FOREWORD

National Institute of Standards and Technology (NIST) Handbook (HB) 112, "Examination Procedure Outlines (EPOs) For Commercial Weighing and Measuring Devices," was first published in 1973 by the National Bureau of Standards, Weights and Measures Program, which is now the NIST Office of Weights and Measures (OWM). NIST developed these EPOs and compiled them into this handbook to serve as a guide for the field examination of commercial weighing and measuring devices. It includes inspection and test procedures, with code references to NIST Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices." The EPOs includes the *minimum* recommended procedures to be used in official inspection and testing of commercial weighing and measuring equipment. Regulatory officials and service companies may find the need to conduct additional testing based upon the results of an examination or the circumstances surrounding the examination.

The EPOs in this document have been updated to include references to the 2015 edition of NIST Handbook 44 and to recognize electronic equipment. Some of the EPOs that appeared in the original version of NIST Handbook 112 have not been updated and are not included in this document.

Although this publication was prepared primarily for use by weights and measures officials of the federal, state, and local jurisdictions, it should also be useful to manufacturers and other commercial and industrial organizations and individuals involved in the design, sale, service, or use of weighing and measuring devices.

This handbook conforms to the concept of primary use of SI (metric) measurements recommended in the Omnibus Trade and Competitiveness Act of 1988 by citing SI units before U.S. customary units where both units appear together and placing separate sections containing requirements in SI units before corresponding sections containing requirements in U.S. customary units. In some cases, however, common trade practice is currently restricted to the use of U.S. Customary units; therefore, some examples in this Handbook will continue to specify only U.S. Customary units until the industry achieves a broad consensus on the permitted SI units.

In accord with NIST policy, the meter/liter spellings are used in this document.

2015 NIST EPO No. 1

Examination Procedure Outline for

Retail Computing Scales

It is recommended that this outline be followed as minimum criteria for examining electronic digital indicating and mechanical analog-indicating retail computing scales and prepackaging scales. Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk (*). Non-retroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the NIST EPO Safety Annex (Safety Considerations and Glossary of Safety Key Phrases) should be duplicated and included with this outline.

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

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

Electrical Hazards

First Aid Kit

Lifting

Location

also:

Wet and Slick Conditions

Chemicals. Petroleum Products and Hazardous Materials

Obstructions

Personal Protection Equipment
e.g., Safety Shoes

Support – for Scale and Test weights

Transportation of Equipment

	H-44 General Code and Scales Code References

Inspection:

SAFETY REMINDER!!!

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

1. Zero-load balance as found. For prepackaging scale, check to determine if tare is being taken. ..... S.1.1., UR.4.1., S.2.1.1., S.2.1.2., G-S.5.2.2.(d) (1/1/86)

2. General Considerations.
   - Selection..... G-UR.1.
   - Installation..... G-UR.2.1., G-UR.2.2.,
   - InstallationG-UR.2.1.,G-UR.2.2., UR.2.2. UR.2.2.
   - Supports and clearance..... UR.2.1., UR.2.4.

SAFTEY REMINDER!!!

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

   - Accessibility for inspection, testing, and sealing. ..... G-UR.2.3.
   - Testing devices at a central location..... G-UR.4.6.
   - Assistance..... G-UR.4.4.
   - Position, customer readability. ..... G-UR.3.3., S.1.8.3.
   - Level indicating means and condition. ..... S.2.4., UR.4.2.
   - Maintenance, use, and environmental factors cleanliness, obstructions, modifications, etc.)..... G-S.2., G-UR.1.2., G-UR.3.1., G-UR.3.2., UR.3.5., G-UR.4., UR.2.3., UR.4.3.

3. Marking..... S.6.3., S.5.1.* (1/1/86), S.6.2, G-S.1.1. (1/1/04), G-S.5.2.4.

   a. Marking requirements – all devices
      - Identification..... G-S.1.
         - Name, initials, or trademark of manufacturer or distributor ..... Retroactive
         - Model identifier ..... Retroactive
         - Model identifier prefix..... (1/1/03)
         - acceptable abbreviations for “model” and “number .... G-S.1. (cont.)

	H-44 General Code and Scales Code References

Inspection (cont.):

Nonrepetitive serial number	(1/1/03)
Serial number prefix	(1/1/68)
acceptable abbreviations for “serial” and “number”	(1/1/86)
Current software version or revision identifier (for not-built-for-purpose software based devices)	(1/1/01) (1/1/04)
Software version or identifier preface (for not-built-for-purpose software based devices.	(1/1/07)
Acceptable abbreviations for version, revision, and number	(1/1/07)
NTEP CC prefix and number (for devices that have an NTEP CC)	(1/1/03)
Devices or main elements remanufactured after January 1, 2002	G-S.1.2.
Name, initials, or trademark of last remanufacturer or distributor, model designation if different from original model designation.	(1/1/02)
Lettering	G-S.7.
Operational controls, indications, and features	G-S.6. (1/1/77)
Visibility of identification.	G-UR.2.1.1.
Interchange or reversal of parts	G-S.4.
b. Marking requirements – weighing, load-receiving, and indicating element in same housing or covered on the same CC (in addition to marking for all devices)	S.6.3.
Accuracy class	(1/1/86)
Nominal capacity	Retroactive
Value of scale division with nominal capacity, if not apparent	(1/1/83)
Value of "e" (if different from "d")	(1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special purposes	(1/1/86)
c. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all devices)	S.6.3.
Accuracy class	(1/1/86)
Nominal capacity	Retroactive
Value of scale division with nominal capacity, if not apparent	(1/1/83)
Value of "e" (if different from "d")	(1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special purposes	(1/1/86)
Maximum number of scale divisions (n_{max})	(1/1/88)
d. Marking requirements - weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices).	S.6.3.
Accuracy class	(1/1/88)
Nominal capacity.	Retroactive
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special purposes	(1/1/86)
Maximum number of scale divisions (n_{max})	(1/1/88)
Minimum verification scale division for which device complies with the requirements (e_{min} or d)	(1/1/88)

	H-44 General Code and Scales Code References

Inspection (cont.):

e. Marking requirements - load cell with Certificate of Conformance (in addition to marking for all devices) S.6.3., S.5.4. (1/1/94)

Note: Requires information on a data plate attached to the load cell or in an accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document. ..... (1/1/88)

Manufacturer's name or trademark, model designation, model prefix, and serial number and prefix shall also be marked on both the load cell and in any accompanying documents ..... (1/1/91)
Accuracy class ..... (1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F) ..... (1/1/86)
Maximum number of divisions (1/1/88) ..... (1/1/88)
"S" or "M" for single or multiple cell applications ..... (1/1/88)
Direction of loading, if not obvious ..... (1/1/88)
Minimum dead load, maximum capacity, safe load limit, and load cell verification interval (V_{min}) ..... (1/1/88)
V_{min} stated in mass units ..... (1/1/01)

4. Indicating and recording elements.

Value of scale division ..... S.1.2.* (1/1/86), S.1.2.1. (1/1/89), S.1.2.2.1.*, S.1.2.2.2.*, S.5.3., UR.1.1.(b), G-S.5.3., G-S.5.3.1., UR.1.3. (1/1/86)
Customer Indications. ..... S.1.8.4.
Prepackaging scales only ..... S.1.9.1.
Value of tare division. S.2.3. (1/1/83)
Tare mechanism. ..... S.2.3.
Combined zero-tare ("0/T") key. ..... S.2.1.6.
Appropriateness of design. G-S.3., G-S.5., S.1.3., S.1.4., S.1.8.1., S.1.8.2., (1/1/86), S.1.8.3. (1/1/01), S.1.9.2. S.5.2.,* S.5.4. (1/1/94)
Recorded representations, General. ..... G-S.5.6.
Prepackaging scales only. ..... UR.1.,UR.1.1., UR.3.1.*
Suitability for use. ..... UR.3.2.,G-UR.1.1. S.2.5.
Damping means. ..... S.1.10.
Adjustable components. ..... S.1.11.(a) (1/1/79)
Provisions for sealing. ..... S.1.11.(b) (1/1/90), S.1.11.(c) (1/1/95), G-S.8. (1/1/90), S.1.8.4.1. (1/1/01), G-UR.4.5.

	H-44 General Code and Scales Code References

Inspection (cont.):

5. Weighing elements

Antifriction means.	S.4.1.
Adjustable components.	S.4.2.
Multiple load-receiving elements.	S.4.3.
Drainage, if wet commodities are weighed.	S.3.2., UR.3.6.
Scoop counterbalances.	S.3.3.

Pretest Determinations:

Tolerances.

1. Acceptance/maintenance. ..... G-T.1., G-T.2.

2. Application. ..... G-T.3.

3. Tolerance values:

Determine number of scale divisions (n)

$$n = \frac{\text{Scale capacity}}{\text{Value of the scale division}}$$

If scale is marked with an accuracy designation.	T.N.2.1., T.N.2.3., T.N.2.4., T.N.3.1., Table 6 (Class III), T.N.3.2., T.N.4.4., T.N.5.
If scale is unmarked and n equals 5000 or less.	T.1.1., T.N.2.1., T.N.2.3., T.N.2.4., T.N.3.1./Table 6 (Class III), T.N.3.2., T.N.4.3., T.N.5.
Operating temperature unmarked scales.	T.N.8.1.4. (1/1/81)
Unmarked postal & parcel post scales.	T.1.2.
Discrimination.	T.N.7.1, T.N.7.2., N.1.5. (1/1/86), N.1.5.1.
Accuracy of Field Standards.	N.2.
Minimum Test Weights and Test Loads.	N.3., Table 4.

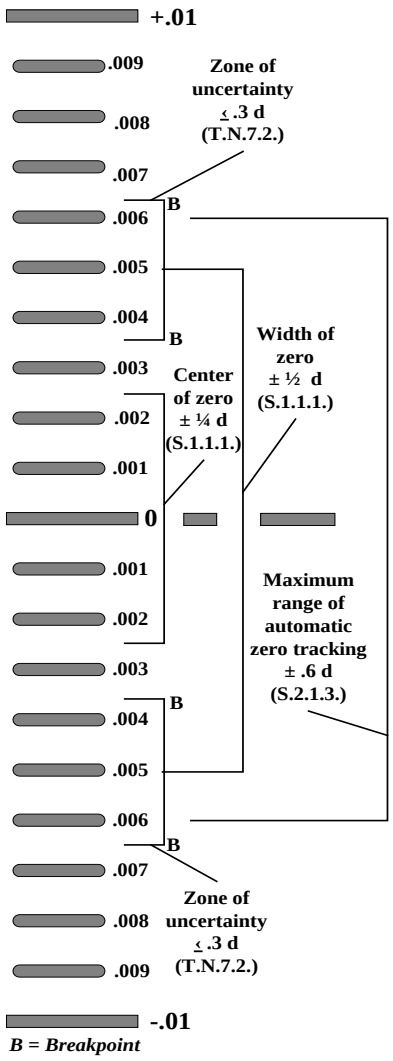
	H-44 General Code and Scales Code References

Test Notes:

1.	Check repeatability of, and agreement between indications throughout test.	G-S.5.2.2.(a) (b), T.N.4.3., T.N.5., G-S.5.4.
2.	Recheck zero load balance each time test load is removed.	N.1.9., G-UR.4.2.
3.	If scale is equipped with a printer, print ticket or label at each test load. Verify;	
	the effectiveness of motion detection.	S.2.5.1.(b)
	that price calculations based on weight are rounded to the nearest cent.	G-S.5.5.
	that any recorded representations for weight, unit price, and total sale agree with their associated corresponding values that are displayed; and	G-S.5.2.2., G-S.5.6., S.2.5.1.(b), S.1.8.2.
	that the value of the scale division as recorded on the recorded representation is the same as the division value indicated.	UR.1.3. (1/1/86)
	Also verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy.	G-S.5.6.
4.	**Electronic scales only** - If, during the conduct of the test, the performance of the device is questionable with respect to the zone of uncertainty or the width of zero (see test procedure below), adequate tests should be conducted to determine compliance.	N.1.5. (1/1/86), N.1.5.1.,S.1.1.1.(a), S.1.1.1.(b) (1/1/93)
5.	**Electronic scales only -** If the device is equipped with operational features such as programmable tare and/or unit prices, multiplier keys, sales accumulation, manual weight entries, price retention, two scales with one printer, etc., check proper operation and appropriateness.	G-UR.4.1., G-UR.4.2., S.4.3., S.1.12. (1/1/93 and 1/1/05), UR.3.9.

H-44 General Code and Scales Code References

Test Notes (cont.):



This example of Automatic Zero-Tracking and the Width of Zero test is based on a scale division of 0.01 lb. The principles used in this example can also be used to test scales with other division sizes, including scales indicating in metric units.

Automatic Zero-Tracking test:

Test action	Required Indication
a. Zero scale	0.00 lb
b. Apply 0.007 lb	+ 0.01 lb

(Repeat three times. Three failures will result in scale rejection.)

c. Zero scale	0.00 lb
d. Apply 0.007 lb	+ 0.01 lb
e. Zero Scale	0.00 lb
f. Remove 0.007 lb	− 0.01 lb or a below zero indication

(Repeat three times. Three successive failures will result in scale rejection. If scale passes go to the next test)

Width of Zero test:

Test action	Required Indication
a. Zero scale	0.00 lb
b. Apply 0.007 lb	+ 0.01 lb
c. Zero scale	0.00 lb
d. Remove 0.007 lb	− 0.01 lb or a below zero indication.
e. Apply 0.015 lb	+ 0.01 lb stable

(Three successive failures will result in rejection.)

Note: The Width of Zero test is predecessor to the test for discrimination and may be performed on scales manufactured prior to 1986. For scales manufactured on or after 1/1/86, the test for discrimination applies.

Important: Apply or remove the test weights all at once in both tests. Use forceps if necessary.

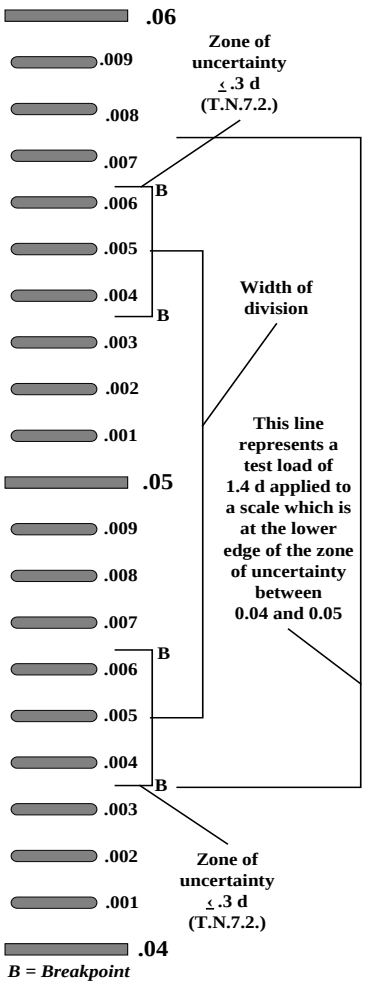
H-44 General Code and Scales Code References

Test for Electronic Scales:

1. Test for discrimination at or near zero load (if environmental conditions permit)..... N.1.5. (1/1/86), N.1.5.1.

SAFTEY REMINDER!!!

- **WEAR SAFETY SHOES!**
- **USE PROPER LIFTING TECHNIQUES!**



This example of a discrimination test at or near zero load is based on a scale division of 0.01 lb. The principles used in this example can also be used to test scales with other division sizes, including scales indicating in metric units.

a. With the device at zero, place decimal weights on scale equal to 1d.

b. Zero the scale and place a test load equal to 5d on the load receiving element.

c. Remove the decimal weights in 0.1d increments until the indication flickers between 0.04 lb and 0.05 lb. If the indication does not flicker but indicates a steady 0.04 lb, add 0.1d. If the scale indicates 0.05 lb, it is at the breakpoint in the zone of uncertainty. (Remove the 0.1d if it was used to verify the breakpoint.)

d. Add a test load equal to 1.4d to the scale (0.014 lb)

e. The indication should read a steady 0.06 lb.

f. If the scale passes this test at a load near zero, the test should be performed near the maximum test load.

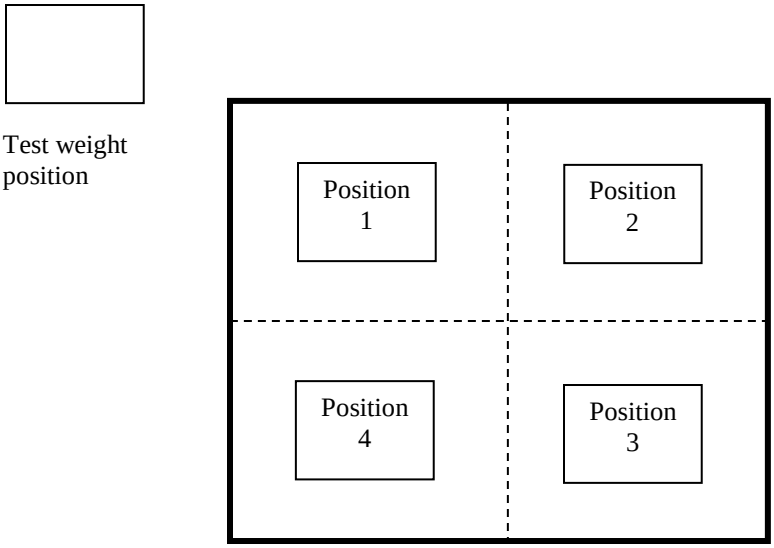
H-44 General Code and Scales Code References

Test for Electronic Scales (cont.):

2. Increasing-load test[1] (with the load approximately centered) at the following minimum test loads (20d):
   For scales indicating in metric units:
   - 100 g; then at each 500 g to 2.5 kg; at 500 g to 2.5 kg intervals thereafter to an amount equal to the shift-test load (i.e., a test-weight load equal to at least 30 % of scale capacity, but not to exceed 35 % of scale capacity).
   - Include test points equal to 500d, 2000d, and 4000d..... N.1.1.

   For other scales:
   - 0.50 lb; then at each pound to 5 lb; at 1 lb, 2 lb, or 5 lb intervals thereafter to an amount equal to the shift-test load, (i.e., a test-weight load equal to at least 30 % of scale capacity, but not to exceed 35 % of scale capacity).
   - Include test points equal to 500d, 2000d, and 4000d..... N.1.1.

3. Shift test: use test weights equal to no less than 30 % of scale capacity, but not to exceed 35 % of scale capacity..... N.1.3.7.(a)



Shift Test Positions - Electronic Scales

4. Continue increasing - load test:
   For scales indicating in metric units - at 2.5 kg intervals to capacity.
   For other scales - at 5 lb intervals to capacity.

[1] For scales that are not marked with an accuracy classification and have less than 1000 scale divisions, use the following procedure: begin test at 20d; then test at 0.50 lb and at each pound thereafter to capacity, including test loads at $^1/_4$, $^1/_2$, and $^3/_4$ capacity.

	H-44 General Code and Scales Code References

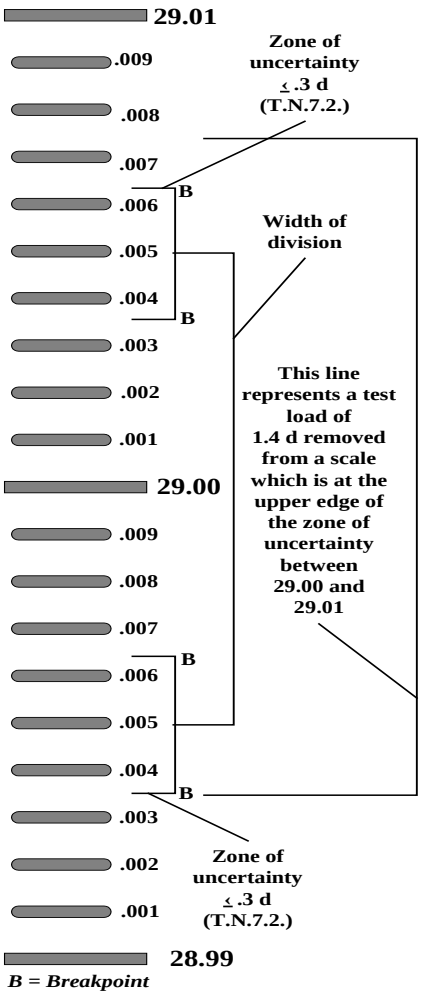
Test for Electronic Scales (cont.):

5. Radio Frequency Interference (RFI)/Electromagnetic Interference (EMI)
   Conduct test at or near capacity when RFI/EMI transmission sources are present or if a problem is suspected. ..... G-UR.1.2., G-N.2., G-UR.3.2., G-UR.4.2., N.1.6., T.4., T.N.9.*

6. Test for over-capacity indication..... S.1.7.(a) retroactive, S.1.7.(b)(1/1/93)

7. Test for discrimination at or near capacity (if environmental conditions permit). ..... N.1.5. (1/1/86), N.1.5.1.

   A test load equivalent to 1.4d shall cause a change in the indicated or recorded value of at least 2.0d..... T.N.7.2.



This example of a discrimination test near capacity is based on a scale division of 0.01 lb at a test load of 29.00 lb. The principles used in this example can also be used to test scales with other division sizes and capacities, including scales indicating in metric units.

a. With the scale at zero, add decimal weights equal to 1.4d and zero the device.

b. Add test weights to make the scale indicate a weight value near capacity (e.g., 29.00 lb).

c. With the scale stable, add decimal weights in 0.1d increments until the indication flickers between 29.00 lb and 29.01 lb. If the indication shows a steady 29.01 lb, remove 0.1d. If the scale indicates 29.00 lb it is at the breakpoint in the zone of uncertainty. (Replace the 0.1d if it was used to verify the breakpoint.)

d. Remove the 1.4d test load (0.014 lb).

e. The scale should indicate a steady 28.99 lb.

f. If the test passes near the maximum capacity, the test should be performed near zero.

	H-44 General Code and Scales Code References

Test for Electronic Scales (cont.):

8. Decreasing-load test - for scales marked with an accuracy class and having 1000 or more scale divisions (d), test with loads equal to the maximum test load at each tolerance value. For example, on a Class III scale, at test loads equal to 4000d, 2000d, and 500d; for all other scales, the test load shall be equal to one-half of the maximum load applied in the increasing-load test. ..... N.1.2., N.1.2.1., or N.1.2.2.

9. Recheck zero-load balance. ..... N.1.9., G-UR.4.2.

10. Test for proper design of automatic zero-tracking mechanism, if the scale is so equipped. ..... S.2.1.3.1.(a), S.2.1.3.2.(b)

    Under normal operating conditions the maximum load that can be "rezeroed" when placed on or removed from the platform all at once, shall be 0.6 scale division for scales manufactured between January 1, 1981 and January 1, 2007, and 0.5 scale division for scales manufactured after January 1, 2007.

11. Check proper design of tare auto-clear, if scale is so equipped. S.2.3. (1/1/83)

12. If scale is equipped with a semi-automatic zero-tracking mechanism, test effectiveness of motion detection. ..... S.2.1.2.(b)

13. Establish correct zero-load balance. ..... N.1.9., G-UR.4.2.

Test for Mechanical Scales:

SAFTEY REMINDER!!!

- **WEAR SAFETY SHOES!**
- **USE PROPER LIFTING TECHNIQUES!**

1. Increasing-load test (include test loads of 500d, 2000d, and 4000d as part of this test -all test loads approximately centered).. ..... N.1.1.

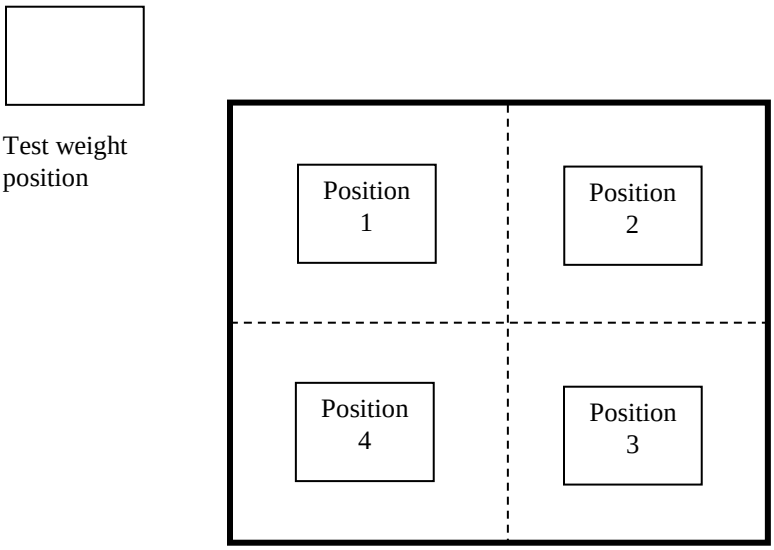
   - For scales that indicate in metric units: test loads of 30 g, 100 g, 200 g, and 500 g
   - For other scales: test loads of 1 oz, 3 oz, 7 oz, and 15 oz or 0.05 lb, 0.15 lb, 0.45 lb, and 0.95 lb

   Then check:
   - For scales that indicate in metric units - at each 500 g to one quarter capacity
   - For other scales at each pound to one-quarter capacity.

