the counterforce is always applied vertically.

S.1.6.1. General. - No part of a poise shall be readily detachable. A locking screw shall be perpendicular to the longitudinal axis of the weighbeam and shall not be removable. Except on a steelyard with no zero graduation, a poise shall not be readily removable from a weighbeam. The knife edge of a hanging poise shall be hard and sharp and so constructed as to allow the poise to swing freely on the bearing surfaces in the weighbeam notches.

NIST Handbook 44, Scales Code, Paragraph S.1.6.1.

Material used for adjusting the weight of the poise must be in a container and firmly fastened in place. Since adjusting weights are often made of soft metal, and could lose material, and thus weight, by sharp contact with a harder surface, adjusting material must not touch the beam if it is softer than brass.

S.1.6.2. Adjusting Material. - The adjusting material in a poise shall be securely enclosed and firmly fixed in position; if softer than brass, it shall not be in contact with the weighbeam.

NIST Handbook 44, Scales Code, Paragraph S.1.6.2.

If the poise is used on a notched weighbeam and is not a hanging poise, as is generally the case with vehicle and axle-load scales, it must have a pawl to seat the poise firmly in the notches. The tip of the pawl should be at least as wide as the notch.

S.1.6.3. Pawl. - A poise, other than a hanging poise, on a notched weighbeam bar shall have a pawl that will seat the poise in a definite and correct position in any notch, wherever in the notch the pawl is placed, and hold it there firmly and without appreciable movement. The dimension of the tip of the pawl that is transverse to the longitudinal axis of the weighbeam shall be at least equal to the corresponding dimension of the notches.

NIST Handbook 44, Scales Code, Paragraph S.1.6.3.

If the notches or the pawl have become so worn that the poise will not seat in a definite position, indications for a given load will vary. You can test the seating of the pawl by carefully positioning the tip inside a notch but as close as possible to an edge. When you release the pawl, it should pull into the center of the notch on its own and seat there securely.

The reading edge of a poise should be sharply defined and parallel to the beam's graduations, as in the example illustrated in Figure 1-10. If this edge is damaged so that it is no longer sharply defined, or is incorrectly aligned, an accurate reading may be difficult.

S.1.6.4. Reading Edge or Indicator. - The reading edge or indicator of a poise shall be sharply defined, and a reading edge shall be parallel to the graduations on the weighbeam.

NIST Handbook 44 Scales Code, Paragraph S.1.6.4.

This requirement should also be considered as applying to the pointer on a fractional bar, like the one shown in Figure 1-10.

Dials and Balance Indicators

The following inspection requirements apply to dial indicators, and also to balance indicators with graduations having a specific weight value. Balance indicators having a single line to indicate balance or a target bar through which the oscillating pointer swings, are not covered. These requirements, which are intended to help assure that graduations are readable, are included in paragraph S.1.3. of the Scales Code.

S.1.3. Graduations.

S.1.3.1. Length. - Graduations shall be so varied in length that they may be conveniently read.

S.1.3.2. Width. - In any series of graduations, the width of a graduation shall in no case be greater than the width of the clear space between graduations. The width of main graduations shall be not more than 50 percent greater than the width of subordinate graduations. Graduations shall be not less than 0.2 mm (0.008 in) wide.

S.1.3.3. Clear Space Between Graduations. - The clear space between graduations shall be not less than 0.5 mm (0.02 in) for graduations representing money values, and not less than 0.75 mm (0.03 in) for other graduations. If the graduations are not parallel, the measurement shall be made:

(a) along the line of relative movement between the graduations at the end of the indicator, or

(b) if the indicator is continuous, at the point of widest separation of the graduations.

NIST Handbook 44, Scales Code, Paragraph S.1.3.

To summarize, graduations on the dial must meet several requirements:

- they must be varied in length so that they may be conveniently read;
- they must be at least 0.2mm (0.008 in) wide, with main graduations not more than 50 percent greater in width than subordinate graduations, and may not be wider than the clear space between graduations;
- the clear space between graduations must be at least 0.75mm (0.03 in) for weight graduations.

It may not be practicable to verify the dimensions specified in S.1.3.2., and S.1.3.3. during a field examination. Since these are minimum dimensions, you may be able to evaluate them without taking a measurement (for comparative purposes, 0.02 inch is the width of a relatively fine mechanical pencil lead). If you have doubts, you may consider requesting that the dial face be removed so that tests can be made with appropriate measuring instruments. Dial indicators that have been type evaluated will meet these basic requirements.

Specific requirements for indicators that are used on dial scales are set forth in paragraph S.1.4. of the Scales Code. In particular, the requirements apply to the **index** of the indicator, that part of the indicator that points to the graduations and is used to make a reading. To summarize these requirements:

- The index of the indicator must be of the same shape as the graduations, and must reach to the finest graduation with which it is used if it is not on the same plane as the graduations. If it is on the same plane, it must reach to within 0.04 inch of the ends of the graduations (for example, in a

case where the dial is inset to minimize parallax effects).

- The index of the indicator may not be wider than the width of the narrowest graduation, and not more than the width of the clear space between graduations.

- Parallax effects must be reduced to the practical minimum. The clearance between the index of the indicator and the graduations may not be more than 0.06 inch.

S.1.4. Indicators.

S.1.4.1. Symmetry. - The index of an indicator shall be of the same shape as the graduations, at least throughout that portion of its length associated with the graduations.

S.1.4.2. Length. - The index of an indicator shall reach to the finest graduations with which it is used, unless the indicator and the graduations are in the same plane, in which case, the distance between the end of the indicator and the ends of the graduations, measured along the line of the graduations, shall be not more than 1.0 mm (0.04 in).

S.1.4.3. Width. - The width of the index of an indicator in relation to the series of graduations with which it is used shall be not greater than:

(a) the width of the narrowest graduation,
[Nonretroactive as of January 1, 2002]

(b) the width of the clear space between weight graduations, and

(c) three-fourths of the width of the clear space between money value graduations.

When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width throughout the length of the index that coincides with the graduation.

S.1.4.4. Clearance. - The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm (0.06 in).

S.1.4.5. Parallax. - Parallax effects shall be reduced to the practicable minimum.

NIST Handbook 44, Scales Code, Paragraph S.1.4.

As with requirements relating to graduations, a visual inspection of the dial should be sufficient to determine conformance in most cases, especially on a dial that has been type evaluated. The one dimension that you may wish to check is the clearance between the index of the indicator and the graduations, since this will have a major impact on parallax effects. If the indicator is bent even by a small amount during assembly (or re-assembly), this clearance may be significantly altered. The scale face cover must be removed to make this check, but it can then be easily accomplished, either with a conventional gap gauge or with a special blade gauge that is used by scale service companies and manufacturers.

Finally, a requirement in the Scales Code (S.1.7.) limits the indicating or recording range of a weighing device to 105 percent of the scale capacity. In addition, the total value of the applied counterforce from units weights or weight ranges in place or in effect must be included in any indicated or recorded value.

S.1.7. Capacity Indication, Weight Ranges, and Unit Weights. -

(a) Gross Capacity. An indicating or recording element shall not display nor record any values when the total platform load (not counting the initial dead load that has been canceled by an initial zero-setting mechanism) is in excess of 105 percent of scale capacity.

(b) Capacity Indication. Electronic computing scales (excluding postal scales and weight classifiers) shall neither display nor record a gross or net weight in excess of scale capacity plus 9 d.

The total value of weight ranges and of unit weights in effect or in place at any time shall automatically be accounted for on the reading face and on any recorded representation.