H-44 General Code and Scales Code References

Test for Mechanical Scales (cont.):

2. Shift test - use test weights equal to no less than 30 % of scale capacity, but not to exceed 35 % of scale capacity. ..... N.1.3.7.(a)



Shift Test Positions - Mechanical Scales

3. Continue increasing-load test at one-half, three-quarters, and nominal capacity ..... N.1.1.

4. Test for discrimination (if environmental conditions permit). N.1.5. (1/1/86)

   A test load equivalent to 1.4d shall cause a change in the indicated or recorded value of at least 1.0d. ..... T.N.7.1.*

5. Decreasing-load test. ..... N.1.2.

   For scales marked with an accuracy class and having 1000 or more scale divisions, test with loads to equal the maximum test load at each tolerance value. For example, on a Class III scale, at test loads equal to 4000d, 2000d, and 500d; for scales with n less than 1000, the test load shall be equal to one-half of the maximum load applied in the increasing-load test. ..... N.1.2.1.

   All other scales, test with one-half of the maximum load applied in the increasing-load test. ..... N.1.2.2.

6. Recheck zero-load balance. ..... N.1.9., G-UR.4.2.

7. Money-value test. Check chart or drum at several points. ..... G-S.5.1.

H-44 General Code and Scales Code References

Test for Mechanical Scales (cont.):

8. The money value computation (analog indications) does not exceed:..... S.1.8.1., S.1.8.2.

Maximum Money Value Interval	Price / Kilogram	Price/Pound
$0.01	$0.55 or less	$0.25 or less
$0.02	$0.56 to $2.75	$0.26 to $1.25
$0.05	$2.76 to $7.50	$1.26 to $3.40
$0.10	greater than $7.50	greater than $3.40

9. Money value computation (analog quantity indications/digital money values)..... S.1.8.3.

SAFETY REMINDER!!!

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

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2015 NIST EPO No. 5

Examination Procedure Outline for

Prescription and Jeweler Scales Part 1 – Electronic

EPO No. 5 is divided into two parts. It is recommended that this outline be followed as minimum criteria for examining electronic digital indicating scales and balances used in prescription and jeweler applications. Included within Part 1, on pages 12 through 16, are procedures for verifying proper operation of a legal for trade counting feature on a Class I and Class II prescription scale. Part 2, which applies to mechanical equal arm scales and balances used in prescription and jeweler applications, begins on page 17.

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

Prescription scales are often located and used in areas where controlled substances are stored. Access to these areas, except by qualified personnel, is generally prohibited. Do not enter any restricted areas unless authorized to do so by personnel having proper authority to grant such access.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the NIST EPO Safety Annex (Safety Considerations and Glossary of Safety Key Phrases) should be duplicated and included with this outline.

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

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

Clothing	**Personal Protection Equipment e.g., Safety Shoes**
Electrical Hazards	**Support – for Scale and Test Weights**
First Aid Kit	**Transportation of Equipment**
Lifting	

Also: Chemicals and Hazardous Materials or Obstructions

Equipment List:

Mass Standards Required[1]	Special Handling Equipment
Class I Scales: OIML E-2, ASTM 1, or standards of greater accuracy.	Clean lint-free and dust-free gloves Tweezers Ash-free, acid-free filter paper
Class II Scales: OIML F-1, ASTM 3, or standards of greater accuracy.	
Class III Scales: NIST Class F, or standards of greater accuracy.	
Unmarked Scales: Use standards of the proper level of accuracy that comply with NIST Handbook 44 Fundamental Consideration as detailed in footnote 1.	

Note: The conversion tables for units of measurement commonly indicated on jewelers and prescription scales are listed in Appendix A to EPO No. 5. Verify the performance of the scale at multiple test points when different units of measurement are in commercial use for a particular application.

Special care is required when handling mass standards to maintain the accuracy level needed to properly test most prescription and jewelers scales and scales marked Class I or Class II.

1. Never touch standards with bare hands or otherwise contaminate standards by placing them on dirty surfaces.
2. Always wear suitable gloves or use tweezers when handling precision standards to prevent substances (oils, lint, moisture, etc.) from adhering to their metal surfaces.
3. Special filter papers are available and should be used to prevent contact with dirty surfaces.
4. Proper cleaning methods are to be used.
5. Exercise care in storing and transporting standards to avoid physical damage.

Inspection:

	H-44 General Code and Scales Code References
1. Accessibility for inspection, testing, and sealing.	G-UR.2.3
2. Zero-load balance as found.	UR.4.1.
Zero indication	G-S.5.2.2.(d), (1/1/86), S.1.1., S.1.1.1.(a), S.1.1.1.(b), (1/1/93)
Zero-load adjustment	S.2.1.1., S.2.1.2.
Zero-tracking (scales manufactured between 1/1/81 and 12/31/06)	S.2.1.3.1.(a)
Zero-tracking (scales manufactured on or after 1/1/07)	S.2.1.3.2.(b)

[1] In accordance with NIST Handbook 44, Fundamental Considerations Section 3 paragraph 3.2., the combined error and uncertainty of any standard used for testing must be less than one-third the applicable device tolerance. The use of the mass standards indicated for each of the scale accuracy classes listed will ensure conformance with this fundamental consideration.

	H-44 General Code and Scales Code References

Inspection (Cont.):

3. Marking:

Identification (Refer to list of required markings provided in the table that follows)... G-S.1., S.6., S.6.3., Table S.6.3.a, Table S.6.3.b.

List of Required Markings for Jeweler and Prescription Scales	
Manufacturer's ID or Name	Special Application (1/1/86)
Model Identifier	Nominal Capacity [1]
Acceptable Model Identifier Prefix (1/1/03)	Nominal Capacity and Value of Scale Division, "d" Displayed Together (1/1/83)
Serial Number (1/1/68)	Value of the Verification Scale Division, "e" if different from the value of the scale division "d" (1/1/86)
Serial Number Prefix (1/1/86)	Temperature Limits Class III Scales (1/1/86)[2]
Acceptable Abbreviations for "Serial" and "Number" (1/1/01)	Accuracy Class (1/1/86)
Certificate of Conformance (CC) Number or CC Addendum Number and Prefix (1/1/03)	

[1] The nominal capacity of a prescription scale that is not marked with an accuracy class designation can be assumed to be ½ apothecary ounce, unless otherwise marked. (Reference N.6.)

[2] Applies only when the temperature range on the NTEP CC is narrower than and within -10 °C to 40 °C (14 °F to 104 °F).

Note: Be aware that the required marking information included in this table was extracted from the 2013 edition of NIST Handbook 44 and is susceptible to change in future editions.

Marking (continued):

- Devices or main elements remanufactured after January 1, 2002. ..... G-S.1.2
- Interchange or reversal of parts. ..... G-S.4.
- Operational controls, indications, and features. G-S.6. (1/1/77)
- Lettering ..... G-S.7.
- Visibility of identification ..... G-UR.2.1.1.

4. General Considerations:

- Selection of equipment ..... G-UR.1.1., G-UR.1.2., UR.1.
- Typical class for weighing applications. ..... UR.1.1., Table 7a*
- Accuracy class designation and parameters. S.5.1.* (1/1/86), S.5.2.* (1/1/86)
- Nominal capacity of Prescription Scale ..... N.6.
- Recommended Minimum Load. ..... UR.3.1.
- Maximum load. ..... U.R.3.2.
- Permanence. ..... G-S.3.

	H-44 General Code and Scales Code References

Inspection (Cont.):

5. Installation.	G-UR.2.1.
Indicating or recording element.	G-UR.2.2.
Position of equipment (not applicable to prescription scales)	G-UR.3.3.
Initial zero-setting mechanism.	S.2.1.5.(a), S.2.1.5.(b), (1/1/09)
Supports.	UR.2.1.

SAFTEY REMINDER

– **Check to ensure that scale supports provide a firm foundation for the scale under all loading conditions, including loading of the platform to device capacity!**

Level indicating means and condition.	S.2.4., (1/1/86), UR.4.2.
Customer Indications.	S.1.8.4.
6. Design of indicating and recording elements:	S.1.2. * (1/1/86), S.1.2.1. (1/1/89), G-S.5.3., G-S.5.3.1.
Value of the scale division	UR.1.3. (1/1/86), UR.1.3.1. (1/1/86)
Recorded representations, General	G-S.5.6.
Indicated and recorded representation of units (Appropriate abbreviations):	G-S.5.6.1. (a)
Equipment manufactured on or after January 1, 2008	G-S.5.6.1. (b)
Equipment manufactured prior to January 1, 2008	S.5.3.
Multi-interval and multiple range scales	S.1.2.2.1., S.1.2.2.2.
Value of the verification scale interval	S.2.3. (1/1/83)
Value of the tare division	S.2.3.
Tare mechanism	S.2.1.6.
Combined Zero-Tare (“0/T”) key	S.2.5.
Damping means	S.1.9.1., S.1.9.2.
Prepackaging scales	S.4.
7. Design of the weighing element.	
8. Security and sealing:	S.1.10.
Adjustable components	G-UR.4.5.
Adjustment mechanisms designed to be sealed	G-S.8. (1/1/90),
Provisions for sealing (does not apply to Class I)	S.1.11.(a) (1/1/79), S.1.11. (b) (1/1/90), S.1.11.(c) (1/1/95)

	H-44 General Code and Scales Code References

Inspection (Cont.):

9. Maintenance, use, and environmental factors:

Facilitation of fraud	G-S.2.
Protection from environmental factors	UR.2.3.
Method of operation	G-UR.3.1.
(scales having special designs)	UR.3.5.
Maintenance of equipment	G-UR.4.1.
Abnormal performance	G-UR.4.2.
Use of adjustments	G-UR.4.3.
Scale modification	UR.4.3.

10. Assistance ..... G-UR.4.4.

Pretest Determinations:

1. Verification scale interval (e) ..... S.1.2.2.1.*, S.1.2.2.2.*

For Class I and II scales equipped with a verification scale division (e) that does not equal the value of the displayed scale division (d), verify that the relationship between "e" and "d" conforms to the expression:

$$d < e \leq 10\ d$$

For Class III scales that are marked with a manufacturer's designated verification scale division (e), verify that the value of "e" is less than or equal to the value of "d."

2. Tolerances:

Acceptance/maintenance	G-T.1., G-T.2.
Application	G-T.3., G-T.4., T.N.2.1.*, T.N.2.2.*, T.N.2.3.*

Tolerance values:
Determine the number of scale divisions (n) [2] using the following formula:

[2] In accordance with Handbook 44 Scales code Table 3, footnote 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 (i.e., do not add "n" for the ranges together). 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 element shall not exceed the maximum specified for the accuracy class. (Added to Table 3 in 1997)

	H-44 General Code and Scales Code References

Pretest Determinations (Cont.):

$$n = \frac{\text{Scale capacity}}{\text{Value of the verification scale division (e)}}$$

Scales marked with an accuracy class	T.N.3.1., Table 6,
Scales not marked with an accuracy class	T.N.3.2., T.N.4, T.N.5 T.1.1., Table T.1.1.
3. Discrimination	T.N.7.2.*
4. Minimum test weights and test loads.....	N.3., Table 4

Test Notes:

1. Scales equipped with Automatic Zero-Tracking (AZT) Mechanism:

manufactured between 1/1/81 and 1/1/07	
manufactured on or after 1/1/07.....	S.2.1.3.1.(a) S.2.1.3.2.(b)

To verify correct operation of an AZT feature on a scale in which the value of the scale division (d) is equal to the value of the verification scale division (e), (i.e., the scale manufacturer has not declared a verification scale division) complete step a. through step f. below.

a. Zero the scale with no load on the platter.
b. Apply <u>all at once</u> test weights equal to 0.7 d.
c. Verify that the indicator is continuously displaying the value of 1 d.
d. Zero the scale with the 0.7 d test weights remaining on the platter.
e. Remove the 0.7 d test weights <u>all at once</u>.
f. The scale must display a continuous behind zero indication using one of the following means:
   - display a value equal to minus 1 d;
   - blank the display; or
   - display error symbols that cannot be interpreted as a weight value.

If the scale is equipped with a verification scale division (e) that is not equal to the value of the scale division (d), the value of "d" rather than "e" is used to calculate the maximum permissible amount of weight that can be rezeroed during this test. However, in instances where multiplying the value of the scale division (d), whether or not the value of "d" and "e" are equal, by 0.7 results in a value that is smaller than the smallest available test standard, a field test of the AZT feature is not possible.

	H-44 General Code and Scales Code References

Test Notes (Cont.):

Be aware that step a. through step c. verify the correct operation of an AZT feature on the positive side of zero while step d. through step f. verify the correct operation of an AZT feature behind zero. A continuous display of 1 d (in step c.) and a continuous display of a behind zero indication (i.e., in accordance with any of the means noted in step f.) confirms the correct operation of an AZT feature on both sides of zero. However, if the displayed indication is zero following the completion of step b. or step e., the AZT feature may not be functioning properly. In this case, verify the feature is not functioning properly by repeating the AZT test before rejecting the device.

2. If the scale is equipped with a semiautomatic zero-setting mechanism (i.e., pushbutton zero), a pushbutton tare feature, or a ticket printer, verify the correct operation of motion detection. ..... S.2.1.2.(b), S.2.5.1.(b)

3. If the scale is equipped with a ticket printer, print a ticket at several test loads. Verify that recorded values agree with corresponding indicated values and that all values are appropriately and correctly identified on the ticket. If scale is equipped with computing capability, verify correct money value agreement. ..... G-S.5.1, G-S.5.2. (except G-S.5.2.1.), G-S.5.3., G-S.5.3.1., G-S.5.4., G-S.5.5., G-S.5.6.

   Also verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy. ..... G-S.5.6.

4. Check proper design of tare auto-clear, if scale is so equipped. S.2.3. (1/1/83)

5. Discrimination. ..... N.1.5. (1/1/86), N.1.5.1., T.N.7.2.*

   Note: A test for discrimination should be performed when environmental conditions permit and when the test standards available for testing are adequate in amount and are of suitable denominations. Steps a. through d., of the Procedures for Testing Discrimination at or Near Zero Load and Procedures for Testing Discrimination Near Maximum Capacity indicated below, specify the total amount and the minimum denominations of the test standards needed to properly perform a discrimination test.

Test Notes (Cont.):

Procedures for Testing Discrimination at or Near Zero Load for a Scale, where d = e

The procedures for testing discrimination near zero load on scales equipped with a scale division value (d) that is equal to the value of the verification division (e), (i.e., d = e) are indicated in step a. through step f. below and illustrated in Figure 1.

a. With the scale on zero, place decimal weights on the scale equal to the value of 1 d.
b. Zero the scale and place a load equal to the value of 5 d on the platter.
c. Remove the decimal weights in 0.1 d increments until the indication flickers between the values representing 4 d and 5 d. If the indication does not flicker but indicates a steady 4 d value, add 0.1 d. If the scale indicates 5 d, it is at the breakpoint in the zone of uncertainty. (remove the 0.1 d if it was added to the 4 d value to verify the breakpoint)
d. Add a test load equal to 1.4 d to the scale.
e. The indication should read a stable 6 d (i.e., the addition of 1.4 d should change the displayed indication 2 d)
f. If the scale passes the discrimination test at a load near zero, a discrimination test should also be performed near the maximum capacity of the scale.

Example: Discrimination Test near Zero Load for a Scale, where d = e
Scale capacity: 610 x 0.01 g

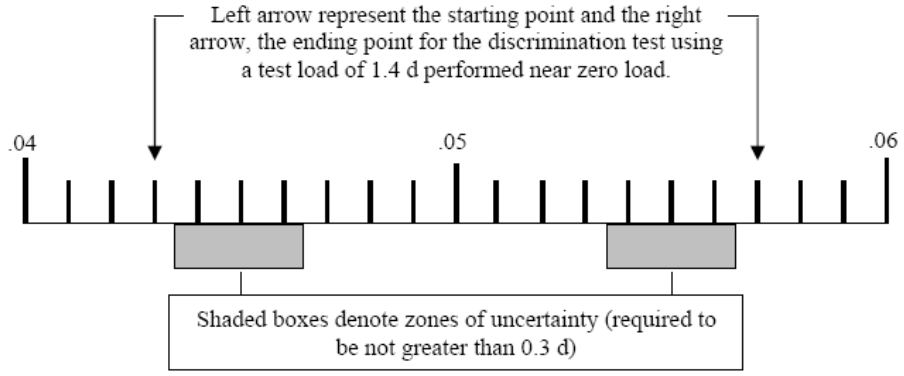


Figure 1

Test Notes (Cont.):

Procedures for Testing Discrimination near Maximum Capacity for a Scale, where d = e

The procedures for testing discrimination near maximum load on scales equipped with a division value (d) that is equal to the value of the verification division (e), are indicated in step a. through step e. below and illustrated in figure 2.

a. With the scale on zero and no load on the load-receiving element, apply test weights equal to 1.4 d and zero the device.
b. Add a test load sufficient in amount to cause the scale to indicate a stable value near maximum capacity.
c. With the scale indication stable at a near capacity test load, add test standards in 0.1 d increments until the indication continually flickers back and forth between the indication that was stable and the next higher increment. Then add 0.1 d to cause the indication to become stable at the higher of the two flickering increments.
d. Remove the 1.4 d test weights.
e. To pass the discrimination test near maximum capacity, the removal of the 1.4 d test weights should cause the indication to change (decrease) by 2 d.

Example: Discrimination Test Near Maximum Capacity for a Scale, where d = e
Scale capacity: 610 x 0.01 g

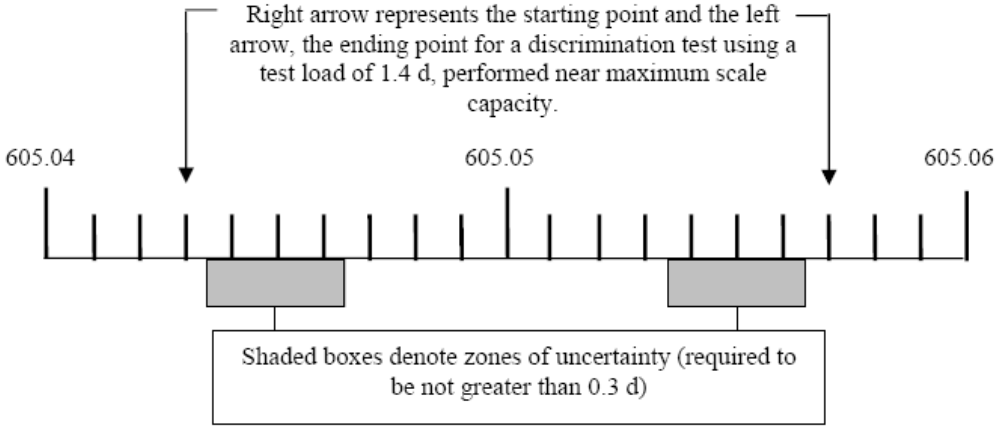


Figure 2

	H-44 General Code and Scales Code References

Test Notes (Cont.):

The procedures for testing discrimination near zero load and near maximum scale capacity when the value of the minimum scale division (d) is not equal to the value of the minimum verification scale division (e), are as follows:

a. Zero the scale with no load on the platter.
b. Apply a test load equal to 2 e to the platter and observe the displayed indication.
c. Apply an additional test load of 2 d to the platter and observe the displayed indication.
d. The addition of 2 d in step c. must increase the displayed indication by 2 d.
e. For the discrimination test at or near maximum capacity, apply a test load near scale capacity, then remove 2 d and observe the change in the displayed indication.
f. The displayed indication must change by 2 d when a test load of 2 d is removed.
g. The results of these tests confirm that a scale is able to detect small changes in weight being added or removed from the platter over the scale's entire weighing range.

Tests:

1. Level condition and Zero-load balance (verify before beginning the increasing-load test).

2. Increasing-load test (test loads approximately centered on the platter)..... N.1.1.

   For scales marked with an accuracy class, test at several points in each tolerance range including at or near the highest test load that can be applied to the scale without the tolerance increasing to the next tolerance range. For scales not marked with an accuracy class, test at several points to capacity, including test loads at or near one-quarter, one-half, and three-quarters of scale capacity and at full capacity.

3. Shift test (one-third nominal capacity test load[3]). ..... N.1.3.7.(a), T.N.4.4.*

   The shift test can be conducted during the increasing load test once one-third capacity test load is achieved.

[3] NIST Handbook 44 Scales Code paragraph N.1.3.7.(a) defines one-third nominal capacity test load as test weights in amounts of at least 30% of scale capacity, but not to exceed 35% of scale capacity.

Tests (Cont.):

Shift Test Pattern
(One-third capacity test load)
The numbered boxes identify the positions for placing the shift test load.

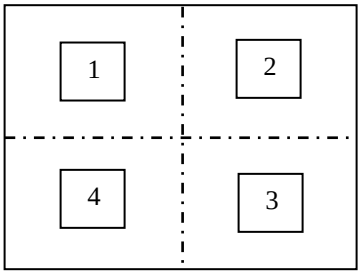


Figure 3. Rectangular Platter Shift Test Pattern.

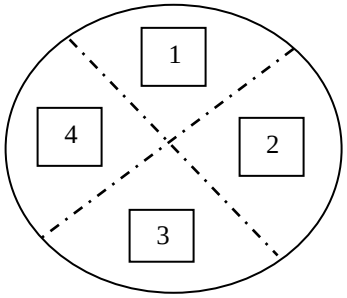


Figure 4. Circular Platter Shift Test Pattern.

4. RFI/EMI (if a problem is suspected) Radio Frequency Interference Electromagnetic Interference. G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2., N.1.6., T.N.9*

5. Check repeatability of, and agreement between indications throughout the test. ..... G.S.5.2.2.(a), G-S.5.4., T.N.5.

6. Over-capacity test..... S.1.7 (a), S.1.7.(b) (1/1/93)

7. Decreasing-load test ..... N.1.2., N.1.2.1*, N.1.2.2.

   For scales marked with an accuracy class and having a total number of scale divisions (d) or verification scale divisions (e), if "e" has been declared, greater than or equal to 100 000 for Class I scales or 10 000 for Class II scales, test with loads equal or near the highest value of each tolerance band. For example, on a Class II scale, test at loads equal or near 20 000 d and 5000 d if a verification scale division has not been declared and at or near 20 000 e and 5000 e if a verification scale division has been declared. For all other scales, test at one-half maximum test load applied during the increasing-load test.

8. Return to zero – verify the scale returns to a zero indication after the entire test load has been removed ..... N.1.9., G-UR.4.2.

It is recommended that the additional requirements in this outline be followed for a Class I or Class II prescription scale equipped with a legal for trade counting feature. The counting feature is based on commodity weight; therefore, accuracy of the weighing function must be verified before conducting a test of the counting feature.

Additional Tests for Prescription and Jeweler Scales with a Legal for Trade Counting Feature.	H-44 General Code and Scales Code References

Inspection:

1. Marking:
   - minimum individual piece weight and minimum sample piece count ..... S.6.6.
   - special application. ..... Table S.6.3.a.,
   - operational controls, indications, features ..... Table S.6.3.b. (note 13)
     G-S.6.

2. Zero indication of count. ..... S.1.1.

   A scale with a legal for trade counting feature shall be capable of indicating zero in the count mode of operation.

3. Tare mechanism ..... S.2.3.
   - Value of the tare division S.2.3. (1/1/83)

   <u>An operational counting feature is only legal for prescription filling applications on a compliant Class I or Class II device</u>.

   A prescription scale with a legal for trade counting feature must be marked:

   "**Counting Feature for Prescription Filling Only**"

   Class I or Class II prescription scales equipped with an operational counting feature that does not comply with all applicable NIST Handbook 44 requirements for the count feature must be marked on both the customer and operator's side:

   "**The Counting Feature is Not Legal for Trade**."

Additional Tests for Prescription and Jeweler Scales with a Legal for Trade Counting Feature.	H-44 General Code and Scales Code References

Pretest Determinations:

1. Tolerances for count ..... T.N.3.10., Table T.N.3.10

2. Determine the scale's maximum counting capacity (i.e., the maximum number of pieces the scale is capable of indicating) by inserting the appropriate corresponding values marked on the device into the following formula:

$$\frac{\text{nominal capacity}}{\text{minimum individual piece weight}}$$

For example: Given a scale marked as follows:

Capacity: 610 x 0.01 g
Minimum individual piece weight: 0.03 g
Minimum sample piece count: 10 pieces

Using the formula, the maximum count value in pieces is calculated as follows:

$$\frac{610 \text{ g}}{0.03 \text{ g/piece}} = 20\,333.3333 \text{ pieces}$$

Then truncate the result to the nearest whole number of 20 333 pieces.

3. Select at least three count values to verify the count accuracy of a legal for trade counting feature similar to that illustrated below:

   A count value between 90 and 100 pieces inclusive;
   A count value between 180 and 200 pieces inclusive; and
   A count value equal or near the scale's maximum counting capacity as determined in 2. above.

Note: When choosing the count value near a scale's maximum counting capacity, select a whole number that is slightly lower than the maximum possible count. For example, one possible choice at the maximum end of the counting capacity for the scale described above is 20 300. The resulting value of 20 300 is slightly less than the actual truncated value of 20 333 and is less likely to introduce rounding errors when converted to a corresponding weight value. The result is also more practical when selecting denominations of test standards for use in testing the count accuracy than if 20 333 were used.[4]

[4] When the 20 300 piece count is converted to weight by multiplying it by the scale's marked "minimum individual piece weight" of 0.03 g, the resulting weight value equals 609 g. If 20 333 is multiplied by this same factor, the resulting weight value equals 609.99 g. It would be considered acceptable to perform the test at 20 333 pieces using a test load of 609.99 g, providing test standards were available in small enough denominations for converting this count value to its exact equivalent in weight; however, it is easier and more practical to use test standards in denominations of whole grams.

Additional Tests for Prescription and Jeweler Scales with a Legal for Trade Counting Feature.	H-44 General Code and Scales Code References

Pretest Determinations (Cont.):

4. Convert the selected count values to weight by multiplying each count value by the minimum individual piece weight[5] marked on the device.

   Given the same device for this example, convert selected count values of 100, 190, and 20 300 pieces to weight using the formula: piece count x minimum individual piece weight = amount of test weight to be applied.

   100 x 0.03 g = 3 g
   190 x 0.03 g = 5.7 g
   20 300 x 0.03 g = 609 g

Test Notes:

1. Accuracy of test standards ..... Fundamental Considerations

   The combined error and uncertainty in any test standard used for testing must be less than one-third the applicable tolerance. Refer to the list of acceptable standards for use in testing precision scales on page 5E-2 of this EPO.

2. Special handling precautions for test standards:

   Special care is required when handling mass standards to maintain the accuracy level needed to properly test most prescription and jewelers scales and scales marked Class I or Class II. Never touch standards with bare hands or otherwise contaminate standards by placing them on dirty surfaces. Always wear suitable gloves or use tweezers when handling precision standards to prevent substances (oils, lint, moisture, etc.) from adhering to their metal surfaces. Special filter papers are available and should be used to prevent contact with dirty surfaces. Proper cleaning methods are to be used. Exercise care in storing and transporting standards to avoid physical damage.

3. If scale is equipped with a ticket printer, print a ticket at several test loads. Verify that recorded values agree with corresponding indicated values and that all values are appropriately and correctly identified on the ticket. ..... G-S.5.1., G-S.5.2. (except G-S.5.2.1.), G-S.5.3., G-S.5.3.1., G-S.5.4., G-S.5.5., G-S.5.6.

[5] Although the weight of an individual piece in any given prescription to be counted will often be greater than a scale's marked minimum individual piece weight, the sample used for the purpose of verifying count accuracy is established from minimum values (i.e., minimum individual piece weight and minimum sample piece count) marked on the device.

Additional Tests for Prescription and Jeweler Scales with a Legal for Trade Counting Feature.	H-44 General Code and Scales Code References

Tests:

Counting feature test ..... N.1.10.

The counting feature test requires the scale meet all three test criteria listed in 1. through 3. below. It is first necessary to determine the "*minimum sample size in weight*" using the formula:

Minimum sample size in weight = minimum individual piece weight x *minimum sample piece count*

The values for "*minimum individual piece weight*" and "*minimum sample piece count,*" must be appropriately marked and identified on a prescription scale equipped with a legal for trade counting feature.

1. Minimum sample piece count..... S.1.2.3.(b), S.2.5.3., N.1.10.

   Verify that the scale's counting feature will not accept a sample containing less than the "*minimum sample piece count*" by completing the following steps:

   a. Verify that the scale is in the counting mode of operation.
   b. With the scale operating in the counting mode, apply a sufficient load to the platter to cause the displayed indication to equal the "*minimum sample size in weight.*"
   c. Attempt to input a sample piece count less than the "*minimum sample piece count*" marked on the device.
   d. The counting feature must reject the entry.

2. Minimum individual piece weight of the sample ..... S.1.2.3.(a), S.2.5.3., N.1.10.

   Verify that a scale's counting feature will not accept the entry of an individual piece weight that is less than the "*minimum individual piece weight*" by completing the following steps:

   a. Verify that the scale is in the counting mode of operation.
   b. With the scale operating in the counting mode, apply a sufficient load to cause the displayed indication to be less than the "minimum sample size in weight."
   c. Attempt to enter the "minimum sample piece count" marked on the device.
   d. The counting feature must reject the entry.

3. Count accuracy verification..... N.1.10, T.N.3.10.

   Complete the following steps in order to verify the accuracy of a legal for trade counting feature:

   a. Place the scale in the counting mode of operation.
   b. Zero the scale with no load on the platter.

Additional Tests for Prescription and Jeweler Scales with a Legal for Trade Counting Feature.	H-44 General Code and Scales Code References

Tests (Cont.):

c. Apply a load sufficient in amount to cause the displayed weight indication to equal the value of the "minimum sample size in weight" as marked on the device.
d. Enter the value of the "minimum sample piece count" as marked on the device using the keyboard or other input means.
e. Remove the sample load that was applied in step c.; scale must indicate zero pieces.
f. Apply test standards equivalent in value to each of the test points selected, including the test point near highest possible count.
g. Observe the displayed count indication after each test point load is applied and verify that no count errors exceed the applicable tolerances indicated in Table T.N.3.10.
h. Remove the entire test load; scale must indicate zero pieces.
i. Return the scale to the weigh mode, and verify a zero balance indication.

4. Display of total quantity ..... S.2.5.3.

5. Minimum count UR.3.11

6. Correct stored piece weight ..... UR.3.12.

2015 NIST EPO No. 5

Examination Procedure Outline for

Jeweler and Prescription Scales Part 2 – Mechanical Equal Arm

It is recommended that this outline be followed for mechanical equal arm scales and balances used in prescription and jeweler applications. Requirements that apply only to scales marked with an accuracy class designation are indicated with an asterisk (*). Nonretroactive requirements are followed by the applicable date in parentheses.

Prescription scales are often located and used in areas where controlled substances are stored. Access to these areas, except by qualified personnel, is generally prohibited. Do not enter any restricted areas unless authorized to do so by personnel having proper authority to grant such access.

Safety Notes – See EPO 5 Part 1

Equipment List – See EPO 5 Part 1

	H-44 General Code and Scales Code References
Inspection:	
1. Accessibility for inspection, testing, and sealing.	G-UR.2.3
2. Zero-load balance as found.	UR.4.1.
Zero indication	S.1.1.
Zero-load adjustment	S.2.1.1.
Manual zero-setting mechanism (not applicable to Class I and Class II scales equipped with a balance ball)	S.2.1.2.
3. Marking:	
Identification (Refer to list of required markings provided in EPO Part 1.)	G-S.1., S.6., S.6.3., Table S.6.3.a, Table S.6.3.b.
Devices or main elements remanufactured after January 1, 2002	G-S.1.2
Interchange or reversal of parts.	G-S.4.
Operational controls, indications, and features.	G-S.6. (1/1/77)
Lettering	G-S.7.
Visibility of identification	G-UR.2.1.1.

	H-44 General Code and Scales Code References

Inspection (Cont.):

Marking (continued):

4. General Considerations:

Selection of equipment	G-UR.1.1., G-UR.1.2., UR.1.
Typical class for weighing applications.	UR.1.1., Table 7a*
Accuracy class designation and parameters.	S.5.1.* (1/1/86), S.5.2.* (1/1/86)
Recommended minimum load	U.R.3.1.*, Table 8*
Maximum load.	U.R.3.2.
Permanence.	G-S.3.

5. Installation. G-UR.2.1.

Position of equipment (not applicable to prescription scales)	G-UR.3.3.
Supports	UR.2.1.
Level indicating means and condition	S.2.4. (1/1/86)
Level condition	UR.4.2.

SAFTEY REMINDER

- **Check to ensure that scale supports provide a firm foundation for the scale under all loading conditions, including loading of the platform to device capacity!**

6. Design of indicating and recording elements:

Appropriateness	G-S.5.1., G-S.5.2., (except G-S.5.2.2.)
Value of the scale division	S.1.2. * (1/1/86), G-S.5.3., G-S.5.3.1.
Indicated and recorded representation of units (Appropriate abbreviations):	
Equipment manufactured on or after January 1, 2008	G-S.5.6.1. (a)
Equipment manufactured prior to January 1, 2008	G-S.5.6.1. (b)
Value of the verification scale interval	S.1.2.2.1., S.1.2.2.2.
Value of the tare division	S.2.3. (1/1/83)
Tare mechanism	S.2.3.
Graduations and indications	S.1.3., S.1.4., G-S.5.7.
Weighbeams and poises	S.1.5., S.1.6.
Adjustable components	S.1.10.
Balance indicator	S.2.2., S.2.2.1., S.2.2.2. (1/1/89)
Damping and arresting mechanism	S.2.5., S.2.5.2.

7. Design of the weighing element. S.4.

8. Security and sealing:

Adjustable components	S.1.10.
Adjustment mechanisms designed to be sealed	G-UR.4.5.

	H-44 General Code and Scales Code References

Inspection (Cont.):

9. Maintenance, use, and environmental factors:
   - Facilitation of fraud ..... G-S.2.
   - Protection from environmental factors ..... UR.2.3.
   - Method of operation ..... G-UR.3.1.
   - (scales having special designs) ..... UR.3.5.
   - Maintenance of equipment ..... G-UR.4.1.
   - Abnormal performance ..... G-UR.4.2.
   - Use of adjustments ..... G-UR.4.3.
   - Scale modification ..... UR.4.3.

10. Assistance ..... G-UR.4.4.

Pretest Determinations:

1. Tolerances:
   - Acceptance/maintenance ..... G-T.1., G-T.2.
   - Application ..... G-T.3.
   - Intermediate values ..... G-T.4.
   - Tolerance values:

     Determine the number of scale divisions (n) using the following formula:

$$n = \frac{\text{Scale capacity}}{\text{Value of the verification scale division (e)}}$$

     Scales that are marked with an accuracy class designation
     - Principles ..... T.N.1.*
     - Tolerance application ..... T.N.2.*, T.N.2.3.*
     - Maintenance tolerance values ..... T.N.3.1.* Table 6
     - Acceptance tolerance values ..... T.N.3.2.*
     - Ratio tests ..... T.N.2.5.
     - Single indicating/recording element ..... T.N.4.2.
     - Repeatability of indications ..... G-S.5.4.
     - Time dependence ..... T.N.4.5.*, T.N.4.5.1.*

     Scales that are not marked with an accuracy class designation
     - Tolerance application ..... T.1.1., Table T.1.1.
     - Ratio tests ..... T.N.2.5.
     - Single indicating/recording element ..... T.N.4.2.
     - Repeatability of indications ..... G-S.5.4.

     Note: Refer to Table T.1.1. Maintenance and acceptance tolerances are the same for unmarked prescription and jewelers scales.

2. Sensitivity Requirement (SR)

   Marked scales:
   - Application ..... T.N.6.*

	H-44 General Code and Scales Code References

Pretest Determinations (Cont.):

Test load	T.N.6.1.(b)*
Minimum change	T.N.6.2.*
Unmarked scales:	
Application	T.2.1.
Test load (prescription scales)	T.2.3.
Test load (jewelers scales)	T.2.4.
Minimum change	T.3.
3. Minimum test weights and test loads	N.3., Table 4

Test Notes:

1. Check repeatability of indications at a minimum of two different test loads during the test. G-S.5.4.,

2. Verify that scale returns to zero-load balance each time the entire test load is removed..... N.1.9., G-UR.4.2.

3. Verify scale accuracy.

   For scales not marked with an accuracy class designation two different methods may be used to verify compliance with accuracy requirements, i.e., the tolerance testing method or the error-weight testing method. Each test method procedure starts with the scale in a zero-load balance condition.

   Scales marked with an accuracy class designation should always be tested using the error-weight method since compliance with T.N.4.4. (shift test agreement) can only be determined if the precise amount of error in each shift test result is known.

   Tolerance Testing: Tolerance testing determines whether or not a scale is performing to within applicable tolerances. This method of testing does not reveal the precise amount of error in a scale. To use the tolerance test method, standards equal to the value of tolerance are added at each test load to the pan of the lighter side and the balance indicator is observed. The addition of standards equal to the value of applicable tolerance must change the position of rest of the indicator back to the initial zero-load balance indication or beyond for a scale to perform within acceptable limits.

   Error-Weight Testing: Error-weight testing determines the precise amount of error in a scale. To use the error-weight method, precision field standards (i.e., error weights) in minimum denominations equal to 0.1 d are added at each test load to the pan of the lighter side in the amount necessary to cause the position of rest of the indicator to return back to the initial zero-load balance indication. The weight values of the precision field standards (i.e., error weights) are then added together and summed, the total result being equal to the amount of error in the scale at that particular test load.

   Note: In cases where precision field standards in denominations equal to 0.1 d are not readily available, the error-weight method of testing should not be performed.

	H-44 General Code and Scales Code References

Test:

Commercial weights, (i.e., weights used in connection with commercial weighing devices) are not to be used in any of the performance tests described herein. Rather, performance testing of prescription and jewelers scales requires the sole use of suitable precision field standards. Guidelines for determining the necessary accuracy level of the precision field standards needed to properly test prescription and jewelers scales are included in the "Equipment List" section of this EPO.

1. Sensitivity test at zero load and maximum test load. N.1.4

2. Ratio test ..... N.1.7.

   Ratio tolerances are to be applied whenever the multiple of the lever system is verified using suitable precision field standards of equal value applied to opposite pans.

3. Increasing-load test ..... N.1.1.

   For scales marked with an accuracy class, test at several points in each tolerance range including at or near the highest test load that can be applied to the scale without the tolerance increasing to the next tolerance range. For scales not marked with an accuracy class, test at several points to capacity, including test loads at or near one-quarter, one-half, and three-quarters scale capacity and at full capacity.

   Testing weighbeams and dials: Verify the accuracy of each weighbeam or dial at a minimum of two points, (i.e., at or near half and full weighbeam or dial capacity). It is recommended that additional verifications be performed at test loads where these elements are regularly used.

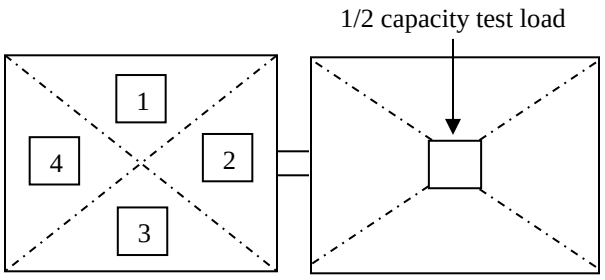
4. Shift test (at <u>one-half</u> capacity test load) ..... N.1.3.2.

   A shift test is to be conducted separately on each pan of an equal arm balance. The test is conducted with mass standards equal to one-half capacity centered on one pan and standards equal to one-half capacity centered successively at four points equidistant between the center and the front, left, back, and right edges of the opposite pan. Once the results of all four positions of the first pan have been determined, remove all test weight, and verify return to zero-load balance. Then conduct a shift test on the pan opposite the first pan, using these same loading procedures, except the test load is applied to the opposite pan.

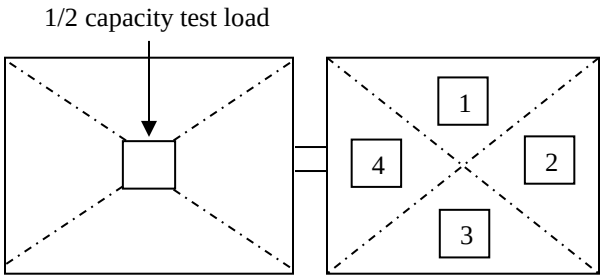
H-44 General Code and Scales Code References

Equal-Arm Scales
Shift Test Patterns - Rectangular Platter
(one-half capacity test load)

The numbered boxes identify the various positions for placing the shift test load.



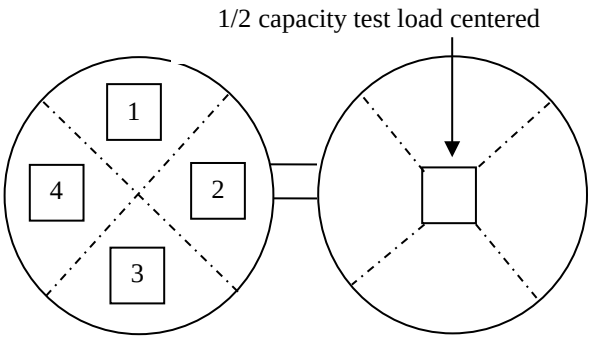
Example: Shift Test Positions - Left Pan



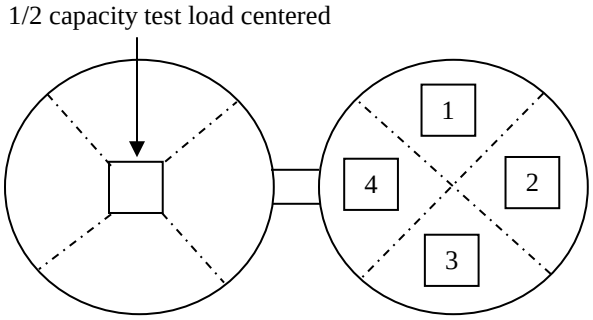
Example: Shift Test Positions – Right Pan

Equal-Arm Scales
Shift Test Patterns – Circular Platter
(one-half capacity test load)

The numbered boxes identify the various positions for placing the shift test load.



Example: Shift Test Positions - Left Pan



Example: Shift Test Positions - Right Pan

5. Return to zero-load balance (verify each time test load is removed) ..... N.1.9.

6. Commercial Weights..... H-44 Section 2.23. (Weights Code)

Note: Commercial weights should be tested on a precision balance using adequate standard weights, the errors of which, when used without correction, do not exceed one third of the smallest tolerance to be applied to the device under test. It may not be appropriate to apply the requirements in Section 2.23 to verify the accuracy of commercial weights used in connection with prescription and jewelers' scales in every field environment. In some instances, accuracy can only be verified in a laboratory that is formally accredited or recognized (i.e., a laboratory having the necessary qualifications to perform the necessary calibrations given the accuracy level of the standards being tested, e.g., OIML E-2, ASTM 1, etc.). In addition, it is recommended that commercial weights be calibrated (i.e., their accuracy verified) at a frequency interval necessary to ensure continued compliance with applicable tolerances and that the calibration frequency interval be based upon the collection of actual performance data.

2015 NIST EPO No. 5
Appendix A to EPO No. 5
Units of Mass Conversion Tables (1)
Carats (metric) to Grams

Conversion Factor: 1 carat (c) = 0.2 gram (g) exactly

Desired Test Load Carats	Equivalent Load Grams	Desired Test Load Carats	Equivalent Load Grams	Desired Test Load Carats	Equivalent Load Grams
1	0.2	60	12	600	120
2	0.4	70	14	700	140
5	1	80	16	800	160
7.5	1.5	90	18	900	180
10	2	100	20	1000	200
12.5	2.5	125	25	1250	250
15	3	150	30	1500	300
17.5	3.5	175	35	1750	350
20	4	200	40	2000	400
25	5	250	50	2500	500
30	6	300	60	3000	600
35	7	350	70	3500	700
40	8	400	80	4000	800
45	9	450	90	4500	900
50	10	500	100	5000	1000

To convert values greater than 5000 carats to grams, multiply the carat value to be converted by a factor of 0.2. The result produced will equal the equivalent value in grams.

All values in this table are exact.

2015 NIST EPO No. 5
Appendix A to EPO No. 5
Units of Mass Conversion Tables (2)
Pennyweight (troy) to Grams

Conversion Factor: 1 pennyweight (dwt) = 1.555 173 84 grams (g)

Desired Test Load Pennyweight	Equivalent Load Grams*	Desired Test Load Pennyweight	Equivalent Load Grams*	Desired Test Load Pennyweight	Equivalent Load Grams*
0.2	0.311	500	777.587	2000	3110.348
0.5	0.778	550	855.346	2250	3499.141
0.75	1.166	600	933.104	2500	3887.935
1	1.555	650	1010.863	2750	4276.728
2	3.110	700	1088.622	3000	4665.522
5	7.776	750	1166.380	3500	5443.108
10	15.552	800	1244.139	4000	6220.695
20	31.103	875	1360.777	4500	6998.282
35	54.431	925	1438.536	5000	7775.869
50	77.759	1000	1555.174	5500	8553.456
75	116.638	1100	1710.691	6000	9331.043
100	155.517	1200	1866.209	6500	10 108.630
150	233.276	1300	2021.726	7000	10 886.217
200	311.035	1400	2177.243	7500	11 663.804
250	388.793	1500	2332.761	8000	12 441.391
300	466.552	1600	2488.278	8500	13 218.978
350	544.311	1700	2643.796	9000	13 996.565
400	622.070	1800	2799.313	9500	14 774.151
450	699.828	1900	2954.830	10000	15 551.738

* All values in this column have been rounded to the nearest one milligram (0.001 g). A rounding error of no more than one-half milligram (0.0005 g) may, therefore, exist for any single gram value shown. This amount of potential rounding error is insignificant and will not adversely affect the results of performance testing on Class I, Class II, or Class III prescription and jewelry scales provided that the scale being tested has a minimum resolution of 0.01 pennyweight or greater and mass standards of proper accuracy level are used in the testing. Refer to EPO No. 5E Equipment List for guidelines on determining the proper accuracy level of mass standards.

Do not sum any two or more gram values shown in this table when calculating the appropriate equivalent load in grams. Instead, to achieve the gram equivalent of any pennyweight value not included in this table, multiply the pennyweight value by 1.555 173 84, then round to the nearest one milligram (0.001 g).

Note: Pennyweight is a unit of mass in the troy system where 20 pennyweight is equal to 1 ounce troy exactly.

2015 NIST EPO No. 5
Appendix A to EPO No. 5
Units of Mass Conversion Tables (3)
Pounds (avoirdupois) to Grams

Conversion Factor: 1 pound (lb) = 453.592 37 grams (g) exactly

Desired Test Load Pounds	Equivalent Load Grams*	Desired Test Load Pounds	Equivalent Load Grams*	Desired Test Load Pounds	Equivalent Load Grams*
0.01	4.536	1.75	793.787	11	4989.516
0.05	22.680	2.00	907.185	12	5443.108
0.10	45.359	2.50	1133.981	14	6350.293
0.15	68.039	3.00	1360.777	16	7257.478
0.20	90.718	3.50	1587.573	18	8164.663
0.25	113.398	4.00	1814.369	20	9071.847
0.30	136.078	4.50	2041.166	22	9979.032
0.40	181.437	5.00	2267.962	24	10 886.217
0.50	226.796	5.50	2494.758	26	11 793.402
0.75	340.194	6.00	2721.554	28	12 700.586
0.95	430.913	7.00	3175.147	30	13 607.771
1.00	453.592	8.00	3628.739	32	14 514.956
1.25	566.990	9.00	4082.331	34	15 422.141
1.5	680.389	10.00	4535.924	36	16 329.325

* All values in this column have been rounded to the nearest one milligram (0.001 g). A rounding error of no more than one-half milligram (0.0005 g) may, therefore, exist for any single gram value shown. This amount of potential rounding error is insignificant and will not adversely affect the results of performance testing on Class I, Class II, or Class III prescription and jewelry scales provided that the scale being tested has a minimum resolution of 0.0002 pound or greater and mass standards of proper accuracy level are used in the testing. Refer to EPO No. 5E Equipment List for guidelines on determining the proper accuracy level of mass standards.