This requirement does not apply to: (1) single-revolution dial scales, (2) multi-revolution dial scales not equipped with unit weights, (3) scales equipped with two or more weighbeams, nor (4) devices that indicate mathematically derived totalized values.
[Nonretroactive as of January 1, 1993]
(Amended 1990, 1992, and 1995)

NIST Handbook 44, Scales Code, Paragraph S.1.7.

The first part of this requirement is intended to prevent the improper use of a scale to weigh loads in excess of its nominal capacity (a **user requirement**, UR.3.2., which states the basic limitation, will be discussed further below). Though included in test procedures outlined in Chapter 6, it is often not possible to test this design feature under field conditions on vehicle scales because sufficient test weights are not available.

The last part of the requirement has specific applicability to large capacity scales with dial indicators. The unit weight or weight range indication is generated separately from the dial indication, but is necessary in order to make an accurate reading; therefore, the total value of unit weights and weight ranges in place or in effect is required to be accounted for on the reading face of the dial and on any recorded representation.

Damping Means

Scales are required to have an effective means for limiting the number of scale oscillations. Appropriate **damping** is typically 3 to 5 oscillations. On mechanical vehicle and axle-load scales, damping is nearly always achieved by using a fluid dashpot.

S.2.5. Damping Means. - An automatic-indicating scale and a balance indicator shall be equipped with effective means to damp oscillations and to bring the indicating elements quickly to rest.

NIST Handbook 44, Scales Code, Paragraph S.2.5.

During the Increasing-Load Test of a dial scale, you will check the scale at different points within its weighing range. During that test, be sure that the dashpot is operating over the full range of indication. Since dust and dirt will settle to the bottom of the dashpot, a scale may work well for small loads but may bind when large loads are applied. The scale is to be maintained in proper operating condition over its entire weighing range.

If the dashpot is not working properly, you should ask the operator or the owner to make the necessary adjustments. If the dashpot cannot be properly adjusted, the scale cannot be approved until this condition is corrected.

Electronic digital indicating vehicle and axle-load scales are either mechanical scale systems with electronic digital indicators or are totally electronic scale systems. Either of the two types must be effectively damped to limit the number of oscillations before coming to rest. This is most often achieved by use of electronic damping in the indicator, and dashpot adjustment is not usually a concern.

S.2.5.1. Digital Indicating Elements. - Digital indicating elements equipped with recording elements shall be equipped with effective means to permit the recording of weight values only when the indication is stable within:

(a) plus or minus 3 scale divisions for scales of more than 2000 kg (5000 lb) capacity in service prior to January 1, 1981, hopper (other than grain hopper) scales with a capacity exceeding 22 000 kg (50 000 lb), and for all vehicle, axle load, livestock, and railway track scales;

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

The values recorded shall be within applicable tolerances.
(Amended 1995)

NIST Handbook 44, Scales Code, Paragraph S.2.5.1.

However, it is sometimes difficult to determine when the oscillation of a digital indicator has become stable. To prevent a value being recorded while the indication is still unstable, electronic devices equipped with printers must have an automatic means to prevent printing of weight values unless the indication is stable within plus or minus 3 scale divisions for all vehicle and axle-load scales. During the Test section of this module, you will test to determine that the printer does not operate unless the scale is stable. The method of conducting that test will be described in Chapter 6.

Suitability

It is the scale owner's responsibility to choose a legal and suitable device for a given commercial application, particularly with regard to the indicating and recording elements that are the primary basis for a commercial transaction. You have already learned about the general requirement relating to this responsibility, which is set forth in UR.1. (described under **Scale Divisions**, above).

A subparagraph of UR.1., UR.1.1.(a), includes a table (Table 7a), which associates types of scales and scale applications with the accuracy classes that are required to be designated on all scales manufactured after January 1, 1986. Requirements for scale divisions on unmarked scales are addressed under UR.1.1.(b) and Table 7b, which were discussed earlier in this chapter.

UR.1.1. General.

(a) For devices marked with a class designation, the typical class or type of device for particular weighing applications is shown in Table 7a.

For devices not marked with a class designation, Table 7b applies.

Table 7a.
Typical Class or Type of Device for Weighing Operations

Class	Weighing Application or Scale Type
I	Precision laboratory weighing
II	Laboratory weighing, precious metals and gem weighing, grain test scales
III	All commercial weighing not otherwise specified, grain test scales, retail precious metals and semi-precious gem weighing, animal scales, postal scales, scales used to determine laundry charges, and vehicle on-board weighing systems
III L	Vehicle, axle-load, livestock, railway track scales, crane, hopper (other than grain hopper) scales, and vehicle on-board weighing systems
IIII	Wheel-load weighers and portable axle-load weighers used for highway weight enforcement

Note: A scale with a higher accuracy class than that specified as "typical" may be used.
(Amended 1985, 1986, 1987, 1988, 1992, and 1995)

NIST Handbook 44, Scales Code, Paragraph UR.1.1. and Table 7a

As explained earlier in this chapter (under **Scale Divisions**), the Scales Code paragraph S.5.2. and Table 3 specify the maximum and minimum number of scale divisions for scales marked with an accuracy class. In order to be suitable, a vehicle or axle-load scale marked accuracy class III L must have no less than 2,000 scale divisions and no more than 10,000 scale divisions.

A wide variety of indicating and recording devices have been developed to meet the needs of the device user. The device manufacturer has considerable latitude to incorporate various device features or capabilities, provided the customer is given information necessary to understand a transaction, and provided the features do not facilitate fraud.

A device must not only be suitable for its application based upon the accuracy class, the scale capacity, and the division size; the features that are operational on the device must also be appropriate for the application. Although it is not possible to give a comprehensive list of specific applications and associated features that are suitable or not suitable, some of the following common examples should illustrate the basic approach to assessing suitability.

- If the system has a “training mode,” in which tickets can be issued, an indication should appear on the tickets printed in that mode that they are not valid weigh tickets.

- Neither push-button tare nor keyboard tare features should interact with a weigh-in/weigh-out feature on a vehicle scale. This prevents tare from effectively being taken twice or changed manually after the weigh-in/weigh-out feature is used. With a weigh-in/weigh-out feature, vehicle weight before loading or unloading is stored in computer memory and then recalled when the vehicle is weighed again and used to determine the net weight. If the weigh-in/weigh-out feature is operated through a computer that is linked to the indicating element of the scale, the scale indicator (and any recording device that is not linked to the computer) should register only gross weight values.

    - Unattended vehicle scales:

        - must indicate the zero balance condition;

        - may indicate plus or minus a few hundred pounds to make it possible for the driver to tell if the scale is in a zero balance condition prior to use and then blank the display to prevent the scale from being used to get a vehicle weight without payment or authorization;

        - must have a weight display for the vehicle driver;

        - must be equipped with a push-button zero feature that allows the driver to zero the scale;

        - may go through the zero-setting process automatically when the vehicle driver inserts a card into a card reader or makes payment; and

        - if equipped with printers, must either make the ticket available at the scale or provide instructions at the scale describing how the ticket can be obtained.

When assessing the appropriateness or suitability of a specific device for a particular application, ask yourself:

- Does this scale make sense in this situation?

- Does the device meet the requirements of this use?

- Is the environment appropriate for this scale?

Remember that human operators, other personnel, buyers, sellers, and others are part of the environment in which the device is operated.

Three additional user requirements (UR.3.1., UR.3.2., and UR.3.3.) relate specifically to the suitability of a scale. As with other user requirements, it is often not possible to determine whether there is strict conformance during a field examination. However, these requirements provide guidelines that can be used in assessing suitability. For example, a scale used to weigh loads that exceed its nominal capacity is obviously not suitable for its application. Paragraph UR 3.2. of the Scales Code specifically prohibits this practice, and thereby establishes a criterion of suitability.