Do not sum any two or more gram values shown in this table when calculating the appropriate equivalent load in grams. Instead, to achieve the gram equivalent of any pound value not included in this table, multiply the pound value by the conversion factor 453.592 37, then round to the nearest one milligram (0.001 g).

2015 NIST EPO No. 5
Appendix A to EPO No. 5
Units of Mass Conversion Tables (4)
Ounces (avoirdupois) to Grams

Conversion Factor: 1 ounce (oz avdp) = 28.349 523 125 grams (g) exactly

Desired Test Load Ounces	Equivalent Load Grams*	Desired Test Load Ounces	Equivalent Load Grams*	Desired Test Load Ounces	Equivalent Load Grams*
0.25	7.087	5	141.748	60	1700.971
0.50	14.175	6	170.097	70	1984.467
0.75	21.262	7	198.447	80	2267.962
0.95	26.932	8	226.796	90	2551.457
1.00	28.350	9	255.146	100	2834.952
1.25	35.437	10	283.495	125	3543.690
1.50	42.524	12	340.194	150	4252.428
1.75	49.612	14	396.893	175	4961.167
1.95	55.282	16	453.592	200	5669.905
2.00	56.699	18	510.291	250	7087.381
2.50	70.874	20	566.990	300	8504.857
3.00	85.049	25	708.738	350	9922.333
3.50	99.223	30	850.486	400	11 339.809
4	113.398	40	1133.981	450	12 757.285
4.5	127.573	50	1417.476	500	14 174.762

* All values in this column have been rounded to the nearest one milligram (0.001 g). A rounding error of no more than one-half milligram (0.0005 g) may, therefore, exist for any single gram value shown. This amount of potential rounding error is insignificant and will not adversely affect the results of performance testing on Class I, Class II, or Class III prescription and jewelry scales provided that the scale being tested has a minimum resolution of 0.005 ounce or greater and mass standards of proper accuracy level are used in the testing. Refer to EPO no. 5E Equipment List for guidelines on determining the proper accuracy level of mass standards.

Do not sum any two or more gram values shown in this table when calculating the appropriate equivalent load in grams. Instead, to achieve the gram equivalent of any ounce value not included in this table, multiply the ounce value by the conversion factor 28.349 523 125, then round to the nearest one milligram (0.001 g).

2015 NIST EPO No. 5
Appendix A to EPO No. 5
Units of Mass Conversion Tables (5)
Ounces (troy) to Grams

Conversion Factor: 1 ounce troy (oz t) = 31.103 476 8 grams (g) exactly

Desired Test Load Ounce Troy	Equivalent load Grams*	Desired Test Load Ounce Troy	Equivalent load Grams*	Desired Test Load Ounce Troy	Equivalent load Grams*
0.01	0.311	11	342.138	55	1710.691
0.05	1.555	12	373.242	60	1866.209
0.1	3.110	13	404.345	65	2021.726
0.25	7.776	14	435.449	70	2177.243
0.45	13.997	15	466.552	75	2332.761
0.5	15.552	16	497.656	80	2488.278
0.75	23.328	17	528.759	85	2643.796
0.95	29.548	18	559.863	90	2799.313
1	31.103	19	590.966	95	2954.830
1.5	46.655	20	622.070	100	3110.348
2	62.207	21	653.173	110	3421.382
2.5	77.759	22	684.276	120	3732.417
3	93.310	23	715.380	130	4043.452
4	124.414	24	746.483	140	4354.487
5	155.517	25	777.587	150	4665.522
6	186.621	30	933.104	160	4976.556
7	217.724	35	1088.622	170	5287.591
8	248.828	40	1244.139	180	5598.626
9	279.931	45	1399.656	190	5909.661
10	311.035	50	1555.174	200	6220.695

* All values in this column have been rounded to the nearest one milligram (0.001 g). A rounding error of no more than one-half milligram (0.0005 g) may, therefore, exist for any single-gram value shown in this table. This amount of potential rounding error is insignificant and will not adversely affect the results of performance testing on Class I, Class II, or Class III prescription and jewelry scales provided that the scale being tested has a minimum resolution of 0.0005 ounce troy or greater and mass standards of proper accuracy level are used in the testing. Refer to EPO No. 5 Equipment List for guidelines on determining the proper accuracy level of mass standards.

Do not sum any two or more gram values shown in this table when calculating the appropriate equivalent load in grams. Instead, to achieve the equivalent of any ounce troy value not included in this table, multiply the ounce troy value by the conversion factor 31.103 476 8, then round to the nearest one milligram (0.001 g).

2015 NIST EPO No. 7

Examination Procedure Outline for

Medium-Capacity Scales

It is recommended that this outline be followed as minimum criteria for examining medium-capacity portable platform scales and warehouse scales, including self-contained and built-in types, with the following types of indicating elements: beams, dials, and electronic digital-indicators. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the NIST EPO Safety Annex (Safety Considerations and Glossary of Safety Key Phrases) should be duplicated and included with this outline.

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

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

Clothing

Electrical Hazards

First Aid Kit

Lifting

Also: Wet/Slick Conditions
Chemicals and Hazardous Materials
Obstructions

Personal Protection Equipment
e.g., Safety Shoes

Support – for Scale and Test Weights

Transportation of Equipment

SAFETY FIRST!!!

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

	H 44 General Code and Scales Code References	Comments[1]

Inspection:

1. Zero-load balance

Zero indication	S.1.1.	
Digital zero indication	S.1.1.1.(a), S.1.1.1.(b)..	E only
Digital display of zero	G-S.5.2.2.(d) (1/1/86)	M & E only
Normal balance position	S.1.5.1.	B only
Adjustment of zero-load balance	S.2.1.1.	
Manual and semiautomatic zero-setting	S.2.1.2.	
Balance condition as found	UR.4.1.	

2. General considerations

Selection of equipment	G-UR.1.1., UR.1.1.	
Installation		
In accordance with manufacturer's instructions	G-UR.2.1.	
Indicating and recording elements	G-UR.2.2.	
Foundation, supports, and clearance	UR.2.1., UR.2.4. (1/1/73)	

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

Accessibility for inspection, testing, and sealing	G-UR.2.3.	
Assistance in testing	G-UR.4.4.	
Position of equipment	G-UR.3.3.	
Customer indications	S.1.8.3.	
Level indicating means	S.2.4.	
Level condition	UR.4.2.	

[1] Key to abbreviations in Comments Column:
B = Beam Scales
D = Dial Scales
E = Electronic digital scales
U = Unmarked scales
M = Scales marked with an accuracy designation

	H 44 General Code and Scales Code References	Comments[1]
Inspection (cont.):		
Use		
Facilitation of fraud	G-S.2.	
Method of operation	G-UR.3.1.	
Special designs or marked for special applications	G-UR.3.2.	
Environment	UR.3.5.	
Suitable for the environment in which it is used	G-UR.1.2.	
Protection from environmental factors	UR.2.3.	
Maintenance requirements	G-UR.4.1.	
Scale modification	UR.4.3.	
3. Marking.	S.6.3.	
a. Marking requirements – all devices		
Identification	G-S.1.	
Name, initials, or trademark of manufacturer or distributor	Retroactive	
Model identifier	Retroactive	
Model identifier prefix	(1/1/03)	
Acceptable abbreviations for “model” and “number”	(1/1/03)	
Nonrepetitive serial number	(1/1/68)	
Serial number prefix	(1/1/86)	M only
Acceptable abbreviations for “serial” and “number”	(1/1/01)	
Current software version or revision identifier (for not built-for-purpose, software based devices)	(1/1/04)	
Version or revision identifier preface and acceptable abbreviations for “version,” “revision,” and “number”	(1/1/07)	
NTEP CC number or CC addendum number and prefix (for devices that have an NTEP CC)	(1/1/03)	
Devices or main elements remanufactured after January 1, 2002.	G-S.1.2. (1/1/02)	
Name, initials, or trademark - last remanufacturer or distributor	(1/1/02)	
Model designation if different from original model designation	(1/1/02)	
Location of marking information for not built-for-purpose, software-based devices	G-S.1.1. (1/1/04)	
	G-S.7.	
Lettering	G-S.6. (1/1/77)	
Operational controls, indications, and features	G-UR.2.1.1.	
Visibility of identification	G-S.4.	
Interchange or reversal of parts		
b. Marking requirements – weighing/load-receiving, and indicating element in same housing or covered on the same CC (in addition to marking for all devices).	S.6.3	
	(1/1/86)	M only
Accuracy class	Retroactive	
Nominal capacity	(1/1/83)	
Value of scale division with nominal capacity, if not apparent	(1/1/86)	
Value of "e" (if different from "d")		
Temperature limits if range on the NTEP CC is narrower than	(1/1/86)	M only
and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)	M only

	H 44 General Code and Scales Code References	Comments[1]
Scales designed for special purposes		
Inspection (cont.):		
c. Marking requirements - indicating element not permanently attached to weighing and load-receiving element or covered by a separate CC (in addition to marking for all devices)	S.6.3.	
Accuracy class	(1/1/86)	M only
Nominal capacity	Retroactive	
Value of scale division with nominal capacity, if not apparent.	(1/1/83)	
Value of "e" (if different from "d")	(1/1/86)	
Temperature limits if range on NTEP CC is narrower than and within - 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)	M only
Scales designed for special purposes	(1/1/86)	M only
Maximum number of scale divisions (n_{max})	(1/1/88)	
d. Marking requirements – weighing and load-receiving element not permanently attached to indicating element or covered by a separate CC (in addition to marking for all devices)	S.6.3	
Accuracy class	(1/1/86)	
Nominal capacity	Retroactive	
Temperature limits if range on NTEP CC is narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)	M only
Scales designed for special purposes	(1/1/86)	M only
Maximum number of scale divisions (n_{max})	(1/1/88)	
Minimum verification scale division for which the device complies with applicable requirements (e_{min})	(1/1/88)	
e. Marking requirements - load cell with Certificate of Conformance (in addition to marking for all devices)	S.6.3., S.5.4. (1/1/94)	E only
Note: Requires information on a data plate attached to the load cell or in an accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document.	(1/1/88)	
Manufacturer's name or trademark, model designation, model prefix and serial number and prefix shall also be marked on both the load cell and in any accompanying documents	(1/1/91)	
Accuracy class	(1/1/88)	
Temperature limits if range on the NTEP CC is narrower than and within - 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)	
Maximum number of scale divisions (n_{max})	(1/1/88)	
"S" or "M" for single or multiple cell applications	(1/1/88)	
Direction of loading, if not obvious	(1/1/88)	
Minimum dead load, maximum capacity, safe load limit, and load cell verification interval, V_{min}	(1/1/88)	

	H 44 General Code and Scales Code References	Comments[1]

Inspection (cont.):

4. Design of weighing devices	S.5.	M only
Designation of accuracy class	S.5.1. (1/1/86)	
Parameters of accuracy class	S.5.2. (1/1/86)	
Multi-interval/multiple-range scale division value	S.5.3. Retroactive	M & E only
Relationship of load cell verification interval to the value of the scale division	S.5.4. (1/1/94)	M & E only
Relationship of the minimum verification scale division (e_{min}) of a weighing/load-receiving element to the value of the scale division	S.1.2.2.2.	M & E only
5. Indicating and recording elements		
Value of scale division	S.1.2. (1/1/86)	M only
Digital indicating scales	S.1.2.1. (1/1/89)	
Values of graduated intervals or increments	G-S.5.3.	
Recorded representations, General	G-S.5.6.	
Devices that indicate or record in more than one unit	G-S.5.3.1.	
Appropriate abbreviations		
Equipment manufactured on or after January 1, 2008	G-S.5.6.1.(a)	
Equipment manufactured prior to January 1, 2008	G-S.5.6.1.(b), Table 1	
Prepackaging scales only	S.1.9.1.	
Tare		
Value of tare division	S.2.3. (1/1/83)	
Tare mechanism	S.2.3.	
Combined zero-tare (“0/T”) key	S.2.1.6.	
Appropriateness of design		
Indicating and recording elements	G-S.5.	
Capacity indication, weight ranges, and unit weights	S.1.7.	
Maximum range of initial zero-setting mechanism		
Complete scales	S.2.1.5.(a)	
Scales with separable components	S.2.1.5.(b) (1/1/09)	E only
Recommended minimum load	UR.3.1	M & E only
Maximum Load	UR.3.2.	
Weighbeams	S.1.5. ex S.1.5.5.	B&D only
Poises	S.1.6.	B&D only
Dials and balance indicators with graduations having a specific value.		
Graduations	S.1.3.1, S.1.3.2.,	
Indicators	S.1.3.3.	B&D only
Clearance	S.1.4.1., S.1.4.2.,	
Parallax	S.1.4.3	B&D only
Damping	S.1.4.4.	
Damping means	S.1.4.5	
Electronic elements		
Adjustable components	S.2.5.	
Provision for sealing	S.2.5.1.(b)	
	S.1.10.	
Multiple weighing elements (common provision for sealing).	S.1.11.(a) (1/1/79)	E only
Security seal	S.1.11.(b) (1/1/90)	E only
	G-S.8.1. 1/1/10	E only
	G-UR.4.5.	E only

	H 44 General Code and Scales Code References	Comments[1]

Inspection (cont.):

6. Weighing elements

Antifriction means	S.4.1.	
Adjustable components	S.4.2.	
Multiple load-receiving elements	S.4.3.	
Drainage, if wet commodities are weighed	S.3.2., UR.3.6.	

Pretest Determinations:

1. Tolerances.

Acceptance/maintenance.	G-T.1., G-T.2.	
Application.	G-T.3.	
Principles.	T.N.1.	M only

Tolerance values:

Determine number of scale divisions (n)[2]

$$n = \frac{\text{Scale capacity}}{\text{Value of the verification scale division (e)}}$$

Tolerance application:

Unmarked scales	T.1.1.	
Unmarked scales with greater than 5000 divisions:	Table T.1.1.	

Apply the tolerances specified in Table T.1.1. Tolerances for Unmarked Scales and the corresponding T.N. paragraphs referenced in the Table.

Unmarked scales with 5000 or fewer divisions:	Table T.1.1.	

Apply Class III, T.N.3.1., Table 6 or T.N.3.2. in accordance with the instructions indicated in Table T.1.1. Tolerances for Unmarked Scales. Also apply "Other Applicable Requirements" (T.N. paragraphs referenced in Table 1.1.)

[2] On a multiple range or multi-interval scale the number of divisions for each weighing range or weighing segment independently shall not exceed the maximum specified for the accuracy class. The number of scale divisions, n, for each weighing range or segment is determined by dividing the scale capacity for each range or segment by the verification scale division, e, for each range or segment (i.e., do not add "n" for the ranges or segments together). 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 element shall not exceed the maximum specified for the accuracy class. (Table 3, footnote 4 added 1997).

	H 44 General Code and Scales Code References	Comments[1]

Pretest Determinations (cont.):

Scales marked with an accuracy class designation.	T.N.2.1.	
Subsequent verification examinations	T.N.2.3.	
Multi-interval and multiple range scales	T.N.2.4.	
Ratio tests (scales equipped with commercial weights)	T.N.2.5.	B only
Maintenance tolerance values	T.N.3.1.[Table 6 (Class III)]	
Acceptance tolerance values	T.N.3.2.	
Tolerances for substitution test	T.N.3.11.	
Tolerances for strain-load test	T.N.3.12.	
Multiple indicating/recording elements	T.N.4.1.	
Single indicating/recording elements	T.N.4.2	
Single indicating element/multiple indications	T.N.4.3	
Shift or section test	T.N.4.4.	M only
Repeatability	T.N.5.	

2. Sensitivity.

Application	T.2.1.	U&B only
General	T.2.2.	U&B only
Sensitivity requirement, equilibrium change	T.3.	U&B only
Sensitivity	T.N.6.	M&B only

3. Discrimination.

Analog automatic indicating (includes balance indicators with graduations having specific values)	T.N.7.1.	M&D only
Digital automatic indicating	T.N.7.2.	E only

4. Minimum test weights and test loads ..... N.3., Table 4

Test Notes:

1. Error Weights. For scales equipped with nonautomatic (beam) indication, balance small error weights on the platform, the smallest weight being equal to the minimum tolerance value at maximum test load.

2. Check repeatability and agreement between indications throughout the test. G-S.5.4., T.N.5.
   - Repeatability of indications ..... G-S.5.2.2.
   - Digital indication and representation .....

3. Recheck zero-load balance each time test load is removed.
   - Zero-load balance change ..... N.1.9.
   - Abnormal performance ..... G-UR.4.2.

	H 44 General Code and Scales Code References	Comments[1]

Test Notes (cont.):

4. If scale is equipped with a ticket printer or type-recording beam, print ticket at each test load. Check effectiveness of motion detection.

Digital indication and representation	G-S.5.2.2.	E only
Recorded representations Also verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy.	G-S.5.6.	
Money value, mathematical agreement	G-S.5.5.	
Motion detection	S.2.5.1.(b)	
Value of the indicated and recorded scale division	UR.1.3.(1/1/86)	

5. If, during the conduct of the test, the performance of the device is questionable with respect to the zone of uncertainty or the width of zero, adequate tests should be conducted to determine compliance; however, they must be conducted under controlled conditions.

Digital indicating elements	S.1.1.1.(a), S.1.1.1.(b) (1/1/93)	E only
Discrimination test	N.1.5. (1/1/86)	M, D, & E only
Digital device	N.1.5.1.	E only

6. If the device is equipped with operational features such as programmable tare, multiple tare memory, weigh-in/weigh-out, or multiple weighing elements, verify proper operation and appropriateness. E only

Maintenance of equipment	G-UR.4.1.
Abnormal performance	G-UR.4.2.
Multiple load-receiving elements	S.4.3.
Manual gross weight entry	S.1.12. (1/1/93) and (1/1/05), UR.3.9.

Test:

WEAR SAFETY SHOES!

USE PROPER LIFTING TECHNIQUES!

1.	Sensitivity test at zero load	N.1.4.	B only
2.	Discrimination test at zero load, if applicable	N.1.5. (1/1/86)	M,D,&E only

	H 44 General Code and Scales Code References	Comments[1]

Test (cont.):

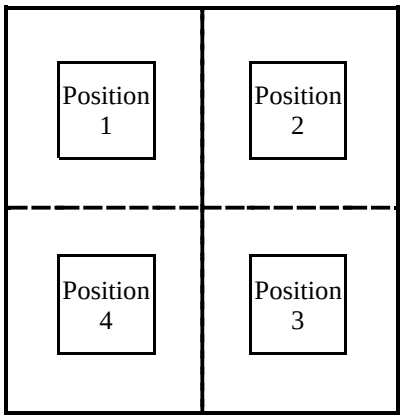
Digital Device	N.1.5.1.	E only
3. Increasing-load test (with the test load approximately centered)	N.1.1.	
Initial verification – to capacity	N.3.	
Subsequent verification		
a. Small scales - at minimum load (20d), 500d, 2000d, 4000d to capacity		
b. Larger scales – at minimum load (20d), 500d, 2000d, 4000d to capacity or, at tolerance intervals to Table 4 values.		
c. Beam scales - at a minimum, test at or near half and full capacity on each weighbeam bar. Scales not equipped with a full capacity beam should be ratio tested by applying field standard weights, specifically designed for this purpose, on the counterpoise hanger. At each test load, test scale counterpoise weights by substituting them for field standard weights. If there is a noticeable change in indication, remove the counterpoise weight from service until it can be determined that it meets the requirements in the Weights Code of NIST Handbook 44.	N.1.7.	B only
4. Shift test:		
Scales with a nominal capacity of 1000 lb or less:	N.1.3.7. (a)	
Use one-third capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible in each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1.		
Scales with a nominal capacity greater than 1000 lb	N.1.3.7. (b)	
Use one-third capacity test load (as defined above for Scales with a nominal capacity of 1000 lb or less) centered as nearly as possible in each quadrant of the load-receiving element as shown in figure 1 or one-quarter capacity test load centered as nearly as possible over each corner of the load-receiving element as shown in figure 2.		

	H 44 General Code and Scales Code References	Comments[1]

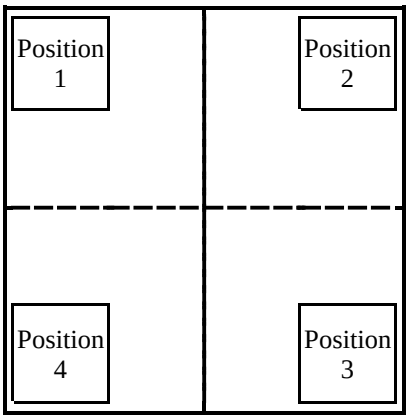
Test (cont.):

Shift-Test Positions
Medium-Capacity Platform Scales

Figure 1 ..... Figure 2



The above test pattern indicates the correct positions of a one-third capacity shift-test load and may be applied when performing the shift test on any medium capacity platform scale.



The above alternative test pattern indicates the correct positions of a one-quarter capacity shift-test load and may be applied alternatively to the positions shown and test loads indicated in Figure 1 when performing a shift test on medium capacity platform scales having a nominal capacity <u>greater</u> than 1000 lb.

Note: When multiple field standards are used as the prescribed shift-test load, do not concentrate those field standards in a test pattern that would be less than if that same load were comprised of only a single field standard.

5.	Sensitivity test at maximum test load	N.1.4.	B only
	Discrimination test at maximum test load (if applicable)	N.1.5.(1/1/86)	M, D, & E only
6.	RFI/EMI tests (if a problem is suspected) (operate each potential source one at a time).	N.1.6.	E only
	Radio Frequency Interference (RFI)		
	Electromagnetic Interference (EMI)		
	Testing with non associated equipment	G-N.2. G-UR.1.2.	
	Environment	G-UR.3.2	
	Associated and nonassociated equipment	G-UR.4.2	
	Abnormal performance	T.N.9.	E only
	Tolerance RFI/EMI tests		

	H 44 General Code and Scales Code References	Comments[1]

Test (cont.):

7. Test for over-capacity indication	S.1.7.	
8. Decreasing-load test	N.1.2.	D & E only
Scales marked with an accuracy designation	N.1.2.1.	M only
For scales having 1000 divisions or greater, tests shall be conducted with test loads equal to the maximum test load at each tolerance value. For example, on a Class III scale, at test loads equal to 4000d, 2000d, and 500d. For marked scales with fewer than 1000 divisions, the test load shall be equal to one-half of the maximum load applied in the increasing-load test.		
All other scales	N.1.2.2.	
The test load shall be equal to one-half of the maximum load applies in the increasing-load test.		
9. Recheck zero-load balance	N.1.9., G-UR.4.2.	
10. Substitution or strain load test	Table 4.	
Scales shall be tested using at least the minimum amount of test weights and to the minimum test loads specified in Table 4. In instances where the amount of test weight available for testing is equal to or greater than the minimum required by Table 4, but less than the amount of test load required, not more than three substitutions are to be performed to achieve a test load that equals at least the minimum required.		
Where practical, scales should be tested to capacity on an initial verification and to at least used capacity on subsequent tests. In accordance with Table 4, not more than three substitutions shall be used during substitution testing, after which the tolerances for strain load tests apply.		
11. Recheck zero load balance	N.1.9., G-UR.4.2.	
12. Conduct out-of-level test (portable scales without level-indicating means only).	S.2.4.	

	H 44 General Code and Scales Code References	Comments[1]

Test (cont.):

13. Test for proper design of automatic zero-tracking mechanism, if scale is so equipped:		
Scales manufactured between 1/1/81 and 1/1/07	S.2.1.3.1.(c)	E only
Scales manufactured on or after 1/1/07	S.2.1.3.2.(b)	E only
Under normal operating conditions the maximum load that can be "rezeroed" when placed on or removed from the platform all at once shall be 0.6 scale division for scales manufactured between January 1, 1981, and January 1, 2007, and 0.5 scale division for scales manufactured on or after January 1, 2007.		
14. Check proper design of tare auto-clear, if scale is so equipped.	S.2.3. (1/1/83)	E only
15. If scale is equipped with a semi-automatic zero-setting mechanism, test the effectiveness of motion detection.	S.2.1.2.	E only
16. Establish correct zero-load balance.	N.1.9., G-UR.4.2.	
After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments	G-UR.4.1., G-UR.4.3.	