NIST Handbook 44 paragraph UR.3.2.1. includes additional limitations on the maximum loading for a vehicle scale. This paragraph prohibits a vehicle scale from being used to weigh loads that exceed the maximum load capacity of the scale's span. These maximums are specified in an accompanying table, Table UR.3.2.1. according to the scale's concentrated load capacity (CLC) and the number of axles on the vehicle being

weighed in a given span. Step-by-step instructions are included at the beginning of Table UR.3.2.1. explaining how to determine whether or not a scale is suitable for use in weighing a specific vehicle.

UR.3.2. Maximum Load. - A scale shall not be used to weigh a load of more than the nominal capacity of the scale.

UR.3.2.1. Maximum Loading for Vehicle Scales. - A vehicle scale shall not be used to weigh loads exceeding the maximum load capacity of its span as specified in Table UR.3.2.1.
(Added 1996)

NIST Handbook 44, Scales Code, Paragraphs UR.3.2. and UR.3.2.1.

Table UR.3.2.1.
Span Maximum Load

Distance in feet between the extremes of any two or more consecutive axles	Ratio of CLC to maximum Load ("r" factor) carried on any group of 2 or more consecutive axles.							
	2 axles	**3 axles**	**4 axles**	**5 axles**	**6 axles**	**7 axles**	**8 axles**	**9 axles**
4[1]	1.000		INSTRUCTIONS:					
5[1]	1.000		1. Determine the scale's CLC.					
6[1]	1.000		2. Count the number of axles on the vehicle in a given span and determine the distance in feet between the first and last axle in the span.					
7[1]	1.000							
8 and less[1]	1.000	1.000						
More than 8[1]	1.118	1.235	3. Multiply the CLC by the corresponding multiplier in the table*.					
9	1.147	1.257						
10	1.176	1.279	*4. The resulting number is the scale's maximum concentrated load for a single span based on the vehicle configuration.*					
11	1.206	1.301	*See note and formula on next page.					
12	1.235	1.324	1.471	1.632				
13	1.265	1.346	1.490	1.651				
14	1.294	1.368	1.510	1.669				
15	1.324	1.390	1.529	1.688	1.853			
16	1.353	1.412	1.549	1.706	1.871			
17	1.382	1.434	1.569	1.724	1.888			
18	1.412	1.456	1.588	1.743	1.906			
19	1.441	1.478	1.608	1.761	1.924			
20	1.471	1.500	1.627	1.779	1.941			
21	1.500	1.522	1.647	1.798	1.959			
22	1.529	1.544	1.667	1.816	1.976			
23	1.559	1.566	1.686	1.835	1.994			
24	1.588	1.588	1.706	1.853	2.012	2.176		
25	1.618	1.610	1.725	1.871	2.029	2.194		
26		1.632	1.745	1.890	2.047	2.211		
27		1.654	1.765	1.908	2.065	2.228		
28		1.676	1.784	1.926	2.082	2.245	2.412	
29		1.699	1.804	1.945	2.100	2.262	2.429	
30		1.721	1.824	1.963	2.118	2.279	2.445	
31		1.743	1.843	1.982	2.135	2.297	2.462	

Table UR.3.2.1. Span Maximum Load								
Distance in feet between the extremes of any two or more consecutive axles	**Ratio of CLC to maximum Load ("r" factor) carried on any group of 2 or more consecutive axles.**							
	2 axles	**3 axles**	**4 axles**	**5 axles**	**6 axles**	**7 axles**	**8 axles**	**9 axles**
32		1.765	1.863	2.000	2.153	2.314	2.479	2.647
33			1.882	2.018	2.171	2.331	2.496	2.664
34			1.902	2.037	2.188	2.348	2.513	2.680
35			1.922	2.055	2.206	2.365	2.529	2.697
36			2.000[2]	2.074	2.224	2.382	2.546	2.713
37			2.000[2]	2.092	2.241	2.400	2.563	2.730
38			2.000[2]	2.110	2.259	2.417	2.580	2.746
39			2.000	2.129	2.276	2.434	2.597	2.763
40			2.020	2.147	2.294	2.451	2.613	2.779
41			2.039	2.165	2.312	2.468	2.630	2.796
42			2.059	2.184	2.329	2.485	2.647	2.813
43			2.078	2.202	2.347	2.502	2.664	2.829
44			2.098	2.221	2.365	2.520	2.681	2.846
45			2.118	2.239	2.382	2.537	2.697	2.862
46			2.137	2.257	2.400	2.554	2.714	2.879
47			2.157	2.276	2.418	2.571	2.731	2.895
48			2.176	2.294	2.435	2.588	2.748	2.912
49			2.196	2.313	2.453	2.605	2.765	2.928
50			2.216	2.331	2.471	2.623	2.782	2.945
51			2.235	2.349	2.488	2.640	2.798	2.961
52			2.255	2.368	2.506	2.657	2.815	2.978
53			2.275	2.386	2.524	2.674	2.832	2.994
54			2.294	2.404	2.541	2.691	2.849	3.011
55			2.314	2.423	2.559	2.708	2.866	3.028
56			2.333	2.441	2.576	2.725	2.882	3.044
57			2.353[3]	2.460	2.594	2.742	2.899	3.061
58				2.478	2.612	2.760	2.916	3.077
59				2.496	2.629	2.777	2.933	3.094
60				2.515	2.647	2.794	2.950	3.110

*Note: This table was developed based upon the following formula. Values may be rounded in some cases for ease of use. $W = r \times 500\left[\left(\frac{LN}{N-1}\right) + 12N + 36\right]$

[1] Tandem Axle Weight.

[2] Exception - These values in the third column correspond to the maximum loads in which the inner bridge dimensions of 36, 37, and 38 feet are considered to be equivalent to 39 feet. This allows a weight of 68 000 lb on axles 2 through 5.

[3] Corresponds to the Interstate Gross Weight Limit.

NIST Handbook 44, Scales Code, Table UR.3.2.1.

It is also an inappropriate use of a scale to regularly weigh loads that are lighter than those for which the scale was designed. This practice can produce large errors. Handbook 44 recommends that scales marked accuracy class III L not be used to weigh loads of less than 50 scale divisions. For example, if a scale marked class III L has a scale division value of 20 lb, the minimum recommended load is 50 d x 20 lb = 1,000 lb. If the scale has a scale division value of 50 lb, the minimum recommended load is 2,500 lb (50 d x 50 lb).

UR.3.1. Recommended Minimum Load. - A recommended minimum load is specified in Table 8 since the use of a device to weigh light loads is likely to result in relatively large errors.

Table 8.
Recommended Minimum Load

Class	Value of scale division (d or e*)	Recommended minimum load (d or e*)
I	equal to or greater than 0.001 g	100
II	0.001 g to 0.05 g, inclusive	20
	equal to or greater than 0.1 g	50
III	All**	20
III L	All	50
IIII	All	10

*For Class I and II devices equipped with auxiliary reading means (i.e., a rider, a vernier, or a least significant decimal differentiated by size, shape or color), the value of the verification scale division "e" is the value of the scale division immediately preceding the auxiliary means. For Class III and IIII devices the value of "e" is specified by the manufacturer as marked on the device; "e" must be less than or equal to "d."

**A minimum load of 10 d is recommended for a weight classifier marked in accordance with a statement identifying its use for special applications.
(Amended 1990)

NIST Handbook 44, Scales Code, Paragraph UR3.1. and Table 8

For example, if a scale marked class III L has a scale division value of 20 lb, the minimum recommended load is 50 d x 20 lb =1,000 lb. In contrast, if the scale has a scale division value of 50 lb, the minimum recommended load is 2,500 lb (50 d x 50 lb).

Note that a separate requirement, UR.3.7., discussed below under **Maintenance, Use, and Environmental Factors**, makes the 50-scale-division minimum net load a requirement on vehicle scales other than those used to weigh scrap metal for recycling, in which case a minimum net load of 10d is required. Another requirement, UR.3.8., also discussed in that section, prohibits the use of a scale with a scale division of 5 lb or less for weighing net loads smaller that 500d (this requirement applies to scales used to measure livestock).

As has been said, the practice of split weighing, that is, determining the gross weight of a vehicle by using an axle-load scale to successively weigh each axle and then summing the separate weighings, is inappropriate, and can result in large errors in measurement. The Scales Code specifically requires single-draft weighing of vehicles.

UR.3.3. Single-Draft Vehicle Weighing. - A vehicle or a coupled vehicle combination shall be commercially weighed on a vehicle scale only as a single draft. That is, the total weight of such a vehicle or combination shall not be determined by adding together the results obtained by separately and not simultaneously weighing each end of such vehicle or individual elements of such coupled combination. However:

(a) the weight of a coupled combination may be determined by uncoupling the various elements (tractor, semitrailer, trailer), weighing each unit separately as a single draft, and adding together the results, or

(b) the weight of a vehicle or coupled-vehicle combination may be determined by adding together the weights obtained while all individual elements are resting simultaneously on more than one scale platform.

Note: This paragraph does not apply to highway-law-enforcement scales and scales used for the collection of statistical data.
(Added 1992)

NIST Handbook 44, Scales Code, Paragraph UR.3.3.

Note that a coupled vehicle may be uncoupled and a gross weight determined by summing the separate weights of the components, provided that each component is weighed as a single draft. In addition, subparagraph (b) recognizes multi-scale weighing as an appropriate method.

Customer Readability — If Applicable

Vehicle scales are sometimes used in direct sales, where both buyer and seller are present when the weight of the vehicle is determined. In a direct sale situation, the customer must be provided with enough information to understand the transaction and to detect accidental or intentional errors that might occur. The customer's presence limits the opportunities for some fraudulent practices, but it is also the customer's responsibility to observe the measurement process.

The customer must be able to verify:

- that the scale is at zero before weighing;
- that the scale deck is empty before vehicles are placed on the scale; and
- that the weighing elements are not being manipulated in any fraudulent way by the scale operator.

The General Code requires that a weighing device be positioned in such a way as to facilitate to the greatest practicable extent customer verification of the weighing.

G-UR.3.3. Position of Equipment. - A device or system equipped with a primary indicating element and used in direct sales, except for prescription scales, shall be positioned so that its indications may be accurately read and the weighing or measuring operation may be observed from some reasonable "customer" and "operator" position. The permissible distance between the equipment and a reasonable customer and operator position shall be determined in each case upon the basis of the individual circumstances, particularly the size and character of the indicating element.
(Amended 1974 and 1998)

NIST Handbook 44, General Code, Paragraph G-UR.3.3.

The customer must be able to accurately read the scale from a reasonable position. Customers must be able to fulfill their responsibility of observing the weight determination of the vehicle in order to benefit from the requirements in Handbook 44 concerning customer readability. If the customer has no direct access to the device's indicating element, a remote display may be required to permit the customer to read the scale's indications.

Before any vehicles are brought onto the scale, the operator must ensure that the scale indication is on zero and the scale deck is empty. The operator must also be able to clearly and accurately read the final weight indication on the scale. Consequently, it is equally important that the operator be able to accurately read the scale from a reasonable operator position.

Adjustable Components

To prevent accidental resetting of adjustments that could affect measurement, or deliberate abuses, the Scales Code requires that all adjustable components of indicating and recording elements, except for the zero-load balance mechanism, be enclosed within the housing of the device.

S.1.10. Adjustable Components. - An adjustable component such as a pendulum, spring, or potentiometer shall be held securely in adjustment and, except for a zero-load balance mechanism, shall be located within the housing of the element.
(Added 1986)

NIST Handbook 44, Scales Code, Paragraph S.1.10.

Provision for Sealing

Adjustable elements that can affect the measurement of electronic devices require further protection from tampering. NIST Handbook 44 Scales Code paragraph S.1.11. and the accompanying table require that indicating and recording elements be designed with provision for sealing these adjustments.

A seal cannot actually *prevent* tampering, but leaves evidence that tampering has occurred. This requirement (and its corresponding paragraph in the General Code, G-S.8) recognizes two general methods of sealing, either or both of which may be used to effectively seal the device.

The first, more traditional method involves the use of physical seals, such as lead-and-wire, plastic wire, or pressure sensitive seals, which must be broken or deformed in order to gain access to or operate an adjustment. For example, if an adjustment is enclosed within a cabinet, inside a box, or behind a door or plate, a lead-and-wire seal can be threaded through a latch, or through a screw that fastens the closure; in order to open the closure to make an adjustment, the wire and/or lead seal must first be broken.

S.1.11. Provision for Sealing.

(a) Except on Class I scales, 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.
[Nonretroactive as of January 1, 1979]

(b) Except on Class I scales, 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.
[Nonretroactive as of January 1, 1990]

(c) Except on Class I scales, audit trails shall use the format set forth in Table S.1.11.
[Nonretroactive as of January 1, 1995]

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.
(Amended 1989, 1991 and 1993)

NIST Handbook 44, Scales Code, Paragraph S.1.11.

Table S.1.11. Categories of Device and Methods of Sealing	
Categories of Device	***Method of Sealing***
Category 1: No remote configuration capability.	*Seal by physical seal or two event counters: one for calibration parameters and one for configuration parameters.*
Category 2: Remote configuration capability, but access is controlled by physical hardware. *Device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode.*	*The hardware enabling access for remote communication must be at the device and sealed using a physical seal or two event counters: one for calibration parameters and one for configuration parameters.*
Category 3: Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).	*An event logger is required in the device; it must include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter. A printed copy of the information must be available through the device or through another on-site device. The event logger shall have a capacity to retain records equal to ten 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.)*
[Nonretroactive as of January 1, 1995] (Table added 1993)	

NIST Handbook 44, Scales Code, Table S.1.11.

This method is effective when the adjustable element does not need to be used during normal operation. However, many electronic indicators are designed to permit calibration type adjustments to be made through the same keyboard or keypad module that is used for data entry during normal service. In this case, a physical seal would not be appropriate; consequently, the Handbook provides for the use of other approved means of providing security.

One such means that has been developed involves the maintenance of an automatic and permanent record of each time the adjustment mode, or the region of electronic memory where adjustment factors are stored, is accessed. This technique is commonly referred to as an **audit trail**. The audit trail must be continuously and automatically maintained, even during power failures, must itself be tamperproof, and must be accessible to the weights and measures official when requested.

Note that S.1.11. refers to "other approved means." Table S.1.11. outlines categories of devices and the required methods of sealing for each category. There are three basic categories of devices, which are categorized according to the way in which metrologically significant changes can be made on the device. A

Category 1 device describes the simplest device; one that has no remote configuration capability. That is, changes to metrological features such as calibration can only be made at the device itself, not through a remote device. Category 2 and 3 devices do have remote configuration capability. That is, metrologically significant adjustments can be made to these devices through a remote device such as a console or controller. The key different between the Category 2 and the Category 3 device is that the Category 3 device has unlimited remote access (or access controlled through a software switch such as a password), whereas remote access to the configuration mode in a Category 2 device is controlled by physical hardware.

Table S.1.11. lists the minimum methods for sealing each category of device. Note that "lower" category devices may use a more advanced method of sealing and still satisfy the requirements. For example, a Category 1 device may use an event logger as outlined for a Category 3 device.