2015 NIST EPO No. 9

Examination Procedure Outline for

Part 1 – Monorail Scales – Electronic Digital Indicators

It is recommended that this outline be followed as minimum criteria for examining monorail scales equipped with electronic digital indicators used to weigh statically or dynamically. See EPO 9, Part 2 for Mechanical Meatbeam and Monorail Scales.

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

SAFETY NOTES

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

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

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

Clothing

Personal Protection Equipment
e.g., Safety Shoes

Electrical Hazards

Support – for scales, test weights, and load-receiving elements (e.g., meat hooks or test platform)

First Aid Kit

Transportation of Equipment

Hardhat – for protection from overhead (e.g., hanging meat hooks)

Eye Protection - for protection from hanging meat hooks

Lifting

Also: Overhead Hazard, Materials or Obstructions

	H-44 General Code and Scale Code References

Inspection:

SAFETY REMINDER!!!

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

1. Zero-load balance as found. ..... S.1.1., S.1.1.1., S.2.1.1., S.2.1.2., S.2.1.4., UR.4.1., G-S.5.2.2(d)*

   If the device is not in balance, the user should be made aware of paragraph UR.4.1., and warning issued if necessary. If device is set for tare, check accuracy of the tare being taken.

2. Indicating and recording elements.

   Scale division, value (d) and number (n). ..... S.1.2.*, S.1.2.1. (1/1/89), S.1.2.2., S.5.*, G-UR.1.1., UR.1., UR.1.1.(b), G-S.5.3., UR 1.3.1.(b), UR.3.10.

   Tare division value..... S.2.3. (1/1/83), S.2.3.1.
   Tare mechanism. ..... S.2.3.
   Appropriateness. ..... G-S.5., S.1.7., S.5.2.*,UR.1.1. (a)*, UR.3.1.*

   Recording elements, General ..... G-S.5.6.
   Customer readability, if applicable. ..... G-UR.3.3.
   Damping means. ..... S.2.5.1.
   Adjustable components. ..... S.1.10.
   Provision for sealing. S.1.11. (1/1/90), G-UR.4.5., G-S.8. G-S.8.1. (1/1/2010)

   Manual Weight Entries. ..... S.1.12. (1/1/93), UR.3.9. S.6.3., S.6.2.

H-44 General Code and Scale Code References

Inspection (cont.):

3. Marking. ..... G-S.1.
   a. Marking requirements - all devices
      - Identification. ..... Retroactive
      - Name or ID of manufacturer. ..... Retroactive
      - Model identifier ..... (1/1/03)
      - Model identifier prefix. ..... (1/1/68)
      - Nonrepetitive serial number. ..... (1/1/86)
      - Serial number prefix. ..... (1/1/03)
      - NTEP CC prefix and number (for devices that have an NTEP CC). ..... (1/1/04)
      - Software version or revision identifier. ..... G-S.1.2.
      - Devices or main elements remanufactured after January 1, 2002. ..... G-S.1.
        - name and ID of remanufacturer or distributor ..... (1/1/02)
        - model number if different from original model number. ..... (1/1/02)

   b. Marking requirements - weighing and indicating elements in same housing or covered on the same CC (in addition to marking for all devices). ..... S.6.3.
      - Accuracy class. ..... (1/1/86)
      - Nominal capacity. ..... Retroactive
      - Value of scale division with nominal capacity, if not apparent. ..... (1/1/83)
      - Value of "e" (if different from "d"). ..... (1/1/86)
      - Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F). ..... (1/1/86)
      - Scales designed for special purposes. (1/1/86)

   c. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all device). ..... S.6.3.
      - Accuracy class. ..... (1/1/86)
      - Nominal capacity. ..... Retroactive
      - Value of scale division with nominal capacity, if not apparent. ..... (1/1/83)
      - Value of "e" (if different from "d"). ..... (1/1/86)
      - Temperature limits if narrower than and within -10 °C to 40 °C (14 °F to 104 °F). ..... (1/1/86)
      - Scales designed for special purposes. ..... (1/1/86)
      - Maximum number of scale divisions (n_{max}). ..... (1/1/88)

   d. Marking requirements for weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices). ..... S.6.3.
      - Accuracy class. ..... (1/1/86)
      - Nominal capacity. ..... Retroactive
      - Temperature limits if narrower than and within -10 °C to 40 °C (14 °F to 104 °F). ..... (1/1/86)
      - Scales designed for special application. ..... (1/1/86)
      - Maximum number of scale divisions (nmax). ..... (1/1/88)
      - Minimum verification scale division for which device complies with the requirements (e_{min} or d). ..... (1/1/88)

   e. Marking requirements - load cell with Certificate of Conformance (in addition to marking for all devices) S.6.3., S.5.4. (1/1/94)

H-44 General Code and Scale Code References

Inspection (cont.):

G-S.1. (cont.)

Note: Requires information on a data plate attached to the load cell or in accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document. ..... (1/1/88)

Manufacturer's name or trademark, model designation, model prefix, and serial number and prefix shall also be marked on both the load cell and in any accompanying documents. ..... (1/1/91)
Accuracy class. ..... (1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F). ..... (1/1/86)
Maximum number of divisions. ..... (1/1/88)
"S" or "M" for single or multiple cell applications. ..... (1/1/88)
Direction of loading, if not obvious. ..... (1/1/88)
Minimum dead load, maximum capacity, safe load limit, and load cell verification interval, $V_{min.}$ ..... (1/1/88)

f. Marking requirements – current software version or revision identifier for not built-for-purpose, software- based devices. ..... G-S.1.(d) (1/1/2004), G-S.1.(d)(1)(2), (1/1/07), G-S.1.1.(1/1/2004)

4. Design of balance, tare, level, damping, and arresting mechanisms. ..... S.2.1., S.2.3., S.2.5.1.

5. Design of weighing elements. ..... S.4.

6. Installation :

Static monorail scales. ..... UR.2.3., UR.2.4., G-UR.2.

Dynamic monorail scale considerations: ..... N.1.3.5.1., UR.2.3., UR.2.4., G-UR.2.

- Space to avoid contact between carcasses,
- Higher resolution checkweigh scales, and
- Carcasses used multiple times.

H-44 General Code and Scale Code References

Inspection (cont.):

SAFETY REMINDER

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Use caution in moving in wet, slippery areas.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**
- **Check to be sure the scale supports are adequate to support the scale, test weights equal to the capacity of the scale, and test platforms or chains to suspend test weights**

7. Maintenance, use, and environmental factors (cleanliness, obstructions, modifications, etc.).....G-S.2., G-UR.1.2., G-UR.3.1., G-UR.3.2., G-UR.4., UR.4.3.

8. Assistance.....G-UR.4.4.

9. Provisions for testing and accessibility.....UR.2.9., G-UR.2.3.

10. Determination of Load Cell Suitability (applicable to load cells with an NTEP Certificate of Conformance):

    a. The number of scale divisions (n) of the scale is less than or equal to the n_{max} of 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 5000, then the scale may use up to 5000 divisions.

    b. The load cell is approved for the required accuracy class. Note: A Class II load cell may be used in a Class III application; however the opposite is not true.

    c. The load cell is rated Single (S) or Multiple (M) use as appropriate to the application.

    Note: A load cell rated for single use may be used in a single or multiple load cell application; however, a load cell rated for multiple uses cannot be used in a single load cell application.

    d. The load cell complies with the requirements for V_{min} and temperature effect on zero-load balance. .....S.5.4., T.N.8.1.3.

H-44 General Code and Scale Code References

Inspection (cont.):

For scales with mechanical lever systems:

$$v_{\min} \leq \frac{d^*}{\sqrt{N} \times (scale\ multiple)}$$

$$v_{\min} \leq \frac{d^*}{\sqrt{N}} = \frac{1\,lb}{\sqrt{2}} = \frac{1\,lb}{1.414} = 0.71\,lb$$

*When the value of the scale division, d, is different from the verification scale division, e, for the scale, the value of e must be used in the formulae above.

Pretest Determinations:

1. Tolerances.
   - Acceptance/Maintenance.....G-T.1., G-T.2.
   - Application.....T.N.2.1., T.N.2.3., T.N.2.4.
   - Tolerance values:
     - Scales marked with an accuracy class. .....T.N.3.1., T.N.3.2., Table 6 (Class III),
     - Scales not marked.....T.N.3.8., T.N.4.1., T.N.4.4., T.N.4.5., T.N.5.
     - Discrimination. .....T.N.7.2.

2. Select trolleys, trees, chains, or other auxiliary gear necessary to suspend test weights on rail or meat hook. If two or more trolley-and-tree combinations are used; they should be uniform in weight (within plus or minus two ounces).

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as hard hats and eye protection to prevent injury from overhead meat hooks, hanging carcasses, falling weights, and slipping on slick surfaces.**
- **Wear safety shoes to prevent possible injury from falling weights and slipping on slick surfaces.**

H-44 General Code and Scale Code References

Pretest Determinations (cont.):

3. Minimum test weights and test loads. ..... N.3.

Test Notes:

1. Suspend auxiliary gear (trolleys, trees, chains) from live rail.

2. Balance in auxiliary gear.

3. Check repeatability and agreement between indications and between indications and recorded representations throughout test. .....T.N.4.1., T.N.5., G-S.5.2.2.(a)

4. Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy. .....G-S.5.6.

5. Check zero-load balance each time test load is removed. N.1.9., G-UR.4.2

6. If the scale is equipped with a printer, print a ticket at each test load; check effectiveness of motion detection. .....G S.5.6., S.2.5.1., UR.1.3. (1/1/86)

7. If, during the conduct of the test, the performance of the device is questionable with respect to the zone of uncertainty or the width of zero, adequate tests should be conducted to determine compliance. .....N.1.5., N.1.5.1., S.1.1.1.

8. If the device is equipped with operational features such as automatic zero-setting mechanism, programmable tare,*manual weight entries, or two scales with one printer, check proper operation and appropriateness.

*Note: See UR.3.9. The use of manual gross weight entries, are not allowed on monorail scales.

	H-44 General Code and Scale Code References

Test:

Static Test:

SAFETY REMINDER!!!

- **Wear safety shoes!**
- **Use proper lifting techniques!**

3. RFI/EMI test (if a problem is suspected)..... G-N.2., G-UR.3.2., G-UR.4.2., G-UR.1.2., N.1.6., T.4., T.N.9.*

   Radio Frequency Interference (RFI)
   Electromagnetic Interference (EMI)

4. Over capacity test, if deemed necessary. ..... S.1.7., S.2.1.5., S.2.1.5.(b) (1/1/2009)

5. Decreasing load test. Test at one half of maximum test load. ..... N.1.2.

6. Remove all test weights and determine any zero load balance change. ..... N.1.9., G-UR.4.2.

7. Test for proper design of automatic zero-setting mechanism, if device is so equipped. S.2.1.3.1.(c), S.2.1.3.2.8.

8. If device is equipped with a semi-automatic zero-setting mechanism (push button), test effectiveness of motion detection..... S.2.1.2.(b)

9. Establish correct zero load balance.

Dynamic Test ..... N.1.3.5.1.

On a dynamic test with 20 or more test drafts, 10 % of the individual test drafts may be two times the basic tolerances, if the error on the total of all test load drafts does not exceed 0.2 %.

1. Conduct dynamic test with livestock carcasses

2. Test no less than 20 test loads using carcasses or portions of carcasses of the type normally weighed (two additional test loads may be included in the test run in the event that one or two of the test load are rendered unusable).

3. Position the test carcasses far enough ahead of the scale so the swaying motion settles to duplicate the normal sway of a continuously running plant chain.

H-44 General Code and Scale Code References

Dynamic Test (cont.).....N.1.3.5.1.

4. If the plant conveyor chain does not space or prevent the carcasses from touching one another, the dynamic test should not be conducted until this condition is corrected.

5. Individually weigh (statistically) the carcasses on the same scale being tested or another monorail scale in close proximity with the same or smaller divisions.

    a. The scale selected for weighing the carcasses must be tested statically with test weights.

6. If the scale being tested is used for weighing freshly slaughtered animals, a static weighment of the carcasses must be taken as quickly as possible before or following the Dynamic weighment to avoid loss due to shrinkage.

~~6~~7. If multiple dynamic tests are conducted using the same carcasses, obtain static weights before and after multiple dynamic tests.

8. If the carcass changes weight between static tests, the amount of weight change should be taken into account, or the carcass should be discarded for tolerance purposes.

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2015 NIST EPO No. 9

Examination Procedure Outline for

Part 2 – Monorail Scales and Meat Beams – Mechanical

It is recommended that this outline be followed for monorail scales equipped with equipped with weigh-beams or mechanical dials. Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk. Nonretroactive requirements are followed by the applicable date in parentheses.

Safety Notes – See EPO 9, Part 1

	H-44 General Code and Scale Code References

Inspection:

SAFETY REMINDER!!!

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

1. Zero-load balance as found..... S.1.1., S.2.1.1., S.2.1.2., UR.4.1

   If the device is not in balance, the user should be made aware of paragraph UR.4.1., and warning issued if necessary. If device is set for tare, check accuracy of the tare being taken.

2. Indicating and recording elements.

   Scale division, value (d) and number (n)..... S.1.2.*, G-UR.1.1., UR.1., UR.1.1.(b), G-S.5.3.

   Tare division value. ..... S.2.3. (1/1/83), S.2.3.1.
   Tare mechanism. ..... S.2.3.
   Weighbeams. ..... S.1.5. except S.1.5.5.
   Poises..... S.1.6.
   Dials and balance indicators. ..... S.1.3., S.1.4., S.2.2.
   Appropriateness..... G-S.5., S.1.7.,
   Damping means..... UR.1.1.(a),* UR.3.1.,*
   Customer readability. S.5.,*UR.3.2.,
   Adjustable appropriateness. ..... S.2.5.

	H-44 General and Scale References	Code Code

Inspection (cont.):

3.	Marking.	S.6.3., S.6.2.
	a. Marking requirements - all devices	
	Identification.	G-S.1.
	Name or ID of manufacturer	Retroactive
	Model identifier	Retroactive
	Model identifier prefix.	(1/1/03)
	Nonrepetitive serial number.	(1/1/68)
	Serial number prefix.	(1/1/86)
	NTEP CC prefix and number (for devices that have an NTEP CC).	(1/1/03)
	Devices or main elements remanufactured after January 1, 2002.	G-S.1.2.
	name and ID of remanufacturer or distributor	(1/1/02)
	Model number if different from original model number.	(1/1/02)
	b. Marking requirements - weighing and indicating elements in same housing or covered on the same CC (in addition to marking for all devices).	S.6.3.
	Accuracy class.	(1/1/86)
	Nominal capacity.	Retroactive
	Value of scale division with nominal capacity, if not apparent.	(1/1/83)
	Value of "e" (if different from "d").	(1/1/86)
	Scales designed for special purposes.	(1/1/86)
	c. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all device).	S.6.3.
	Accuracy class.	(1/1/86)
	Nominal capacity.	Retroactive
	Value of scale division with nominal capacity, if not apparent.	(1/1/83)
	Scales designed for special purposes.	(1/1/86)
	Maximum number of scale divisions (n_{max}).	(1/1/88)
	d. Marking requirements for weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices).	S.6.3.
	Accuracy class.	(1/1/86)
	Nominal capacity.	Retroactive
	Scales designed for special application.	(1/1/86)
	Maximum number of scale divisions (n_{max}).	(1/1/88)
	Minimum verification scale division for which device complies with the requirements (e_{min} or d).	(1/1/88)
4.	Installation.	UR.2.3., UR.2.4., G-UR.2.
5.	Design of balance, tare, level, damping, and arresting mechanisms.	S.2.1., S.2.3., S.2.5.1.
6.	Design of weighing elements.	S.4.

	H-44 General Code and Scale Code References

Inspection (cont.):

7. Maintenance, use, and environmental factors (cleanliness, obstructions, modifications, etc.). ..... G-S.2., G-UR.1.2., G-UR.3.1., G-UR.4., UR.4.3.

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Use caution in moving in wet, slippery areas.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**
- **Check to be sure the scale supports are adequate to support the scale, test weights equal to the capacity of the scale, and test platforms or chains used to suspend test weights.**

8. Assistance. ..... G-UR.4.4.

9. Provisions for testing and accessibility. ..... UR.2.9., G-UR.2.3.

Pretest Determinations:

1. Tolerances.
   Acceptance/Maintenance. ..... G-T.1., G-T.2.

   Application. ..... T.N.2.1., T.N.2.3., T.N.2.4.

   Tolerance values:
   Scales marked with an accuracy class. ..... T.N.3.1., T.N.3.2., Table 6 (Class III), T.N.4., T.N.5.
   Scales not marked. ..... T.1.1., T.N.3.1., Table 6 (Class III), T.N.3.2. T.N.4.1., T.N.4.2., T.N.5.

   Discrimination. ..... T.N.7.1.*

	H-44 General Code and Scale Code References

Pretest Determinations (cont.):

2. Select trolleys, trees, chains, or other auxiliary gear necessary to suspend test weights on rail or meat hook. If two or more trolley-and-tree combinations are used; they should be uniform in weight ± 52 grams (± 2 ounces).

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as hard hats and eye protection to prevent injury from overhead meat hooks, hanging carcasses, falling weights, and slipping on slick surfaces.**
- **Wear safety shoes to prevent possible injury from falling weights and slipping on slick surfaces.**

3. Minimum test weights and test loads. ..... N.3.

Test Notes:

1. Suspend auxiliary gear (trolleys, trees, chains) from live rail.
2. If beam scale, place small error weights on or suspend from the live rail or hook. The value of the smallest weight should be equal to the minimum tolerance value and the total of all the weights should be equal to the tolerance at maximum test load.
3. Balance in auxiliary gear and test weights.
4. Check repeatability and agreement between indications and between indications and recorded representations throughout test. ..... T.N.4.1., T.N.5., G-S.5.2.2.(a)
5. Check zero-load balance each time test load is removed. N.1.9., G-UR.4.2
6. If scale is equipped with a type-recording beam or printer, print a ticket at each test load.. ..... G S.5.6., UR.1.3.(1/1/86)

Static Test:

SAFETY REMINDER!!!

- **Wear safety shoes!**
- **Use proper lifting techniques!**

	H-44 General Code and Scale Code References

Static Test (cont.):

1.	Sensitivity teat at zero[load (weighbeams only).....	N.1.4.
	Discrimination test at zero only (dial indicators only).....	N.1.5.
2.	Increasing load test.	N.1.1.
	a. Beam scales. Test at not less than three points or notches on weigh-beam. Scales not equipped with a full capacity beam should be ratio tested using standard weights on counterpoise hanger.	
	When ratio testing, test poise and beam by substituting poise position with the removal of standard weights from counterpoise hanger.	N.1.7.
	b. Dial scales. Test at not less than three points on reading face, including all possible quarters of capacity. Test all unit weights possible. If equipped with tare bars, test at one half and full capacity of each bar.	
3.	Shift test. Use test load equal to the largest load that can be anticipated to be weighed at the installation, but never less than one-half capacity. Apply load successively on the right end, the left end, and the center of the live rail. This can be conducted during the increasing load test.	N.1.3.5.
4.	Beams and balance indicators only, test for SR at the maximum test load.	N.1.4.
	Dials only. Conduct the discrimination test at maximum test load.	N.1.5.
5.	Dials only. Conduct the decreasing-load test at one-half of the maximum test load (at no less than one-half of the dial face capacity.	*N.1.2.1., N.1.2.2.
6.	Beams only. Conduct a counterpoise weight accuracy test (see *HB 44 Section 2.23. Weights* paragraph T.1. and appropriate Table 1. Maintenance Tolerance for Avoirdupois Weights or Table 1. Maintenance Tolerance for Metric Weights).	HB 44 Section 2.23 paragraph T.1.
7.	Remove all test weights and determine any zero-balance change.	N.1.9., G-UR.4.2.

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2015 NIST EPO No. 12

Examination Procedure Outline for

Part 1 – Livestock and Animal Scales – Electronic Digital Indicating

It is recommended that this outline be followed as minimum criteria for examining livestock and animal scales equipped with electronic digital indicators. See Part 2 for livestock and animal scales equipped with weighbeams or dials.

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

SAFETY NOTES

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

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

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

Clothing	**Personal Protection Equipment e.g., Safety Shoes**
Electrical Hazards	**Safety Cones/Warning Signs**
First Aid Kit	**Support – for scales and test weights**
Location	**Transportation of Equipment**
Lifting	

Also:

Wet/Slick Conditions
Overhead Hazard, Materials, or Obstructions

H-44 General Code and Scale Code References

Inspection:

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Use caution while moving in wet, slippery areas.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

1. Zero-load balance as found. If the device is not in balance, the user should be made aware of paragraph UR.4.1. and a warning issued if necessary. If at a ring scale and a tare has been taken for a ring man, check accuracy of the tare taken..... S.1.1., S.2.1.1., S.2.1.2., UR.4.1., G-S.5.2.2.(d) (1/1/86)*

2. General Considerations
   - Selection ..... G.S.3., G-UR.1.1, UR.1.
     - Installation ..... G-UR.2.
     - Supports for portable scale. ..... UR.2.1.
     - Protection from environment. ..... UR.2.3.
     - Foundation, supports, and clearance ..... UR.2.4.
     - Access to weighing elements. ..... UR.2.5.
     - Stock racks ..... UR.2.7.

SAFETY REMINDER!!!

- **Check to be sure the scale supports are adequate to support the scale <u>and</u> test loads equal to the capacity of the scale!**

   - Maintenance, use, and environmental factors.
     - Facilitation of fraud. ..... G-S.2.
     - Environment ..... G-UR.1.2.
     - Operation. ..... G-UR.3.1.
     - Maintenance. ..... G-UR.4.
     - Maximum load. ..... UR.3.2.
     - Minimum load for livestock. ..... UR.3.8.
     - Manual gross weights. ..... UR.3.9., S.1.12.
     - Scale modification. UR.4.3
   - Accessibility for inspection, testing, and sealing. ..... G-UR.2.3.
   - Assistance. ..... G-UR.4.4.
   - Position, customer readability. ..... G-UR.3.3.

	H-44 General Code and Scale Code References

Inspection (cont.):

3. Marking.	S.6.3., S.6.2., S.6.5., G-S.1.1.
a. Marking requirements - all devices	
Identification.	G-S.1.
Name, initials or trademark of manufacturer or distributor.	Retroactive
Model identifier designation.	Retroactive
Model prefix.	(1/1/03)
Nonrepetitive serial number.	(1/1/68)
Serial number prefix.	(1/1/86)
Software version or revision number.	(1/1/04)
NTEP CC prefix and number (for devices that have an NTEP CC).	(1/1/03)
Remanufacturer information, as appropriate:	
name and ID of remanufacturer or distributor.	(1/1/02)
model number if different from original model number.	(1/1/02)
Lettering.	G-S.7.
Operational controls, indications, and features.	G-S.6. (1/1/77)
Visibility of identification.	G-UR.2.1.1.
Interchange or reversal of parts.	G-S.4.
b. Marking requirements - weighing and indicating elements in same housing or covered on the same CC (in addition to marking for all devices).	S.6.3.
Accuracy class.	(1/1/86)
Nominal capacity.	Retroactive
Value of scale division with nominal capacity, if not apparent.	(1/1/83)
Value of "e" (if different from "d").	(1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special application.	(1/1/86)
c. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all device).	S.6.3.
Accuracy class.	(1/1/86)
Nominal capacity.	Retroactive
Value of scale division with nominal capacity, if not apparent.	(1/1/83)
Value of "e" (if different from "d")	(1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special application.	(1/1/86)
Maximum number of scale divisions (n_{max})	(1/1/88)
Concentrated Load Capacity (CLC) or Section Capacity.	S.6.5. (1/1/03) Table S.6.3.(a)(b)
d. Marking requirements - weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices).	S.6.3. (1/1/86)
Accuracy class.	Retroactive
Nominal capacity.	(1/1/89) (livestock only)
Nominal capacity on load-receiving element.	S.6.5. (1/1/03)
Concentrated Load Capacity (CLC) or Section Capacity.	Table S.6.3.(a)(b)

	H-44 General Code and Scale Code References

Inspection (cont.):

Marking (cont.)

Temperature limits if narrower than and within –10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special application.	(1/1/86)
Maximum number of scale divisions (n_{max}).	(1/1/88)
Minimum verification scale division for which device complies with the requirements (e_{min} or d)	(1/1/88)

e. Marking requirements - load cell with Certificate of Conformance (in addition to marking for all devices). S.6.3., S.5.4. (1/1/94)

Note: Requires information on a data plate attached to the load cell or in accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document. S.6.3., (1/1/88)

Manufacturer's name or trademark, model designation, model prefix and serial number and prefix shall also be marked on both the load cell and in any accompanying documents.	(1/1/91)
Accuracy class.	(1/1/88)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Maximum number of divisions.	(1/1/88)
"S" or "M" for single or multiple cell applications.	(1/1/88)
Direction of loading, if not obvious.	(1/1/88)
Minimum dead load, maximum capacity, safe load limit, and load cell verification interval, V_{min}.	(1/1/88)

4. Determination of Load Cell Suitability (applicable to load cells with an NTEP Certificate of Conformance):

a. The number of scale divisions (n) of the scale is less than or equal to the n_{max} of 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 5000, then the scale may use up to 5000 divisions.

b. The load cell is approved for the required accuracy class. **Note:** A Class III load cell may be used in a Class III L application; however, the opposite is not true.

c. The load cell is rated Single (S) or Multiple (M) use as appropriate to the application. **Note:** A load cell rated for single use may be used in a single or multiple load cell application; however, a load cell rated for multiple uses cannot be used in a single load cell application.

d. The load cell complies with the requirements for temperature effect on zero-load balance. S.5.4. (1/1/94), T.N.8.1 Appendix to EPO 12-E

H-44 General Code and Scale Code References

Inspection (cont):

Marking (cont.)

Note: Testing to determine the effect of temperature on zero-load balance cannot be performed in the field; however, for purposes of field inspection, a load cell is considered to comply with T.N.8.1.3. if the V_{min} value marked on the load cell is less than or equal to the V_{min} value as calculated below based upon the d and N for the scale; if it is not, the scale does not comply with T.N.8.1.3.

Full electronic scale with more than one load cell: The verification scale division V_{min}, for the load cells must be less than or equal to the scale division, d, divided by the square root of the number of load cells, N, used in the scale:

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

Note: Maximum values of v_{min} for commonly encountered multiple load cell scales are listed in the Appendix to EPO 12-E.

For scales with mechanical lever systems:

$$v_{\min} \leq \frac{d^*}{\sqrt{N} \times (scale\ multiple)}$$

**When the value of the scale division, d, is different from the verification scale division, e, for the scale, the value of e must be used in the formulae above.*

5. Indicating and Recording Elements

Value of scale division.	S.1.2.* (1/1/86)
Weight units.	S.1.2.1. (1/1/89)
Designation of accuracy class.	S.5.*
Value of graduated interval.	G-S.5.3.
Marked devices.	UR.1.1.(a)
Unmarked devices.	UR.1.1.(b)(animal only)
Recording elements, General.	G-S.5.6.
Recorded scale division.	UR.1.3. (1/1/86)
Tare division value, if equipped with a keyboard[1].	S.2.3.(1/1/83)
Tare mechanism	S.2.3.(1/1/83)
Appropriateness.	
Indicating and recording elements.	G-S.5.
Parameters for Accuracy Class.	S.5.2.(1/1/86)
Selection.	UR.1.
Initial zero-setting mechanism.	S.2.1.5.
Recommended minimum load.	UR.3.1.
Minimum load for weighing livestock	UR.3.8.

[1] Generally, tare is not considered appropriate on these scales. If the device is located in an auction market and is a ring scale, a tare capability may be considered appropriate.

	H-44 General Code and Scale Code References

Inspection (cont):

Marking (cont.)

Maximum load.	UR.3.2.
Manual gross weight entries.	S.1.12.(1/1/05), G-S.8. (1/1/90), UR.3.9.(e)
Damping means.	S.2.5., S.2.5.1.
Adjustable components.	S.1.10.
Provisions for sealing.	G-UR.4.5. S.1.11., (1/1/93)

6. Design of weighing elements. ..... S.4.

Pretest Determinations:

1. Tolerances.

Acceptance/maintenance.	G-T.1., G-T.2.
Application.	G-T.3., G-T.4., T.N.2.1., T.N.2.3.

Tolerance values:

Determine number of scale divisions (n) e division if scale is marked with an accuracy designation.

$$n = \frac{scale\ capacity}{value\ of\ scale\ division}$$

Maintenance tolerance.	T.N.3.1./Table 6 (Class III L - Livestock) (Class III - Animal)
Acceptance tolerance.	T.N.3.2.
Agreement of indications.	T.N.4.
Repeatability.	T.N.5.
Unmarked scales.	T.1.1.
Discrimination.	T.N.7.1.*
Substitution or Strain Tests (if necessary).	T.N.3.11., T.N.3.12.

2. Determine "used capacity."

For calculation in metric units:

Multiply area of platform in square meters (length x width = area) by: 540 kg for cattle, 340 kg for calves and hogs, and 240 kg for sheep.

For calculation in U.S. customary units:

Multiply area of platform in square feet (length x width = area) by: 110 lb for cattle, 70 lb for calves and hogs, and 50 lb for sheep.

3. Minimum test weights and test loads. N.3./Table4

H-44 General Code and Scale Code References

Pretest Determinations (cont.)

SAFETY REMINDER

– **Carefully inspect electrical supply lines for test equipment for wear or damage; correct potentially hazardous conditions before use; protect lines from damage during use.**

Test Notes:

SAFETY REMINDER

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

1. Check repeatability of, and agreement between, indications throughout test. ..... G-S.5.2.2.(b), T.N.5.

2. Recheck zero-load balance each time test load is removed. ..... N.1.9., G-UR.4.2.

3. If the scale is equipped with printer, print ticket at each test load. G-S.5.6., UR.1.3. (1/1/86)

   Also verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy. ..... G-S.5.6.

Test:

SAFETY REMINDER

– **WEAR SAFETY SHOES!**

– **USE PROPER LIFTING TECHNIQUES!**

1. Discrimination test at zero load (dials and balance indicators only). ..... N.1.5.(1/1/86)

2. Increasing-load test.
   Test to used capacity with the test load distributed. ..... N.1.1.

Test (cont.):

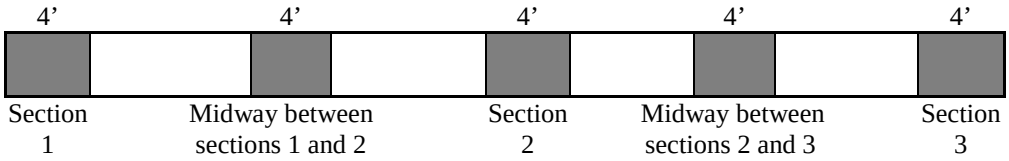
3. Shift test. (May be conducted during increasing-load test).
Vehicle Scales, Axle-Load Scales, and Livestock Scales..... N.1.3.3.

Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales. .... N.1.3.3.1.

Minimum Shift Test. At least one shift test shall be conducted with a minimum test load of 12.5 % of scale capacity, which may be performed anywhere on the load-receiving element using the prescribed test patterns and maximum test loads specified below.

Combination Vehicle/Livestock Scales shall also be tested consistent with N.1.3.3.2. Prescribed Test Pattern and Test Loads for Livestock Scales with More Than Two Sections and Combination Vehicle/Livestock Scales.)

Prescribed Test Pattern and Loading for Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales. – The normal prescribed test pattern shall be an area of 1.2 m (4 ft) in length and 3.0 m (10 ft) in width or the width of the scale platform, whichever is less. Multiple test patterns may be utilized when loaded in accordance with Paragraph (c), (d), or (e) as applicable. An example of a possible test pattern is shown in the following diagram.



Loading Precautions for Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales. – When loading the scale for testing, one side of the test pattern shall be loaded to no more than half of the concentrated load capacity or test load before loading the other side.

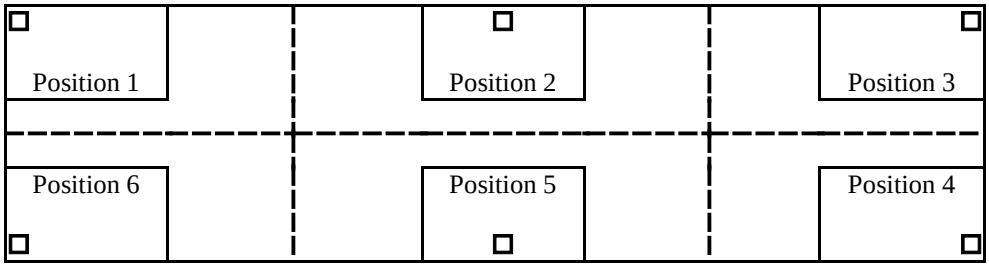
To test to the nominal capacity, multiple patterns may be simultaneously loaded in a manner consistent with the method of use. ..... N.1.3.3.2.

Special design scales and those that are wider than 3.7 m (12 ft) shall be tested in a manner consistent with the method of use but following the principles described above.

Prescribed Test Pattern and Test Loads for Livestock Scales with More Than Two Sections and Combination Vehicle/Livestock Scales..... N.1.3.3.1.

A minimum test load of 5000 kg (10 000 lb) or one-half of the rated section capacity, whichever is less, shall be placed, as nearly as possible, successively over each main load support as shown in the diagram below.

Test (cont.)



□ = Load Bearing Point

Two-section livestock scales. ..... N.1.3.3.3., N.1.3.7.

A shift test shall be conducted using the following prescribed test loads and test patterns, provided the shift test load does not exceed one-half the rated section capacity or one-half the rated concentrated load capacity whichever is applicable, using either:

A one-half nominal capacity test load centered as nearly as possible, successively at the center of each quarter of the load-receiving element as shown in N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers Figure 1 (below); or

A one-quarter nominal capacity test load centered as nearly as possible, successively over each main load support as shown in N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers Figure 2 as shown in the following diagram:

Figure 1

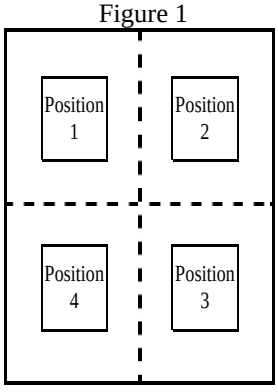
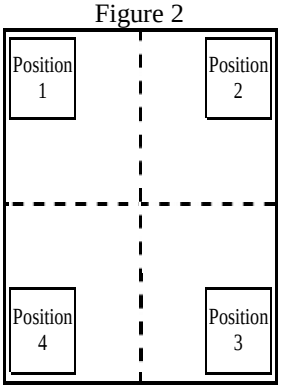


Figure 2



(Added 2003)

	H-44 General Code and Scale Code References

Test (cont.)

	Animal Scales For scales with a nominal capacity of 500 kg (1000 lb) or less, a shift test shall be conducted using a one-third nominal capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible at the center of each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1 (as shown above under Two-section livestock scales). For scales with a nominal capacity greater than 500 kg (1000 lb), a shift test may be conducted by either using a one-third nominal capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible at the center of each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1, or by using a one-quarter nominal capacity test load centered as nearly as possible, successively, over each corner of the load-receiving element using the prescribed test pattern as shown in Figure 2 (as shown above under Two-section livestock scales).	N.1.3.7.
4.	Time Dependence Test.	T.N.4.5.Class III (Animal Scales) T.N.4.5.1.Class III L (Livestock scales)
5.	Discrimination test at maximum test load.	T.N.4.5.2.
6.	Decreasing-load test at one-half of maximum test load.	N.1.5.
7.	Remove all test weights and determine any zero-load balance change.	N.1.2.
8.	Remove error weights and establish correct zero-load balance.	N.1.9., G-UR.4.2.

2015 NIST EPO No. 12

Examination Procedure Outline for

Livestock and Animal Scales
Part 2 – Mechanical/Analog Indicating

It is recommended that this outline be followed for livestock and animal scales equipped with weighbeams or dials. Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk. Nonretroactive requirements are followed by the applicable date in parentheses.

Safety Notes: See EPO 12, Part 1

	H-44 General Code and Scale Code References

Inspection:

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Use caution while moving in wet, slippery areas.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

1. Zero-load balance as found ..... S.1.1., S.2.1.1., S.2.1.2., S.1.5.1., S.2.2., UR.4.1.
2. General Considerations
   - Selection ..... G.S.3., G-UR.1.1, UR.1.
   - Installation ..... G-UR.2.
   - Supports for portable scale. ..... UR.2.1.
   - Protection from environment. ..... UR.2.3.
   - Foundation, supports, and clearance ..... UR.2.4.
   - Access to weighing elements. ..... UR.2.5.
   - Stock racks ..... UR.2.7.

SAFETY REMINDER!!!

- **Check to be sure the scale supports are adequate to support the scale <u>and</u> test loads equal to the capacity of the scale!**

	H-44 General Code and Scale Code References

Inspection (cont.):

Maintenance, use, and environmental factors.	
Facilitation of fraud.	G-S.2.
Environment	G-UR.1.2.
Operation.	G-UR.3.1.
Maintenance.	G-UR.4.
Maximum load.	UR.3.2.
Minimum load for livestock.	UR.3.8.
Scale modification.	UR.4.3
Accessibility for inspection, testing, and sealing.	G-UR.2.3.
Assistance.	G-UR.4.4.
Position, customer readability.	G-UR.3.3.
3. Marking.	S.6.3., S.6.2., S.6.5., G-S.1.1.
a. Marking requirements - all devices	
Identification.	G-S.1.
Name, initials, or trademark of manufacturer or distributor.	Retroactive
Model identifier designation.	Retroactive
Model prefix.	(1/1/03)
Nonrepetitive serial number.	(1/1/68)
Serial number prefix.	(1/1/86)
NTEP CC prefix and number (for devices that have an NTEP CC).	(1/1/03)
Remanufacturer information, as appropriate:	
name and ID of remanufacturer or distributor	(1/1/02)
model number if different from original model number.	(1/1/02)
Lettering.	G-S.7.
Operational controls, indications, and features.	G-S.6. (1/1/77)
Visibility of identification.	G-UR.2.1.1.
Interchange or reversal of parts.	G-S.4.
b. Marking requirements - weighing and indicating elements in same housing or covered on the same CC (in addition to marking for all devices).	S.6.3.
Accuracy class.	(1/1/86)
Nominal capacity.	(1/1/83)
Value of scale division with nominal capacity, if not apparent.	(1/1/86)
Value of "e" (if different from "d").	(1/1/86)
Temperature limits if narrower than and within − 10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special application.	Retroactive
c. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all device).	S.6.3.
Accuracy class.	(1/1/86)
Nominal capacity.	Retroactive
Value of scale division with nominal capacity, if not apparent.	(1/1/83)
Value of "e" (if different from "d")	(1/1/86)
Temperature limits if narrower than and within −°10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)

	H-44 General Code and Scale Code References

Inspection (cont.):

Scales designed for special application.	(1/1/86)
Maximum number of scale divisions (n_{max})	(1/1/88)
Concentrated Load Capacity (CLC) or Section Capacity.	S.6.5. (1/1/03) Table S.6.3.(a)(b)
d. Marking requirements - weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices).	S.6.3.
Accuracy class.	(1/1/86)
Nominal capacity.	Retroactive
Nominal capacity on load-receiving element.	(1/1/89) (livestock only)
Concentrated Load Capacity (CLC) or Section Capacity.	S.6.5. (1/1/03)
Temperature limits if narrower than and within −10 °C to 40 °C (14 °F to 104 °F).	Table S.6.3.(a)(b)
Scales designed for special application.	(1/1/86)
Maximum number of scale divisions (n_{max}).	(1/1/86)
Minimum verification scale division for which device complies with the requirements (e_{min} or d)	(1/1/88)
4. Indicating and Recording Elements	
Value of Scale Division.	S.1.2.* (1/1/86)
Designation of accuracy class.	S.5.*, UR.1.1.
Weighbeams.	S.1.5. except S.1.5.5.
Poises.	S.1.6.
Dials and balance indicators.[1]	S.1.3., S.1.4.
Damping means.	S.2.5.
Appropriateness.	
Indicating and recording elements.	G.S.5. except G-S.5.2.2.
Parameters for Accuracy Class.	S.5.2.(1/1/86)*
Selection.	UR.1.1.
Suitability.	G-UR.1.1.
Recommended minimum load.	UR.3.8
Maximum load.	UR.3.2.
Adjustable components.	S.1.10.
5. Design of weighing elements.	S.4.

Pretest Determinations:

1. Tolerances.	
Acceptance/maintenance.	G-T.1., G-T.2.
Application.	G-T.3., G-T.4., T.N.2.1., T.N.2.3.
Ratio tests.	T.N.2.5.

[1] A balance indicator with graduations having specific values shall be considered a dial.

H-44 General Code and Scale Code References

Pretest Determinations (cont.):

Tolerance values:

Determine number of scale divisions (n) e division if scale is marked with an accuracy designation.

$$n = \frac{scale\ capacity}{value\ of\ \ scale\ division}$$

Maintenance tolerance	N.3.1./Table 6 (Class III L - Livestock) (Class III - Animal)
Acceptance tolerance	T.N.3.2.
Agreement of indications.	T.N.4.
Repeatability	T.N.5.
Unmarked scales.	T.1.1.
Repeatability	T.N.5.
Discrimination.	T.N.7.1.*

Sensitivity:

Marked scales.	T.N.6.1.(a), T.N.6.2.
Unmarked scales.	T.2.1.,T.2.7., T.3.(a) or (c)
Substitution or Strain Tests (if necessary).	T.N.3.11., T.N.3.12.

2. Determine "used capacity."
   For calculation in metric units:
   Multiply area of platform in square meters (length x width = area) by: 540 kg for cattle, 340 kg for calves and hogs, and 240 kg for sheep.

   For calculation in inch pound units:
   Multiply area of platform in square feet (length × width = area) by: 110 lb for cattle, 70 lb for calves and hogs, and 50 lb for sheep.

3. Minimum test weights and test loads. N.3./Table 4

SAFETY REMINDER!!!

– **Carefully inspect electrical supply lines for test equipment for wear or damage; correct potentially hazardous conditions before use; protect lines from damage during use.**

H-44 General Code and Scale Code References

Test Notes:

SAFETY REMINDER!!!

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

1. For beam scales, balance small error weights on platform, the smallest weight equal to the minimum tolerance applicable, and the total value of the weights equal to the tolerance at maximum test load.

2. Check repeatability of, and agreement between, indications throughout test. ..... G-S.5.2.2.(b), T.N.5.

3. Recheck zero-load balance each time test load is removed. ..... N.1.9., G-UR.4.2.

4. If the scale is equipped with a type-registering (TR) beam or printer, print ticket at each test load. ..... G-S.5.6., UR.1.3.(1/1/86)

Test:

SAFETY REMINDER!!!

– **WEAR SAFETY SHOES!**

– **USE PROPER LIFTING TECHNIQUES!**

1. Sensitivity test at zero load (for weighbeams only). ..... N.1.4.
   Discrimination test at zero load (dials and balance indicators only). ..... N.1.5.(1/1/86)

2. Increasing-load test.
   Test to used capacity with the test load distributed. ..... N.1.1.

   a. For beam scales, the minimum test includes testing at half and full capacity on fractional beam, 100 lb increments to 1000 lb, and three other points on main weighbeam, including used capacity.

      Scales not equipped with a full capacity beam should be ratio tested using standard weights on counterpoise hanger. At each test load, test scale counterpoise weights by substituting them for standard counterpoise weights. If there is any noticeable change in the indication, remove the scale weight from service until it can be determined that it meets requirements in the Weight Code of NIST Handbook 44.

      Ratio Test. ..... N.1.7.

Test (cont.)

When ratio testing, test poise and beam by the removal of standard weights from the counterpoise hanger

b. Dial scales. Test at 100 lb increments to 1000 lb and at each quarter of dial capacity. Test all unit or drop weights normally used.

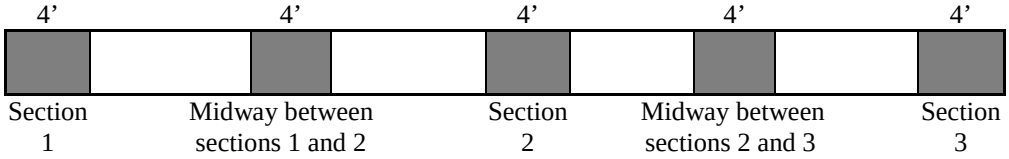
3. Shift test. (May be conducted during increasing-load test).
Vehicle Scales, Axle-Load Scales, and Livestock Scales..... N.1.3.3.

Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales. ..... N.1.3.3.1.

Minimum Shift Test. At least one shift test shall be conducted with a minimum test load of 12.5 % of scale capacity, which may be performed anywhere on the load-receiving element using the prescribed test patterns and maximum test loads specified below.

Combination Vehicle/Livestock Scales shall also be tested consistent with N.1.3.3.2. Prescribed Test Pattern and Test Loads for Livestock Scales with More Than Two Sections and Combination Vehicle/Livestock Scales.

Prescribed Test Pattern and Loading for Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales. - The normal prescribed test pattern shall be an area of 1.2 m (4 ft) in length and 3.0 m (10 ft) in width or the width of the scale platform, whichever is less. Multiple test patterns may be utilized when loaded in accordance with Paragraph (c), (d), or (e) as applicable. An example of a possible test pattern is shown in the following diagram.



Loading Precautions for Vehicle Scales, Axle-Load Scales, and Combination Vehicle/Livestock Scales. When loading the scale for testing, one side of the test pattern shall be loaded to no more than half of the concentrated load capacity or test load before loading the other side.

To test to the nominal capacity, multiple patterns may be simultaneously loaded in a manner consistent with the method of use. ..... N.1.3.3.2.

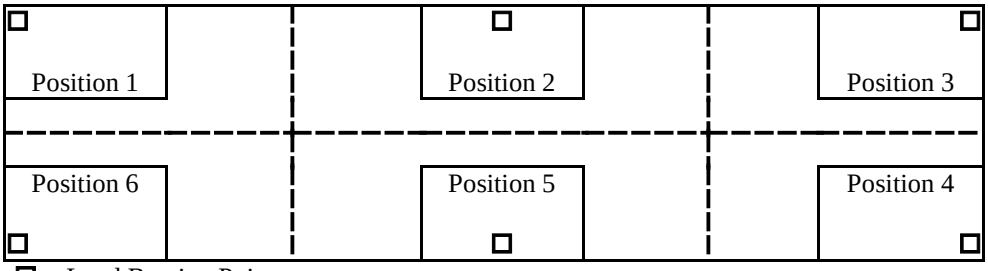
Special design scales and those that are wider than 3.7 m (12 ft) shall be tested in a manner consistent with the method of use but following the principles described above.

Prescribed Test Pattern and Test Loads for Livestock Scales with More Than Two Sections and Combination Vehicle/Livestock Scales. ..... N.1.3.3.1.

H-44 General Code and Scale Code References

Test (cont.)

A minimum test load of 5000 kg (10 000 lb) or one-half of the rated section capacity, whichever is less, shall be placed, as nearly as possible, successively over each main load support as shown in the diagram below.



□ = Load Bearing Point

Two-section livestock scales. ..... N.1.3.3.3., N.1.3.7.

A shift test shall be conducted using the following prescribed test loads and test patterns, provided the shift test load does not exceed one-half the rated section capacity or one-half the rated concentrated load capacity whichever is applicable, using either:

A one-half nominal capacity test load centered as nearly as possible, successively at the center of each quarter of the load-receiving element as shown in N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers Figure 1 (below); or

A one-quarter nominal capacity test load centered as nearly as possible, successively over each main load support as shown in N.1.3.7. All Other Scales Except Crane Scales, Hanging Scales, Hopper Scales, Wheel-Load Weighers, and Portable Axle-Load Weighers Figure 2 as follows:

Figure 1

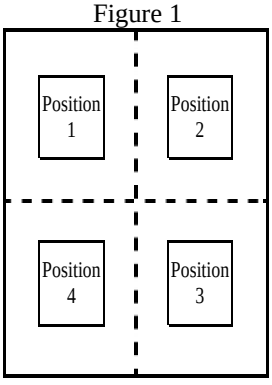
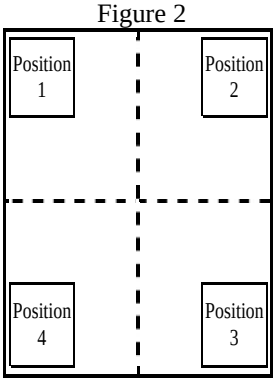


Figure 2



(Added 2003)

	H-44 General Code and Scale Code References

Tests (cont.)