If a device has been type evaluated, the NTEP Certificate of Conformance will describe the provision for sealing, and whether it is acceptable. For devices that have not been type evaluated, you must first identify all elements that require sealing and then assess the sealing technique used. This may necessitate reviewing technical manuals or contacting the scale manufacturer to verify the adequacy of the security and to check that all adjustments are currently secure.

When inspecting a device sealed through an audit trail, pertinent information from the audit trail such as the values of the event counters, should be recorded on the inspection report. By comparing information currently displayed on an audit trail with the information from the last inspection, you will be able to assess the number and types of changes that have been made to the device's calibration and configuration settings. A significant number of changes may indicate that further investigation of the device is warranted. If you find such a situation, you should consult your supervisor for further guidance or follow your jurisdiction's policies.

The General Code makes it the responsibility of the device owner to make sure that seals are correctly installed and that they remain effective.

G-UR.4.5. Security Seal. - A security seal shall be appropriately affixed to any adjustment mechanism designed to be sealed.

NIST Handbook 44, General Code, Paragraph G-UR.4.5.

This requirement should also be construed as applying to all sealing methods, including audit trails. For the seal to remain effective, it must either be maintained continuously intact or, when an adjustment is made, it must be fully documented.

Installation

All weighing and measuring devices must be installed in accordance with the manufacturer's instructions, in a manner that will not adversely affect its accuracy, obscure markings or indications, or inhibit operation or monitoring based upon either direct or indirect observation of the weighing. In addition, devices must be installed so that they are accessible for examination purposes. Some States have "Pit Laws," which specify construction details for scale pits. If your State has such a law, you will need to check to make sure that its requirements have been met.

G-UR.2. Installation Requirements.

G-UR.2.1. Installation. - A device shall be installed in accordance with the manufacturer's instructions, including any instructions marked on the device. A device installed in a fixed location shall be installed so that neither its operation nor its performance will be adversely affected by any characteristic of the foundation, supports, or any other detail of the installation.

G-UR.2.1.1. Visibility of Identification. - Equipment shall be installed in such a manner that all required markings are readily observable.
(Added 1978)

G-UR.2.2. Installation of Indicating or Recording Element. - A device shall be so installed that there is no obstruction between a primary indicating or recording element and the weighing or measuring element; otherwise there shall be convenient and permanently installed means for direct communication, oral or visual, between an individual located at a primary indicating or recording element and an individual located at the weighing or measuring element. [See also G-UR.3.3.]

G-UR.2.3. Accessibility for Inspection, Testing, and Sealing Purposes. - A device shall be located, or such facilities for normal access thereto shall be provided, to permit:

(a) inspecting and testing the device;

(b) inspecting and applying security seals to the device; and

(c) readily bringing the testing equipment of the weights and measures official to the device by customary means and in the amount and size deemed necessary by such official for the proper conduct of the test.

Otherwise, it shall be the responsibility of the device owner or operator to supply such special facilities, including such labor as may be needed to inspect, test, and seal the device, and to transport the testing equipment to and from the device, as required by the weights and measures official.
(Amended 1991)

NIST Handbook 44, General Code, Paragraph G-UR.2.

Note that paragraph G-UR.2.2. is intended to insure that the operator of the scale who is stationed at the indicating element can have accurate information about the application of the load to the load-receiving element, either based on his/her own visual observation, upon a report from a third party who is a direct observer, or through other means such as a live camera which allows visual contact. In the case of vehicle and axle-load scales, for example, it is essential that the operator know when the vehicle is entirely on the platform, with its axles positioned correctly and the driver out of the truck and off the platform, before recording the weight. This does not necessarily require that indicating and weighing elements be simultaneously visible by the customer (this stricter requirement is set forth in another paragraph of the General Code, G-UR.3.3., applicable to devices used in direct sales only).

Paragraph G-UR.2.3. requires that a device be located or access provided such that the device can be inspected and tested, security seals can be applied to the device, and the inspector can bring the necessary test

equipment to the device through normal means. Otherwise, the device owner must provide assistance or labor to allow the inspector to accomplish these tasks.

In the environments in which vehicle and axle-load scales are used, exposure to wind, rain, dust, etc., may be a very real hazard to proper operation of a scale. Therefore, Paragraph UR.2.3.of the Scales Code requires that the indicating elements, lever system, and load-receiving element on a permanently installed scale must be protected from environmental factors that could affect their operation, including protection for electronic elements from the effects of electromagnetic or radio-frequency interference (RFI/EMI). Tests for the adequacy of protection from RFI/EMI will be described in Chapter 6.

Because plumb and level conditions are generally necessary for accurate scale operation, the foundations and supports must be installed in such a manner as to provide a rigid footing for the scale components. They must be sufficiently strong, rigid, and permanent for the purpose. There must be enough clearance between the scale and surrounding walls to prevent any contact between the two, either during a weighing or when the deck is empty. Paragraph UR.2.4. requires these conditions.

UR.2.3. Protection From Environmental Factors. - The indicating elements, the lever system or load cells, and the load-receiving element of a permanently installed scale, and the indicating elements of a scale not intended to be permanently installed, shall be adequately protected from environmental factors such as wind, weather, and RFI that may adversely affect the operation or performance of the device.

UR.2.4. Foundation, Supports, and Clearance. - The foundation and supports of any scale installed in a fixed location shall be such as to provide strength, rigidity, and permanence of all components, and clearance shall be provided around all live parts to the extent that no contacts may result when the load-receiving element is empty, nor throughout the weighing range of the scale. *On vehicle and livestock scales, the clearance between the load-receiving elements and the coping at the bottom edge of the platform shall be greater than at the top edge of the platform.*
[Nonretroactive as of January 1, 1973]

NIST Handbook 44, Scales Code, Paragraphs UR.2.3. and UR.2.4.

The scale deck should be made of a material suitable for its use, with a surface that provides appropriate traction for vehicles. In addition, the nonretroactive portion of UR.2.4. states that the clearance between the deck and the coping at the bottom edge of the deck must be greater than at the top edge of the deck, as illustrated in Figure 3-6.