Animal Scales ..... N.1.3.7.

For scales with a nominal capacity of 500 kg (1000 lb) or less, a shift test shall be conducted using a one-third nominal capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible at the center of each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1 (as shown above under Two-section livestock scales).

For scales with a nominal capacity greater than 500 kg (1000 lb), a shift test may be conducted by either using a one-third nominal capacity test load (defined as test weights in amounts of at least 30 % of scale capacity, but not to exceed 35 % of scale capacity) centered as nearly as possible at the center of each quadrant of the load-receiving element using the prescribed test pattern as shown in Figure 1, or by using a one-quarter nominal capacity test load centered as nearly as possible, successively, over each corner of the load-receiving element using the prescribed test pattern as shown in Figure 2 (as shown above under Two-section livestock scales).

4. Time Dependence Test (Non-Automatic Weighing Instruments). ..... T.N.4.5.Class III (Animal Scales) T.N.4.5.1.Class III L (Livestock scales) T.N.4.5.2.

5. Sensitivity test at maximum test load (weighbeams and balance indicators only). ..... N.1.4.
   Discrimination test at maximum test load (dials and balance indicators only). ..... N.1.5.

6. Decreasing-load test (dials only) at one-half of maximum test load (at no less than one-half dial face capacity). ..... N.1.2.

7. Remove all test weights and determine any zero-load balance change. ..... N.1.9., G-UR.4.2.

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

2015 NIST EPO No. 13

Examination Procedure Outline for

Vehicle and Axle-Load Scales
Part 1 – Electronic Digital Indicating

It is recommended that this outline be followed as minimum criteria for examining vehicle and axle-load scales (load-receiving elements) equipped with electronic digital indicators. Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk. Non-retroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the NIST EPO Safety Annex (Safety Considerations and Glossary of Safety Key Phrases) should be duplicated and included with this outline.

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

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

Clothing

Electrical Hazards

First Aid Kit

Lifting

Location

also: Wet/Slick Conditions
Chemicals, Petroleum Products, and Hazardous Materials
Overhead Hazards
Obstructions

Personal Protection Equipment

e.g., Safety Shoes

Hard Hat - for protection from overhead hazards

Safety Cones/Warning Signs

Support - for scale, test weights, and test equipment

Transportation of Equipment

H-44 General Code and Scales Code References

Inspection:

SAFETY REMINDER!!!

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

1. Position of equipment ..... G-UR.3.3.

2. Zero-load balance as found. ..... S.1.1., UR.4.1.
   If the device is not in balance, the user should be made aware of paragraph UR.4.1. and a warning issued if necessary.
   - Display of digital zero ..... G-S.5.2.2.(d) (1/1/86)
   - Digital zero indication ..... S.1.1.1.(a)
   - Center of zero indication S.1.1.1.(b) (1/1/93)
   - Zero-load adjustment ..... S.2.1.1., S.2.1.2., S.2.1.3.

3. Indicating, and recording elements.
   - Appropriateness ..... G-S.5.1.
   - Graduations, indications, and recorded representations ..... G-S.5.2.
   - Values of graduated intervals or increments ..... G-S.5.3., S.1.2.*, S.1.2.1.
   - Repeatability ..... G-S.5.4.
   - Money values, mathematical agreement ..... G-S.5.5.
   - Recorded representations, General G-S.5.6., UR.1.3. (1/1/86)
   - Magnified graduations and indications ..... G-S.5.7.
   - Rounding (digital values) ..... G-.5.2.2.(c)
   - Manual Gross Weight Entries ..... S.1.12.(1/1/93) (1/01/05), UR.3.9.
   - Tare ..... S.2.3.(1/1/83)
   - Damping and motion detection ..... S.2.5., S.2.5.1.(a)

4. Design of weighing devices,
   - Accuracy class ..... S.5.1.*, S.5.2.*
   - Multi-interval and multiple range scales, division value ..... S.5.3.
   - Adjustable components/Sealing ..... S.1.10., G-S.8.(1/1/90) G-S.8.1.(1/1/10), S.1.11.(a) (1/1/79), S.1.11.(b) (1/1/90), S.1.11.(c) (1/1/95)
   - Relationship of load cell v_{min} to scale division d S.5.4. (1/1/94)
   - Assistance ..... G-UR.4.4.

	H-44 General Code and Scales Code References

Inspection (cont.)

5. Suitability	G-UR.1.1., G-UR.1.2., UR.1., UR.1.1.(a), UR.1.1.(b), UR.3.1., UR.3.5., UR.3.7.
6. Marking	S.6., S.6.3., S.6.2.
Nominal capacity (Suitability)	S.6.1. (1/1/89)
Nominal capacity must satisfy the relationship of: nominal capacity $\leq$ CLC x (N - 0.5), where N = the number of sections in the scale	
a. Marking requirements - all devices	
Identification	G-S.1.
Name or ID of manufacture	Retroactive
Model designation	Retroactive
Model prefix	(1/1/03)
Nonrepetitive serial number except not built-for-purpose devices	(1/1/68)
Serial number prefix	(1/1/86)
Serial number – appropriate abbreviations	(1/1/01)
Version or revision number - not built-for-purpose software-based devices	(1/1/04)
Version or revision number – appropriate abbreviations	(1/1/07)
NTEP CC prefix and number (for devices that have an NTEP CC)	(1/1/03)
Remanufacturer information, as appropriate:	
name and ID of remanufacturer	G-S.1.2. (1/1/02)
model number if different from original model number	G-S.1.2. (1/1/02)
Visibility of identification	G-UR.2.1.1.
Location of information - not built-for-purpose, software-based devices	G-S.1.1. (1/1/04)
Lettering	G-S.7.
Operational controls, indications, and features	G-S.6. (1/1/77)
Interchange or reversal of parts	G-S.4.
b. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all device)	S.6.3.
Accuracy class	(1/1/86)
Nominal capacity	Table S.6.3.b. footnote 18
Value of scale division with nominal capacity, if not apparent	(1/1/83)
Value of "e" (if different from "d")	(1/1/86)
Temperature limits if other than -10 °C to 40 °C (14°F to 104 °F)	(1/1/86)
Concentrated load capacity (CLC)	(1/1/89)
Section capacity (Sec Cap)[1]	Retroactive[1]

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

Inspection (cont.)

Combination vehicle (CLC)/railway scales (Sec Cap)	(1/1/00)
Scales designed for special purposes	(1/1/86)
Maximum number of scale divisions (n_{max})	(1/1/88)

c. Marking requirements - weighing and load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices) S.6.3.

Accuracy class	(1/1/86)
Nominal capacity on load receiving element	(1/1/89)
Concentrated load capacity (CLC)	(1/1/89)
Section capacity (see note below)	Retroactive
Combination vehicle (CLC)/railway scales (Sec Cap)	(1/1/00)
Temperature limits if other than -10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Scales designed for special purposes	(1/1/86)
Maximum number of scale divisions (n_{max})	(1/1/88)
Minimum verification scale division (e_{min} or d_{min})	(1/1/88)

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

d. Marking requirements - load cell with Certificate of Conformance (in addition to marking for all devices) S.6.3., S.5.4. (1/1/94)

Accuracy class	(1/1/86)
Temperature limits if other than -10 °C to 40 °C (14 °F to 104 °F)	(1/1/86)
Maximum number of divisions (n_{max})	(1/1/88)
"S" or "M" for single or multiple cell applications	(1/1/88)
Direction of loading, if not obvious	(1/1/88)
Minimum dead load, maximum capacity, safe load limit, and load cell verification interval, v_{min}	(1/1/88)

Note: Requires information on a data plate attached to the load cell or in accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document (1/1/88).

Note: Manufacturer's name or trademark, model designation, model prefix and serial number and prefix shall also be marked on both the load cell and in any accompanying documents (1/1/91).

If possible, observe normal weight determinations that are equal to or greater than the weight of the test equipment and test weights to verify the adequacy of the scale supports!

	H-44 General Code and Scales Code References

Inspection (cont.)

7. Design of weighing/load-receiving elements ..... S.4. UR.2.8.
   Access UR.2.5

8. Load cell installation and suitability

   Full electronic scale ..... S.5.4. (1/1/94), Appendix A in EPO 13

   Number of scale divisions (n) configured for the scale is less than or equal to n_{max} of the indicator or load cells, whichever is less.

   For a full electronic scale, the verification scale division, v_{min}, for the load cells shall be less than or equal to the scale division, d, divided by the square root of the number of load cells, N:

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

   * When the value of the scale division, d, is different from the verification scale division, e, for the scale, the value of e shall be used in the above formula.

$$v_{min} \leq \frac{d*}{\sqrt{N} \times (scale\,multiple)}$$

   Verification scale division, v_{min}, for mechanical lever system scales with a single load cell:

   Note: Maximum values of v_{min} for commonly encountered multiple load cell scales are listed in Appendix A in EPO 13.

9. Installation ..... G-UR.2., UR.2.3., UR.2.4., UR.2.5., UR.2.6., UR.2.8.

If possible, observe normal weight determinations that are equal to or greater than the weight of the test equipment and test weights to verify the adequacy of the scale supports!

10. Approaches
    Vehicle scales UR.2.6.1. (1/1/76)
    Axle-load scales ..... UR.2.6.2.

H-44 General Code and Scales Code References

Inspection (cont.)

11. Maintenance, use, and environmental factors.
    - Facilitation of fraud ..... G-S.2.
    - Environment ..... G-UR.1.2.
    - Operation ..... G-UR.3.1.
    - Maintenance ..... G-UR.4.
    - Maximum load ..... UR.3.2.
    - Single draft vehicle weighing ..... UR.3.3.
    - Manual gross weight entries ..... UR.3.9.
    - Minimum load ..... UR.3.7.
    - Scale modification ..... UR.4.3.

12. Assistance ..... G-UR.4.4.

Pretest Determinations:

1. Tolerances:
    - Acceptance/maintenance ..... G-T.1., G-T.2.
    - Application:
        - Scales marked with an accuracy class ..... T.N.2.1., T.N.2.3., T.N.2.4.
    - Tolerance values:
        - Scales marked with an accuracy class ..... T.N.1.1, T.N.1.2.
        - Scales not marked with an accuracy class T.1.1./Table T.1.1.,
        - Both marked and unmarked scales ..... T.N.3.1./Table 6 (Accuracy Class III L), T.N.3.2.
    - Discrimination ..... T.N.7.2.
    - Repeatability. ..... T.N.5.
    - Agreement of indications. ..... T.N.4.1., T.N.4.2., T.N.4.4.

    Note: Many "TN" tolerances apply to unmarked vehicle scales. See NIST HB 44 Table T.1.1. for a list of applicable "TN" paragraphs applicable to unmarked scales.

2. Determine maximum test load to be applied during test: A test load not to exceed marked concentrated load capacity (or for scales manufactured prior to January 1, 1989, the marked section capacity) may be applied to any section or between any two sections using the normal prescribed test pattern specified in N.1.3.3.1. A test load of 100 percent of capacity may be distributed over the entire platform.

H-44 General Code and Scales Code References

Pretest Determinations (cont.):

3. Minimum test weights and test loads ..... N.3., Table 4

SAFETY REMINDER!!!

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

Test Notes:

SAFETY REMINDER!!!

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

1. Check repeatability of, and agreement between, indications throughout the test ..... T.N.5., G-S.5.2.2.(a), G-S.5.2.2.(c)

2. Recheck zero-load balance each time the test load is removed..... N.1.9., G-UR.4.2.

3. If the scale is equipped with a printer, print ticket at each test load. If the device will print only one load without returning to "zero," check printer with at least four different loads at convenient times during test..... G-S.5.6., UR.1.3. (1/1/86)

   Also verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy..... G-S.5.6.

   Check effectiveness of motion detection (See test procedure in Appendix C). ..... S.2.1.2.(a), S.2.5.1.(a),

4. If, during the conduct of the test, the performance of the device is questionable with respect to the zone of uncertainty and the width of zero, additional tests may be conducted to determine compliance..... N.1.5. (1/1/86)* N,1.5.1.*, S.1.1.1.

	H-44 General Code and Scales Code References

Test Notes (cont.):

5. If the device is equipped with operational features such as manual weight entries, programmable tare, multiple tare memory, weigh-in/weigh-out capability, or multiple weighing elements, check proper operation and appropriateness. ..... G-UR.4.1, G-UR.4.2, S.4.3., S.1.12. (1/1/93) (1/1/05), UR.3.9., See also Appendix C for EPO 13

Test:

SAFETY REMINDER!!!

- **WEAR SAFETY SHOES**
- **USE PROPER LIFTING TECHNIQUES**

1. Discrimination test at or near zero load, if deemed necessary and if environmental conditions can be controlled ..... N.1.5. (1/1/86)*, N.1.5.1.*

2. Test for proper configuration of automatic zero-tracking mechanism, if device is so equipped:

   Scales manufactured between January 1, 1981 and January 1, 2007..... S.2.1.3.1.
   Scales manufactured on or after January 1, 2007 ..... S.2.1.3.2.
   Means to disable AZT..... S.2.1.3.3. (1/1/01)

3. If equipped with a semi-automatic zero-setting mechanism (push button), test effectiveness of motion detection unless the mechanism is enclosed in a cabinet. ..... S.2.1.2.(a), See Appendix C for EPO 13E (motion detection)

   Check proper design of tare auto-clear, if device is so equipped..... S.2.3. (including auto clear Note 1/1/83)

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

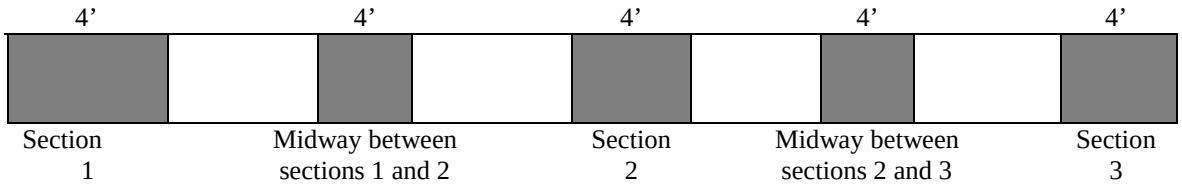
4. Establish correct zero-load balance.

5. Increasing-load and shift (section) test..... N.1.1., N.1.3.3.

Test (cont.):

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

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



For test patterns less than 1.2 meters (4 feet) in length: Determine the maximum loading by the formula: [(wheelbase of test cart or length of test load ÷ 48 in) x 0.9 x CLC]

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

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

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

Other designs: Special design scales and those that are wider than 3.7 meters (12 feet) shall be tested in a manner consistent with the method of use but following the principles described above.

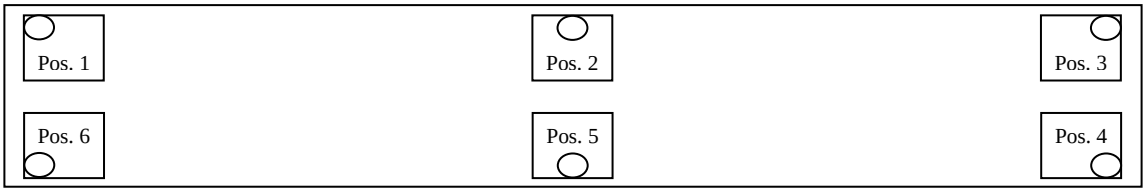
Note: When testing scales manufactured prior to January 1, 1989, caution should be exercised when loading test weights equivalent to the rated section capacity onto areas between sections.

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

6. Prescribed test pattern and test loads for combination vehicle/livestock scales with more than two sections. ..... N.1.3.3.2.

A minimum test load of 5000 kg (10,000 lb) or one-half of the rated section capacity or CLC, whichever is less, shall be placed, as nearly as possible, successively over each main load support as shown below. Two section livestock scales shall also be tested consistent with N.1.3.7.

	H-44 General Code and Scales Code References



⬭ = main load bearing point

7. RFI/EMI Test.To test for effects of EMI and RFI using equipment found at the site in a manner that is ***usual*** and ***customary***[2] ..... G-N.2., G-UR.3.2., G-UR.4.2., G-UR.1.2., N.1.6., T.1.1., T.N.9.*

8. Decreasing-load test, at one-half of maximum test load..... N.1.2., N.1.2.2.

9. Zero-load balance change N.1.9., G-UR.4.2

10. Strain-load or substitution test on at least two sections; ..... N.1.11, N.1.12., N.3. (See Appendix B for EPO 13)

    For strain-load tests:

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

11. Discrimination test at maximum test load, if deemed necessary and if environmental conditions are controlled..... N.1.5. (1/1/86)*, N.1.5.1.*

12. Over capacity test (if practical)..... S.1.7.

13. Return to zero - check zero-load balance change..... N.1.9., G-UR.4.2.

[2] Procedures have been developed by the Scale Manufacturers Association and were adopted by the National Conference on Weights and Measures as part of the Final Report of the Committee on Specifications and Tolerances 63rd annual meeting, 1978. A revised SMA "Recommendation on Electrical Disturbance – SMA RED-0499" are available at www.scalemanufacturers.org by selecting the link to SMA Standards on the SMA homepage. SMA intends this document as an educational tool for manufacturers, distributors, inspectors, and customers.

2015 NIST EPO No. 13
Examination Procedure Outline for

Vehicle and Axle-Load Scales
Part 2 - Mechanical-Analog Indicating

It is recommended that this outline be followed for vehicle and axle-load scales equipped with weighbeams and/or mechanical dials. Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk. Non-retroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES: See EPO 13, Part 1.

	H-44 General Code and Scales Code References

Inspection:

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Learn the nature of hazardous products used at, or near, the inspection site.**
- **Use caution when moving in wet, slippery areas.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Position safety cones and warning signs if necessary.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

1. Position of equipment. ..... G-UR.3.3.

2. Zero-load balance as found.. ..... S.1.1., S.1.5.1., S.2.1.1., S.2.1.2., UR.4.1.

   If the device is not indicating a zero-balance condition, the user should be made aware of paragraph UR.4.1. and a warning issued if necessary.

3. Indicating and recording elements. ..... G-S.5.

   Weighbeams ..... S.1.5.
   Poises ..... S.1.6.
   Graduations, indicators, capacity indication ..... S.1.3., S.1.4., S.1.7.
   Scale division, value (d) and number(n) ..... S.1.2. (1/1/86)*, UR.1., UR.1.1.(b), UR.1.3. (1/1/86)
   Tare division value S.2.3. (1/1/83)
   Tare mechanism ..... S.2.3.
   Damping means ..... S.2.5.
   Adjustable components ..... S.1.10.

	H-44 General Code and Scales Code References

Inspection (cont.):

4. Suitability.	G-UR.1.1., G-UR.1.2., UR.1., S.5.2. (1/1/86)*, UR.1.1., UR.3.1.*, UR.3.2.
Customer readability, if applicable	G-UR.3.3.
Adjustable components	S.1.10.
5. Design of weighing devices, accuracy class	S.5.*, S.5.4. (1/1/94), S.1.10., G-S.8. (1/1/90), G-UR.4.5.
6. Marking.	S.6.
Nominal capacity (Suitability)	S.6.1. (1/1/89)
Nominal capacity must satisfy the relationship of: nominal capacity ≤ CLC x (N - 0.5), where N = the number of sections in the scale	
a. Marking requirements - all devices	
Identification	G-S.1.
Name or ID of manufacturer	Retroactive
Model designation	Retroactive
Model prefix	(1/1/03)
Nonrepetitive serial number	(1/1/68)
Serial number prefix	(1/1/86)
Serial number – appropriate abbreviation	(1/1/01)
NTEP CC prefix and number (for devices that have an NTEP CC)	(1/1/03)
Remanufacturer information, as appropriate:	
name and ID of remanufacturer	(1/1/02)
model number if different from original model number	(1/1/02)
Lettering.	G-S.7.
Operational controls, indications, and features	G-S.6. (1/1/77)
Visibility of identification	G-UR.2.1.1.
Interchange or reversal of parts	G-S.4.
b. Marking requirements - indicating element not permanently attached or covered on separate CC (in addition to marking for all devices)	S.6.3.
Accuracy class	(1/1/86)
Nominal capacity	Table S.6.3.b. Note 18
Value of scale division with nominal capacity, if not apparent	(1/1/83)
Value of "e" (if different from "d")	(1/1/86)

	H-44 General Code and Scales Code References

Inspection (cont.):

b. Marking Requirements (cont.)

Maximum number of scale divisions (nmax)	(1/1/88)
Concentrated load capacity (CLC)	(1/1/89)
Section capacity (Sec Cap) (see note below)	Retroactive
Combination vehicle (CLC)/railway scales (Sec Cap)	(1/1/00)
Scales designed for special purposes	(1/1/86)

Note: Indicating elements manufactured prior to 1/1/89 are required to be marked with a section capacity rating. However, it is acceptable for these devices to be marked with a CLC instead. It is not permissible to substitute a section rating for a CLC on vehicle scales manufactured or placed into service on or after 1/1/89.

c. Marking requirements - weighing/load-receiving element not permanently attached or covered on separate CC (in addition to marking for all devices) ..... S.6.3.

Location of Marking Information.	S.6.2.
Accuracy class	(1/1/88)
Nominal capacity on weighing/load-receiving element	(1/1/89)
Maximum number of scale divisions (n_{max})	(1/1/88)
Minimum verification scale division (e_{min} or d_{min})	(1/1/88)
Concentrated load capacity (CLC)	(1/1/89)
Section capacity (Section Cap) (see note below)	Retroactive
Combination vehicle (CLC)/railway scales (Section Cap)	(1/1/00)
Scales designed for special purposes	(1/1/86)

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

7.	Weighing and load-receiving elements	S.4., UR.2.8.
	Access	UR.2.5.
8.	Installation	G-UR.2., UR.2.3., UR.2.4.

SAFETY REMINDER!!!

– **If possible, observe normal weight determinations that are equal to or greater than the weight of the test equipment and test weights to verify the adequacy of the scale supports!**

9. Approaches

Vehicle scales	UR.2.6.1. (1/1/76)
Axle-load scales	UR.2.6.2.

	H-44 General Code and Scales Code References

Inspection (cont.):

10. Maintenance, use, and environmental factors.
    - Facilitation of fraud ..... G-S.2.
    - Environment ..... G-UR.1.2.
    - Operation ..... G-UR.3.1., G-UR.3.2.
    - Maintenance ..... G-UR.4.
    - Maximum load ..... UR.3.2.
    - Single draft vehicle weighing ..... UR.3.3.
    - Minimum load ..... UR.3.7.
    - Scale modification ..... UR.4.3.

11. Assistance ..... G-UR.4.4.

Pretest Determinations:

1. Tolerances.
    - Acceptance/maintenance. ..... G-T.1., G-T.2.
    - Application. ..... T.N.2.1., T.N.2.3.
    - Principles ..... T.N.1.1., T.N.1.2.
    - Tolerance values:

        Scale marked with an accuracy designation.
        - Maintenance tolerances ..... Table 6 (Class III L),
        - Acceptance tolerances ..... T.N.3.2.
        - Sensitivity (nonautomatic indicating scales). ..... T.N.6., T.N.6.1., T.N.6.2.
        - Discrimination (automatic indicating scales) ..... T.N.7.1.
        - Agreement of indications ..... T.N.4.1., T.N.4.2., T.N.4.3., and T.N.4.4., (optional T.N.4.5.)
        - Repeatability. ..... T.N.5.

        Scale not marked with an accuracy class. ..... T.1.1./Table T.1.1.
        - Maintenance tolerances ..... T.N.3.1. Table 6 (Class III L)
        - Acceptance tolerances ..... T.N.3.2.
        - Sensitivity requirement (SR) (nonautomatic indicating scales) ..... T.2.1., T.2.2., T.2.7., T.3.
        - Agreement of indications ..... T.N.4.1., T.N.4.2., T.N.4.3., and T.N.4.4.
        - Repeatability. ..... T.N.5.

        Note: Many "T.N." tolerances apply to unmarked vehicle scales. See NIST HB 44 Table T.1.1. for a list of applicable "T.N." paragraphs applicable to unmarked scales.

Pretest Determinations (cont.):

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

3. Minimum test weights and test loads ..... N.3., Table 4

SAFETY REMINDER!!!

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

Test Notes.

SAFETY REMINDER!!!

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

Note: If the scale uses a beam indicating element (e.g., full- or type-registering beam), balance small error weights on the platform, the smallest weight equal to the minimum tolerance value and the total value of the weights being equal to the tolerance value at maximum test load.