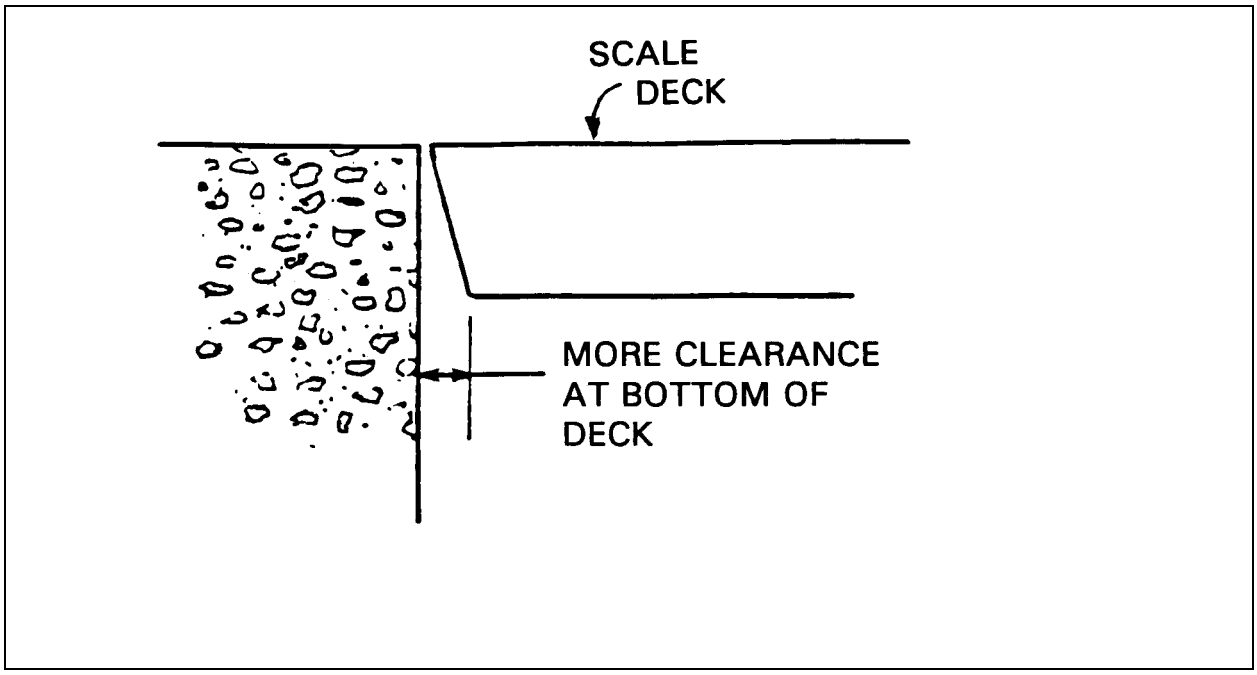

Figure 3-6. Typical Deck Configuration

This helps to prevent a stone or other material from binding in the scale. With a wooden deck, this is accomplished by undercutting, sawing the wood of the deck so that it angles in. On concrete decks, a small strip of steel — called a crushing strip — is usually attached to the upper edge of the deck where it meets the pit coping.

Weighing And Load-Receiving Elements

Design

The weighing elements must be designed in a way that minimizes friction between opposing surfaces. Wherever friction occurs, some of the energy transmitted through the system is converted to heat and lost. To the degree that this energy loss due to friction is not controlled, the repeatability of the scale is likely to suffer. The Scales Code, therefore, requires adequate provision in the design of weighing elements for minimizing friction.

S.4.1. Antifriction Means. - Frictional effects shall be reduced to a minimum by suitable antifriction elements. Opposing surfaces and points shall be properly shaped, finished, and hardened. A platform scale having a frame around the platform shall be equipped with means to prevent interference between platform and frame.

NIST Handbook 44, Scales Code, Paragraph S.4.1.

In a mechanical vehicle or axle-load scale, friction normally occurs primarily at the lever pivots. Pivots — sharpened to a knife edge — receive and transmit the force, support levers, and serve as axes for levers. Pivots should be of hardened steel and each should be opposed by a bearing of suitable shape.

Friction should not occur between the deck and the surrounding surface. The requirement that clearance be maintained between the load-receiving element and the adjacent coping was also stated in UR.2.4 described above.

You will recall from an earlier discussion that the only adjustable element on mechanical weighing elements, except for the zero-balance elements, are nose-irons, which may be used to vary slightly the power arm of one or more levers in the system when major adjustment is necessary. The Scales Code requires that such elements must be capable of holding their setting.

S.4.2. Adjustable Components. - An adjustable component such as a nose-iron or potentiometer shall be held securely in adjustment. The position of a nose-iron on a scale of more than 1000-kg (2000-lb) capacity, as determined by the factory adjustment, shall be accurately, clearly, and permanently defined. (Amended 1986)

NIST Handbook 44, Scales Code, Paragraph S.4.2.

In addition, the position of a nose-iron on vehicle and axle-load scales, and other large-capacity scales, as set by the manufacturer prior to installation, must be clearly marked. This is usually accomplished by filing a mark on the fixed surface upon which the nose-iron slides. This mark should be clearly visible.

Multiple-scale systems generally have indicating and recording elements that sum the weights of the individual weighing elements, although each scale may also have its own indicating and recording elements as well. Depending upon the length of a given vehicle and the configuration of the scales, in some cases, a vehicle may not be resting on all load-receiving elements in the system. This is acceptable as long as all parts of the vehicle are resting on one or more of the load receiving elements in the system. However, a shared indicating or recording element must be designed to prohibit the activation of scale elements that are not in use, and to indicate those which are in use at any given time.

S.4.3. Multiple Load-Receiving Elements. - Except for mechanical bench and counter scales, a scale with a single indicating or recording element, or a combination indicating-recording element, that is coupled to two or more load-receiving elements with independent weighing systems, shall be provided with means to prohibit the activation of any load-receiving element (or elements) not in use, and shall be provided with automatic means to indicate clearly and definitely which load-receiving element (or elements) is in use.

NIST Handbook 44, Scales Code, Paragraph S.4.3.

This requirement is intended to prevent fraudulent or accidental addition of loads that are not part of the current transaction. The shared indicator may use indicating lights or other means to show which scales are active. The correct operation of this indication, and of the mechanism that locks out non-active scales, should be checked during the test of the system.

Some mechanical systems are equipped with a scissor type hoist beneath the load-receiving deck, which can be used to lift the deck and weighbridge off the weighing elements while the vehicle is being loaded or unloaded, making it possible to determine tare without driving the vehicle off the scale. If a scale is so equipped, there must be means for the operator to determine when the load-receiving element is in the weighing position, that is, resting fully on the load bearing points.

UR.2.8. Hoists. - On vehicle scales equipped with means for raising the load-receiving element from the weighing element for vehicle unloading, means shall be provided so that it is readily apparent to the scale operator when the load receiving element is in its designed weighing position.

NIST Handbook 44, Scales Code, Paragraph UR.2.8.

Again, during the test of the system, you should observe the operation of this indicator while the scale is in operation.

Access

Most vehicle and axle-load scales are designed to have a pit underneath the weighing deck that allows access to the weighing elements. Maintenance personnel and weights and measures officials must have ready access to the pit in order to inspect, adjust, and repair the scale, and the Scales Code requires provision for such access.

A clearance height of at least 48 inches is recommended as the minimum for ready access, but pit requirements vary from one jurisdiction to another. Your instructor will explain guidelines adopted by your jurisdiction. Note that both above- and below-ground vehicle scales must also be designed to provide access to scale elements beneath the deck.

UR.2.5. Access to Weighing Elements. - Adequate provision shall be made for ready access to the pit of a vehicle, livestock, animal, axle-load, or railway track scale for the purpose of inspection and maintenance. Any of these scales without a pit shall be installed with adequate means for inspection and maintenance of the weighing elements.
(Amended 1985)

NIST Handbook 44, Scales Code, Paragraph UR.2.5.

Approaches

As explained in Chapter 1, correct design and construction of the entrance and exit ends of a vehicle or axle-load scale are essential to accurate weighing of vehicles. If correctly designed and constructed, they help reduce wear on the weighing element, insure that the vehicle will be positioned properly over the load-receiving element, that any load inside the truck is stable and is not likely to shift during weighing, and, in the case of axle-load scales, that the entire vehicle, including the part not bearing directly on the deck, is level. The Scales Code specifies relative dimensions for approaches, which you should check in the course of your inspection.

UR.2.6. Approaches.

UR.2.6.1. Vehicle Scales. *- On the entrance and exit ends of a vehicle scale installed in any one location for a period of 6 months or more, there shall be a straight approach as follows:*

(a) the width at least the width of the platform,

(b) the length at least one-half the length of the platform but not required to be more than 12 m (40 ft), and

(c) not less than 3 m (10 ft) of any approach adjacent to the platform shall be constructed of concrete or similar durable material to ensure that this portion remains smooth and level and in the same plane as the platform. However, grating of sufficient strength to withstand all loads equal to the concentrated load capacity of the scale may be installed in this portion. Any slope in the remaining portion of the approach shall ensure (1) ease of vehicle access, (2) ease for testing purposes, and (3) drainage away from the scale.

[Nonretroactive as of 1976]
(Amended 1977, 1983, and 1993)

UR.2.6.2. Axle-Load Scales. - At each end of an axle-load scale there shall be a straight paved approach in the same plane as the platform. The approaches shall be the same width as the platform and of sufficient length to insure the level positioning of vehicles during weight determinations.

NIST Handbook 44, Scales Code, Paragraph UR.2.6.

These requirements are illustrated in Figure 3-7.

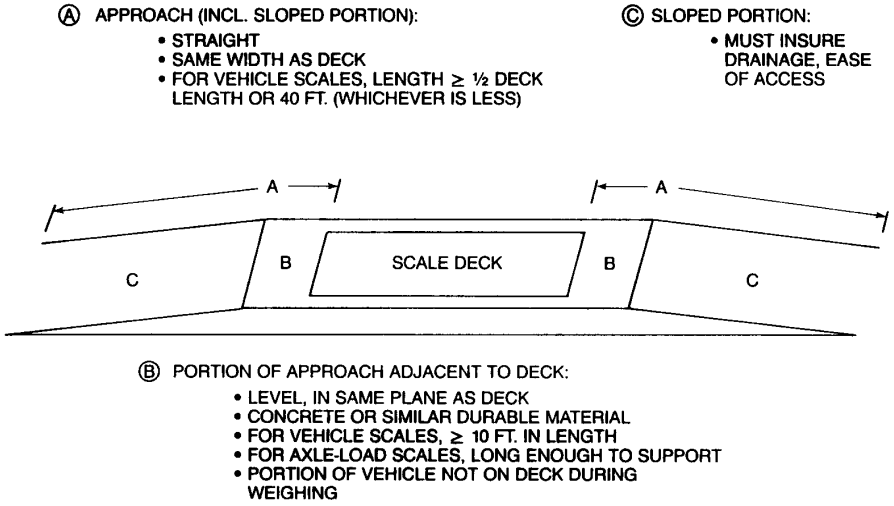

Figure 3-7. Requirements for Approaches

Maintenance, Use, And Environmental Factors

All weighing and measuring devices must be maintained in proper operating condition and operated only in the manner for which they are designed. A number of general requirements relating to maintenance are set forth in the General Code.

The second part of G-UR.4.1. establishes an important point regarding adjusting of devices, which is also addressed in G-UR.4.3. Adjustments should always be made with the objective of bringing the device as close as possible to zero-error accuracy. The fact that tolerances allow a small degree of inaccuracy must not be construed by device operators or repair personnel as a license to adjust devices in a way that, while nominally meeting performance requirements, favors the device owner or operator.

If in the course of an examination you observe a consistent pattern in performance on a number of scales which could indicate this type of abuse, you should question the operator and, if necessary, repair service personnel, about their practices in adjusting scales. Since it is unlikely that they will admit to an improper practice and since the evidence for abuse or possible fraud will, in that case, be entirely circumstantial, you should also consider the following in making your determination:

- number of devices at the same location,
- results of recent tests of these devices, and
- complaints that have been received from the public.

If you have strong suspicions, but the evidence is inconclusive, you should inform the operator of the seriousness of this violation, require that the scales be readjusted properly, and make careful notes for comparison at the next examination. If the observed pattern is strongly supported by historical evidence or complaints, you may consider compliance action, especially if there is evidence (such as a prior warning) of willful intent to defraud the public. Your instructor will explain your jurisdiction's policies and procedures regarding this type of violation.

G-UR.4. Maintenance Requirements.

G-UR.4.1. Maintenance of Equipment. - All equipment in service and all mechanisms and devices attached thereto or used in connection therewith shall be continuously maintained in proper operating condition throughout the period of such service. Equipment in service at a single place of business found to be in error predominantly in a direction favorable to the device user shall not be considered "maintained in a proper operating condition."
(Amended 1973 and 1991)

G-UR.4.2. Abnormal Performance. - Unstable indications or other abnormal equipment performance observed during operation shall be corrected and, if necessary, brought to the attention of competent service personnel.
(Added 1976)

G-UR.4.3. Use of Adjustments. - Weighing elements and measuring elements that are adjustable shall be adjusted only to correct those conditions that such elements are designed to control, and shall not be adjusted to compensate for defective or abnormal installation or accessories or for badly worn or otherwise defective parts of the assembly. Any faulty installation conditions shall be corrected, and any defective parts shall be renewed or suitably repaired, before adjustments are undertaken. Whenever equipment is adjusted, the adjustments shall be so made as to bring performance errors as close as practicable to zero value.

NIST Handbook 44, General Code, Paragraph G-UR.4.

Note also, that because a device is capable of performing within tolerances on an official test does not mean that it is being correctly maintained. A badly worn or malfunctioning device can often be hastily and improperly adjusted to pass a test, but will soon be inaccurate again and is likely to perform more and more erratically. You should point out to the operator of worn or improperly maintained equipment that the ultimate cost of replacing equipment, including the cost of taking it out of service for some period of time, generally outweighs the cost of regular and thorough preventative and corrective maintenance.

During a scale examination, you should be on the lookout for elements of design, application, or installation that could facilitate fraud, since this is specifically prohibited by the General Code.

G-S.2. Facilitation of Fraud. - All equipment and all mechanisms and devices attached thereto or used in connection therewith shall be so constructed, assembled, and installed for use such that they do not facilitate the perpetration of fraud.

NIST Handbook 44, General Code, Paragraph G-S.2.

Note that facilitation of fraud does not require evidence of intent to defraud or fraudulent acts; in fact, in some cases, the device owner may be innocent of any deceitful intent. Often facilitation of fraud arises from installing equipment that is not suitable for its application in an effort to save money on the equipment purchase and/or installation, rather than from an attempt to cheat customers. You should be especially aware of features that have no apparent purpose in a particular application — the example of tare on a livestock scale is a good example — and for modifications which are not described in the manufacturer's instructions or plans.

In this regard, also remember that a device may only be operated in the manner for which it was designed and constructed. For example, a zero-balance adjustment must not be used to take tare. The proper method of operation is also required by the General Code.

G-UR.3.1. Method of Operation. - Equipment shall be operated only in the manner that is obviously indicated by its construction or that is indicated by instructions on the equipment.

NIST Handbook 44, General Code, Paragraph G-UR.3.1.

Another requirement relating to suitability of a scale applies to money-operated devices. If the user must deposit money in an automatic payment-taking device in order to make the scale operate, information must be displayed at or near the device regarding how to contact the person or agency responsible for the device for refunds if the scale does not work correctly. Note that this information is not required at locations where employees are present and responsible for resolving any discrepancies.

G-UR.3.4. Responsibility, Money-Operated Devices. - Money-operated devices other than parking meters shall have clearly and conspicuously displayed thereon, or immediately adjacent thereto, adequate information detailing the method for the return of monies paid when the product or service cannot be obtained. This information shall include the name, address, and phone number of the local responsible party for the device. This requirement does not apply to devices at locations where employees are present and responsible for resolving any monetary discrepancies for the customer.
(Amended 1977 and 1993)

NIST Handbook 44, General Code, Paragraph G-UR.3.4.

As stated earlier, the suitability of a device includes its capability to perform correctly and accurately under the environmental conditions of its normal service. Since vehicle and axle-load scales are often installed outdoors, and are thus exposed to wind, sun, moisture, pollution, and temperature variations, they must be adequately protected. Electronic devices must also be adequately shielded against the effects of RFI and EMI, which can be generated either by electrical equipment used on the site, radio transmitting equipment, or other environmental sources. The General Code includes suitability for service under normal environmental factors as a user requirement.

G-UR.1.2. Environment. - Equipment shall be suitable for the environment in which it is used including, but not limited to, the effects of wind, weather, and RFI.
(Added 1976)

NIST Handbook 44, General Code, Paragraph G-UR.1.2.

Among the requirements listed on the EPOs under this heading are two which are also listed under **Appropriateness**, and were discussed earlier. These paragraphs in the Scales Code, UR.3.2., and UR.3.3., stated, respectively, that a scale may not be used to weigh loads that exceed its nominal capacity, and that single-draft weighing is required for all commercial weighing of vehicles. Related to these requirements are two paragraphs which specify minimum net loads for vehicle and livestock scales.

UR.3.7. Minimum Load on a Vehicle Scale. - A vehicle scale shall not be used to weigh net loads smaller than:

(a) 10 d when weighing scrap material for recycling;

(b) 50 d for all other weighing.

As used in this paragraph, scrap materials for recycling shall be limited to ferrous metals, paper (including cardboard), textiles, plastic, and glass.
(Amended 1988 and 1992)

UR.3.8. Minimum Load for Weighing Livestock. - A scale with scale divisions greater than 2 kg (5 lb) shall not be used for weighing net loads smaller than 500 d.
(Amended 1989)

NIST Handbook 44, Scales Code, Paragraphs UR.3.7. and UR.3.8.

Paragraph UR.3.7. specifies that the smallest net load that is permitted to be weighed on a vehicle scale (other than those use to weigh scrap metal) is 50d (1,000 lb for a scale with a division value of 20d). The basis for this requirement is that the magnitude of potential round-off errors increases as the size of the load decreases. For example, the following table shows, for various loads from 100d to 10d, the potential error that could exist because devices are permitted a round-off error of up to plus or minus one-half the value of the scale division (0.5d). Column 1 of the table shows potential round-off error for gross loads weighed on an "accurate" scale.

Test Load in d	Column 1 — Gross Loads Potential error (±0.5d)	Column 2 — Net Loads Potential error (±1.0d)
100	0.5%	1.0%
50	1.0%	2.0%
20	2.5%	5.0%
10	5.0%	10.0%

As you can see, the same amount of error (±0.5d) becomes more significant as the test load decreases (0.5d is an error of 0.5% at 100d but it represents a 5% error at 10d).

Note that, for vehicle scales used to weigh scrap material for recycling, the minimum is 10d. This application is permitted a smaller minimum load because of the special conditions under which these weighments are made.

Column 2 shows the potential round-off error for net loads that may have ±0.5d round-off error with both the gross and tare weight. Because vehicle scales are frequently used to determine both gross and net loads, the potential error at small loads may be as much as double that for a scale used to record only gross loads.

For example, a 100,000 lb × 20 lb scale is used to weigh an empty vehicle; the actual weight of the vehicle is 20,010 lb, but the scale indicates 20,000 lb because of the round-off error of 0.5d. Then, the

truck is loaded with product and reweighed to get a gross weight; the actual weight is 21,990 lb, but the scale rounds off and indicates 22,000 lb. If the indicated weight of the empty truck is then subtracted from the indicated weight of the loaded truck, the resulting net weight is 2,000 lb; however, the actual net weight for this example is 1,980 lb. The difference between 2,000 lb and 1,980 lb is 20 lb or the value of 1 scale division.

As mentioned before, the potential errors shown are those for an "accurate" scale — one that meets the performance requirements of Handbook 44. If the scale is inaccurate, additional error will be introduced. In order to keep net loads within acceptable limits of inaccuracy, Handbook 44 specifies the minimum loads that can be weighed on vehicle scales. As indicated above, this limits the potential error from rounding off to no more than 2 percent of the value of the net load for vehicle weighing applications other than the weighing of scrap metal for recycling.

Many stockyards use the same Class III L vehicle scale to weigh both trucks loaded with livestock and animals on the hoof. Paragraph UR.3.8. permits this established practice when the scale division is 5 lb, without any minimum load requirement (a scale division of 5 lb is considered to be adequate resolution for weighing individual animals). A 50,000 × 5 lb vehicle scale could thus be used both for weighing livestock loaded on trucks or on the hoof. However, if a scale with larger scale divisions is used, the minimum net load is 500d. This means that the minimum net load of livestock (excluding the truck) that can be weighed on a vehicle scale with 20-lb divisions is 10,000 lb when the livestock is on a truck.

Obviously, you will not be able to determine compliance with UR.3.7. or UR.3.8. by observing the scale. However, you can ask to review records of transactions to see whether any net loads have been less than the required minimums.

Finally, the Scales Code includes a requirement that prohibits specific modifications that:

- increase the length or width of the scale deck beyond the dimensions specified by the manufacturer, or

- increase the system capacity by installing an indicator with a higher capacity, unless the modification is approved by a competent engineering authority and the weights and measures jurisdiction.

UR.4.3. Scale Modification. - The dimensions (e.g., length, width, thickness, etc.) of the load receiving element of a scale shall not be changed beyond the manufacturer's specifications, nor shall the capacity of a scale be increased beyond its design capacity by replacing or modifying the original primary indicating or recording element with one of a higher capacity, except when the modification has been approved by a competent engineering authority, preferably that of the engineering department of the manufacturer of the scale, and by the weights and measures authority having jurisdiction over the scale.
(Amended 1996)

NIST Handbook 44, Scales Code, Paragraph UR.4.3.

This requirement is intended to prevent modifications that could affect the measurement accuracy of the scale from being made simply for the purpose of increasing the capacity or platform size of the scale. You may need to review the manufacturer's specifications for the equipment to determine whether modifications described in this requirement have been made.

Assistance

Owners of weighing and measuring devices are required to provide assistance to weights and measures officials in conducting tests if special equipment or an extraordinary amount of labor is required because of the design, construction, or location of that device.

G-UR.4.4. Assistance in Testing Operations. - If the design, construction, or location of any device is such as to require a testing procedure involving special equipment or accessories or an abnormal amount of labor, such equipment, accessories, and labor shall be supplied by the owner or operator of the device as required by the weights and measures official.

NIST Handbook 44, General Code, Paragraph G-UR.4.4.

You will recall that G-UR.2.3. requires that devices be installed in such a manner as to provide access for testing purposes. However, some installations may still require assistance as is recognized by both paragraph G-UR.4.4. and paragraph G-UR.2.3.

The most common problem of this sort arises when the scale is located under hoppers, or where the weights and weight movers cannot be maneuvered. You may require the use of a forklift, or whatever devices and labor are needed, to position and remove the test weights.

Summary

A field examination of vehicle and axle-load scales begins with the inspection of the device to determine if the equipment complies with all applicable specifications of NIST Handbook 44 concerning scale design, installation, and use.

The EPOs for vehicle and axle-load scales list the following major items that must be checked.

- zero-load balance as found
- marking
- suitability of system components
- indicating and recording elements
- installation
- weighing elements and load-receiving elements
- approaches
- maintenance, use, and environmental factors
- assistance

Items to be checked on indicating and recording elements include the following:

- scale division: value (d) and number (n)
- rounding
- tare division value
- tare mechanism
- weighbeams
- poises
- dials and balance indicators
- damping means
- appropriateness
- customer readability, if applicable
- marking
- adjustable elements
- provision for sealing
- audit trail information, if applicable

Marking requirements may also apply to weighing elements (including load cells) and load-receiving elements.

The EPOs also list specific General Code and Scales Code references in NIST Handbook 44 for each item to be inspected. You must know how to interpret these code references to determine the "correctness" of the equipment being examined.