1. Check repeatability of, and agreement between, indications throughout the test..... T.N.4. T.N.5., G-S.5.4.

2. Recheck zero-load balance each time test load is removed..... N.1.9., G-UR.4.2.

3. If the scale is equipped with a type-registering (T.R.) beam or a printer,print ticket at each test load..... G-S.5.6., UR.1.3. (1/1/86)*, G-S.5.2.2.(b)

	H-44 General Code and Scales Code References

Test:

SAFETY REMINDER!!!
- **WEAR SAFETY SHOES!**
- **USE PROPER LIFTING TECHNIQUES!**

1. Sensitivity test at zero load (for weighbeams and balance indicators only) ..... N.1.4.

   Discrimination (dials and balance indicators with graduations having a specific value only) ..... N.1.5. (1/1/86),* T.N.7.1.

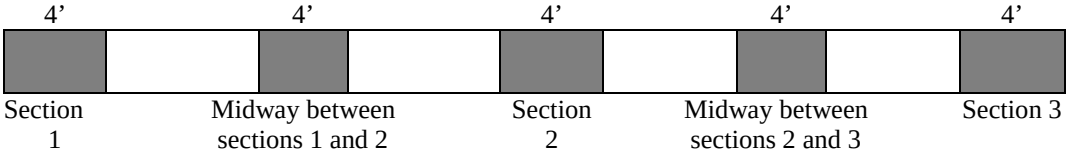
2. Increasing-load and shift (section) test. ..... N.1.1., N.1.3.
   a. If beam scale, test at not less than two points on each weighbeam.

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

   c. Minimum shift test ..... N.1.3.3.1.(a)

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

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



- For test patterns less than 1.2 meters (4 feet) in length: Determine the maximum loading by the formula: [(wheelbase of test cart or length of test load ÷ 48 in) x 0.9 x CLC]

- For test patterns that exceed 1.2 meters (4 feet): The maximum test load applied shall not exceed CLC x the largest “r” factor in Table UR.3.2. for the length of the area covered by the test load.

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

Test (cont.)

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

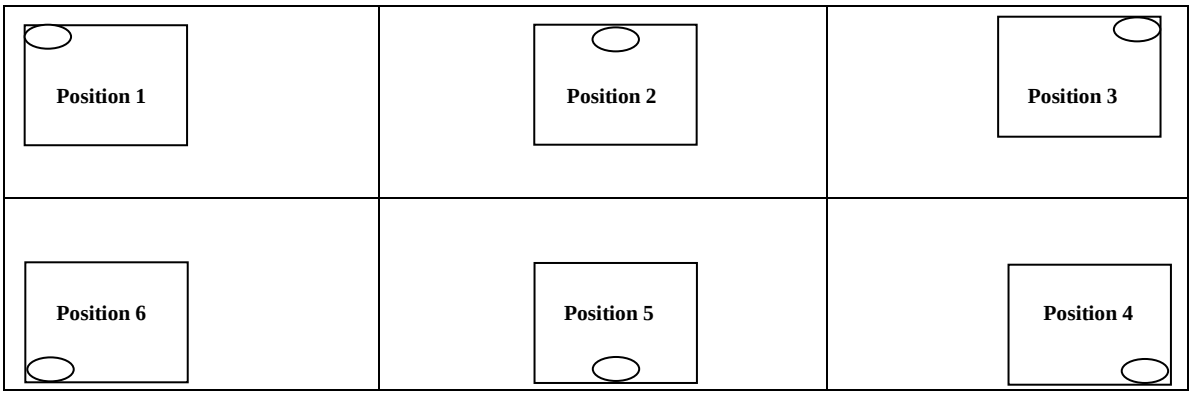
- Other designs: Special design scales and those that are wider than 3.7 meters (12 feet) shall be tested in a manner consistent with the method of use but following the principles described above.

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

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

3. Prescribed test pattern and test loads for combination vehicle/livestock scales with more than two sections.

   A minimum test load of 5000 kg (10,000 lb) or one-half of the rated section capacity or CLC, whichever is less, shall be placed, as nearly as possible, successively over each main load support as shown below. Two section livestock scales shall also be tested consistent with N.1.3.7.



◯ = Load Bearing Point

4. Decreasing-load test (automatic-indicating only), at one-half of maximum test load. (for dials, test at no less than one-half dial-face capacity)..... N.1.2., N.1.2.2.

5. Strain-load or substitution test on at least two sections ..... N.1.11., N.1.12., N.3., T.N.3.11., T.N.3.12.

   - Strain-load Tests: Follow the procedures in Appendix B for EPO 13. Tolerances apply only to the test weights or substitution test load.

   - Substitution Test: Follow the procedures in Appendix B for EPO 13. Tolerances are applied to the substitution test load.

	H-44 General Code and Scales Code References

Test (cont.)

6.	Sensitivity test at maximum test load (weighbeams and balance indicators only).....	N.1.4.
	Discrimination (dials and balance indicators with graduations having a specific value only).....	N.1.5. (1/1/86),* T.N.7.1.
7.	Remove test load and determine any zero-load balance change.....	N.1.9., G-UR.4.2.
8.	Remove error weights and establish correct zero-load balance.	

Appendix A - Maximum Values of Multiple Load Cell Scales

(Table values are in pounds.)

Full electronic scales

Example: For a vehicle scale with four sections (eight load cells) and a displayed scale division of 20 lb, the maximum value permitted for each load cell is 7.1 lb. The calculation is shown below. If the value marked on the load cell is less than or equal to the value computed for the v_{min}, then the load cell is considered to comply with T.N.8.1.3.

$$v_{min} \le \frac{d^*}{\sqrt{N}} = \frac{20\,lb}{\sqrt{8}} = \frac{20\,lb}{2.83} = 7.07\,lb \quad rounded\ to \quad 7.1\,lb$$

No. of Load Cells	Scale Division (lb)						
	1	2	5	10	20	50	100
	Minimum v_{min} rating for each cell (lb)						
2	0.71	1.41	3.54	7.07	14.1	35	70
4	0.50	1.00	2.50	5.00	10.0	25	50
6	0.41	0.82	2.04	4.08	8.2	20.4	41
8	0.35	0.71	1.77	3.54	7.1	17.7	35
10	0.32	0.63	1.58	3.16	6.3	15.8	32
12	0.29	0.58	1.44	2.89	5.8	14.4	29
14	0.27	0.53	1.34	2.67	5.4	13.4	27

Mechanical Scales with single load cell

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

$$v_{min} \le \frac{d^*}{\sqrt{N} \times (scale\ multiple)} = \frac{20\,lb}{\sqrt{1} \times 400} = 0.05\,lb$$

2015 NIST EPO No. 13
Vehicle & Axle-Load Scales

Appendix B - Strain-Load and Substitution Load Method of Testing

(Excerpt from NBS Handbook 94 – Out-of-print)

and

Strain-Load Testing Using Error Weights
(Excerpt from OWM Newsletter Archive)

When Test-Weight Load is Inadequate. In the test of a large-capacity scale where the amount of test weights available is less than the "used" or full capacity of the scale, it is necessary for the inspector to resort to a substitution method of test (which may be referred to as a "build-up" or "step" test), or to the use of from one to several "strain" loads in addition to the available load of test weights. The former method is generally the better when carefully carried out but will usually consume a considerably greater amount of time than the strain-load method.

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

The test would then proceed as before until the platform load reached 20,000 pounds, when another substitution would be made in the same manner as has been outlined. *[No more than three substitutions shall be used during substitution testing, after which the tolerances for strain load tests shall be applied to each set of tests. (HB 44 2.20 Table 4 Note 2)]*

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

Another caution that must be observed during a substitution test is never to change the adjustment of the regular balancing means of the scale during the progress of the test. When a temporary balancing operation is made necessary in order to establish a reproducible balance condition prior to removal of the test-weight load, the inspector must always restore the original conditions that prevailed when the scale was originally balanced at zero

after the substitution is completed and before proceeding with the test; this cannot be done with precision if the adjustment of the regular balancing means has been changed, hence the instruction that these temporary balancing operations be performed by means of poise movement or weights added to platform or counterpoise hanger. When a full-capacity beam scale has an error of overregistration and is equipped with a notched fractional bar, it may be necessary to accomplish this temporary balancing by setting the fractional poise out one or more notches until the beam is balanced low, and then adding enough small weights to the platform to produce the desired balance; when an automatic-indicating scale has a similar error, enough small weights may be added to the platform to bring the indicator into coincidence with the next forward graduation so that a precise reading can be made[3].

Strain-Load Method of Testing. *(NBS Handbook 94 discussion on Strain-Load Method has been deleted. WMD recommends using the procedure outlined in the newsletter article following the excerpts of Handbook 94.)*

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

Strain-Load Testing Using Error Weights
(Excerpt from OWM Newsletter Quarterly Archive at http://www.nist.gov/pml/wmd/pubs/upload/A-009.pdf or http://www.nist.gov/pml/wmd/pubs/newsletter-archives.cfm)

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

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

3 See the OWM article on the use of error weights at the end of this appendix to determine the breakpoint between adjacent scale divisions on an electronic or mechanical automatic indicating scale.

Appendix B (continued)

Using Error Weights on a Digital Scale. To perform the strain-load test on a scale having digital indications, error weights are used to establish, as a reference point, the center of the displayed division representing the unknown load. Once the center of the displayed division has been established, test weights can then be added and scale errors determined by direct reading of the indication. The procedure for conducting a strain-load test on a scale having digital indications is as follows:

1. Apply 10 error weights, each having a value of 0.1 d, to the platform and zero the scale.

2. Apply the unknown load. Record the displayed value and identify it as the weight of the unknown load.

3. Remove error weights from the platform in 0.1 d increments until the indication just begins flashing to the next lower division.

4. In a separate location on the platform begin a second group of error weights by adding back all of the error weights that were just removed in the previous step.

5. Continue adding additional error weights to this second group in 0.1 d until the displayed indication just begins flashing to the next higher division.

6. Total the error weight in the second group and remove one-half of it from the platform. Doing so places the indication at the proper reference, i.e., in the center of the displayed division and properly establishes your reference point for the strain-load test.

7. Apply known test weights in predetermined increments or all at one time.

8. Add the weight of the unknown load (determined in step 2) to the value of the known test weights applied.

9. Scale error is determined by subtracting the summed value from step 8 from the displayed indication.

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

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Vehicle & Axle-Load Scales

Appendix C - Tests for Motion Detection

A digital electronic device must have a motion detection capability that prevents the device from zeroing (push-button zero) or taring (pushbutton tare) part of a load when the semi-automatic zero or tare key is activated at the same time that a load is added, changed, or removed from the scale.

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

(a) plus or minus 3 scale divisions for:

a. axle-load,
b. railway track,
c. vehicle scales,
d. combination vehicle/livestock scales,
e. combination vehicle/railway track scales and
f. hopper (other than grain hopper) scales with a capacity exceeding 22 000 kg (50 000 lb); and

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

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

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

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

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

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

2015 EPO No. 14

Examination Procedure Outline for

Belt-Conveyor Scale Systems

Introduction

It is recommended that this outline be followed as minimum criteria for examining belt-conveyor scale systems. This document has been prepared as a guide for determining if devices are correct and suitable for commercial service for owners, users, operators, service agencies and officials with statutory authority. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

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

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Lifting

Location

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment

e.g.,

Safety Shoes, Safety Aprons, Respirators, Gloves, Barrier Cream, etc., if deemed necessary.

Hard Hat -- for protection from overhang in rear of vehicle tank truck

Safety Cones/Warning Signs

also: **Wet/Slick Conditions, Hazardous Materials, Traffic, Obstructions and Overhead Hazards**

SAFTEY REMINDER

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Use caution while moving in wet, slippery areas.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

	H-44 General Code and BCS Systems Code References

Pre-Test Inspection – Installation:

1. General Considerations:

Selection	G-S.3., G-UR.1.1.
Installation	G-UR.2.
Protection from environment	G-UR.1.2. UR.2.1.
Foundation, supports, and clearance	G-UR.2.1., UR.2.2.(a)
Access to weighing elements	G-UR.2.3.
A belt-conveyor scale manufactured after January 1, 1981 shall be installed so that material tests can be conveniently conducted	U.R.1.3.
Retention of Maintenance, Test, and Analog or Digital Recorder Information	UR.2.6.
Notification of compliance.	UR.4.

2. Material handling ..... G-UR.2.1., G-UR.3.2., G-UR.4.1.

Inspect the entire material handling system, from load point to the discharge, inspecting all hoppers and transfer chutes, to ensure that there is no buildup of material or spillage that might create problems with normal measurements and material test results.

Material buildup in the hoppers or chutes must be removed prior to testing. Spillage must be removed and the cause of the spillage repaired prior to the test.

Verify that device meets all performance requirements when all associated or non-associated equipment is operated during testing (i.e., metal detectors/magnets, product additives, sampling equipment).

Magnets must not be located in close proximity to the scale area. Material additives not included as part of the product description must be introduced to the flow of product downstream from the belt-conveyor scale area. "Sweep-type" samplers are recommended to be located a minimum of 18 meters (60 feet) from the center of the belt-conveyor scale weigh area.

	H-44 General Code and BCS Systems Code References

Pre-Test Inspection – Installation (cont.):

3. Scale Conveyor

If practicable, the scale should be material tested to determine the as-found accuracy of the scale before conveyor inspections and corrections are made.....	UR.1.3. (1/1/1981), UR.3.1.
Inspect the entire conveyor. The inspection should include checking for damage, malfunctions, or wear in: chutes; belting; infeed skirting; tail pulley; impact idlers; troughing idlers; training idlers; return idlers; bend pulleys; snubbing pulley; head pulley; belt scrapers; take-up device; take up weight; support steel; feed points; clearances; guard devices; and the conveyor drive.	UR.1.
Inspect all idlers of the conveyor, both loaded and unloaded. If the belt will not conform to the requirements of NIST Handbook 44 installation requirements or faulty bearings are found then this must be corrected.....	UR.1.2. (m)
Inspect the skirt boards at the infeed point for proper alignment. If any spillage at this point exists, adjustments must be made to eliminate all spillage prior to the materials test.	UR.1.2., UR.1.2. (l)
The conveyor structure must be rigid in design to prevent vibration and significant deflection.	UR.1.2. (a)
Inspect the Take Up Unit, the bend pulley must travel freely when the belt is running and not bottom out at start up.....	UR.1.2. (d)
Inspect the Drive unit for slippage or spillage, which must be corrected before testing begins.	UR.1.2.

4. Scale

Inspect the weigh area idlers for worn bearings and belt alignment. The weigh area idlers should freely rotate and have no signs of material build-up, holes in the rollers, or corrosion. Excessive noise from the idlers indicates friction or worn bearings that may also affect scale performance. Inspect any load cell stay rods or flexure plates for distortion or binding.	UR.1.2.
Inspect the speed sensor; if the speed sensor is mounted on a non-driven bend pulley, it should be on the clean side of the return belt. Also check the bend pulley wrap to ensure positive contact. Check for material build-up on the speed sensing pulley, ensure sensor coupling is secure and has no worn bearings. The sensor should be corrected if a loose bearing exists on the shaft.	UR.1.4., G-UR.4.2.
Inspect the weighbridge support steel and bracing for the load cells and weighbridge.	UR.1.2. (i)

	H-44 General Code and BCS Systems Code References

Pre-test Inspection – Installation (cont.):

Inspect belt alignment. The belt must not extend beyond the edge of the idler roller in any area of the conveyor, either empty or loaded and must not touch any structure on the return side. Verify that belt is tracking properly on idlers and rollers. Belt (or sections of belt) should not deviate excessively in its tracking location on the idlers or rollers during revolutions.	UR.1.2. (m)
Inspect belt composition and maintenance. Belt should not exhibit excessive wear or extreme variation in uniform composition. The belt should make contact with all the rollers in the weigh area empty and loaded.	UR.1.2. (k)
Based on observations, corrections must be made to the scale or the area surrounding the scale if foreign material adheres to the scale structure at any time during normal operation and materials tests.	UR.3.1. (b)

Pre-Test Inspection – Scale:

1. Identification.	
1.1. Manufacturer's name or trademark, model number, and serial number on major components.	G-S.1.
2. Design of indicating and recording element	
2.l. Units installed after January 1, 1986 must be equipped with a recording element and a rate of flow indicator and recorder.	S.1.1.
3. Marking requirements.	S.4.
3.1. Rated capacity - units of weight per hour, both maximum and minimum.	S.4. (a)
3.2. The value of the scale division.	S.4. (b)
3.3. The belt speed in terms of feet or meters per minute at which the belt will deliver the rated capacity.	S.4. (c)
3.4. The belt load in terms of pounds per foot or kilograms per meter (determined by material tests).	S.4. (d)
3.5. On all new units installed after January 1, 1986, the operational temperature range if it is other than - 10 °C to 40 °C (14 °F to 104 °F).	S.4. (e)
3.6. For units installed after January 1, 1986 check that the rated belt speed and material loading of the Scale is within the parameters outlined in the manufacturer's certificate of conformance.	S.1.5. (1/1/1986), S.2.3., UR.2.4.

	H-44 General Code and BCS Systems Code References

Pre-Test Inspection – Scale (cont.):

3. Marking requirements (cont.). ..... S.4.

   3.7. Visibility of Identification and other required markings, including identification of scale area..... G-UR. 2.1.1. UR.1.2. (k)

4. Provisions for Sealing

   The MWT shall not be resettable without breaking a security means for devices manufactured after January 1, 1986..... S.1.7. (1/1/1986)

   Provisions shall be made to seal access to load cell and integrator calibration adjustments. Devices manufactured after January 1, 1999 are permitted to have an approved means for providing security such as a data change audit trail available to the inspector at the time of inspection..... S.5. (1/1/1999)

Pre-Test Determinations:

1. Determine if the conveyor scale is suitable for the amount of product weighed.

   1.1. The belt-conveyor scale system may be operated between 20 and 100 percent of its rated capacity. Record the maximum and minimum feed rate and run time it takes to deliver a test load. Determine the percentage of rated capacity..... UR.2.

   Example:

   The scale has a rated capacity of 500 tph.
   A test load of 80 tons was delivered in 15 minutes.

$$\frac{60 \text{ minutes (in one hour)}}{15 \text{ minutes}} \times \text{test load} = 4 \times 80 \text{ tons}$$

4 hours x 80 tons = 320 tons in one hour or tph (feed rate in tph)

$$\frac{320 \text{ tph}}{500 \text{ tph}} \times 100 = 64\ \% \quad \text{(feed rate as a percentage of scale capacity)}$$

The above example could also be stated as follows:

$$\frac{80 \text{ tons}}{15 \text{ minutes}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \frac{320 \text{ tons}}{1 \text{ hour}}$$

$$\frac{320 \text{ tph}}{15 \text{ minutes}} \times \frac{}{100} = 64\ \%$$

	H-44 General Code and BCS Systems Code References

Pre-Test Determinations (cont.):

1.2. Delivered quantities of less than the minimum test load shall not be considered a valid weighment. ..... UR.2.2.

1.3. Material must not slip on the belt due to the angle of belt incline, belt speed or loading process. Material slipping backwards (in the opposite direction of belt travel) on an inclined belt-conveyor scale results in material being weighed more than once. ..... UR.1.2. (h), UR.1.2. (l)

2. Recording Elements and Recorded Representations

2.1. Recorded representations, General ..... G-S.5.6.

2.2. The value of the scale division of the recording element shall be the same as that of the indicating element. S.1.4. (1/1/1986)

All of the information in (a) and (b) must be recorded for each delivery for systems installed after January 1, 1994. ..... S.1.4. (1/1/1994)

The belt-conveyor scale system shall be capable of recording the results of automatic or semi-automatic zero load test installed after January 1, 2004. ..... S.1.4.1. (1/1/2004)

2.3. Rate of flow indicators and recorders. S.1.5. (1/1/1986)

a) The belt-conveyor scale system shall record the unit of measurement (i.e., kilograms, tonnes, pounds, tons, etc.); the date; and the time.

b) The belt-conveyor scale system shall record the initial indication and the final indication of the master weight totalizer and the quantity.

3. Value of the scale division. ..... S.1.3.

3.1. Scales installed ***after*** January 1, 1986 must have a scale division not greater than 1/800 of the minimum totalized load (0.125 percent) S.1.3.1. (1/1/1986)

3.2. Scales installed ***before*** January 1, 1986 must have a scale division not greater than 1/1200 of the minimum totalized load. ..... S.1.3.2.

Example:
Belt Scale Capacity = 1000 tons per hour (tph)
Max. Smallest Unit = 1000 tph × 1/1200 = 0.83 ton – rounded to 0.50 ton.

Note that 0.83 is <u>rounded down</u> to 0.50 to coincide with the MWT minimum increment requirement. Rounding to the <u>nearest</u> increment of 1.00 ton does not comply with the requirement.

	H-44 General Code and BCS Systems Code References

Pre-Test Determinations (cont.):

4. Determine the minimum amount of material to pass over the belt-conveyor scale for materials test..... N.2.3.

   Each test is to be run for not less than:

   (a) 800 scale divisions,
   (b) the load obtained at maximum flow rate in one revolution of the belt, or
   (c) at least 10 minutes of operation.

   For applications where a normal weighment is less than 10 minutes (e.g., belt-conveyor scale systems used exclusively to issue net weights for material conveyed by individual vehicles and railway track cars) the minimum test load shall be the normal weighment that also complies with (a) and (b).

   The official with statutory authority may determine that a smaller minimum totalized load down to 2 % of the load totalized in 1 hour at the maximum flow rate may be used for subsequent tests, provided that:

   1. the smaller minimum totalized load is greater than the quantities specified in (a) and (b), and

   2. consecutive official testing with the minimum totalized loads described in N.2.3. (a), (b), or (c) and the smaller minimum test load has been conducted that demonstrates the system complies with applicable tolerances for repeatability, acceptance, and maintenance.

5. Reference scale and reference material

   5.1. The containers used in the material test should be inspected. They may be railroad cars, trucks, hoppers, or barges. They must not leak and should be large enough so that overloading or spillage does not occur. ..... N.3.2. (a)

   5.2. Determine accuracy of reference scale. It is preferable to verify the accuracy of the reference scale within 24 hours of the weight determination of the material used for the belt-conveyor materials test. (For vehicle scales refer to test procedure in NIST Examination Procedure Outline Numbers 13 and 13E.)

   The quantity of material used to conduct a material test shall be weighed on a reference scale to accuracy within 0.1 %..... N.3.2. (d), N.3.2.1.

   5.3. After the reference scale test and before commencing the belt scale materials test, attempt to establish the weight of a reference load. This reference load can be used to re-verify the reference scale after the reference scale test equipment has left the test site..... N.3.2. (e)

	H-44 General Code and BCS Systems Code References

Pre-Test Determinations (cont.):

6. Material test conditions..... N.3.2. (f)

Note (record) the following conditions before starting the test.

- Current weather and temperature.
- Check security system to determine if any metrological integrity items have been changed.
- The "as found" zero and span numbers.
- The "as found" auto zero track deviation from zero.
- The zero-load repeatability test, before and immediately after the official materials test.

7. Determine tolerance requirements

7.1. Zero Tests ..... N.3.1.2.

A series of zero-load tests shall be carried out immediately before conducting the simulated load or materials test until the three consecutive zero-load tests each indicate an error which does not exceed ± 0.06 % of the totalized load at full scale capacity for the duration of the test. No adjustments can be made during the three consecutive zero-load test readings.

Example: Belt-conveyor scale capacity: 700tph
Test duration: 3 minutes
Calculate permissible error zero test error:

$(0.06/100) \times 700\text{tph} \times (3\text{min}/60\text{min}) = 0.021$ tons

7.2 Zero stability following a materials test. ..... T.1.1.

The change in the accumulated or subtracted weight during the zero-load test shall not exceed 0.12 % of the totalized load at full scale capacity for the duration of that test. (See the example above but using 0.12% to replace 0.06 %.) If the range of zero adjustments during a complete (official) verification test exceeds 0.18 % of the totalized load at full scale capacity for the duration of the zero-load test, the official with statutory authority may establish an interval for zero-load testing during normal operation.

7.3. Check For Consistency of the Conveyor Belt Along Its Entire Length. ..... N.3.1.3.

During a zero-load test with any operational low-flow lock-out disabled, the absolute value of the difference between the maximum and minimum totalizer readings indicated on the totalizer during any complete revolution of the belt shall not exceed 0.12 % of the minimum test load.

Note: The end value of the zero-load test must meet the ± 0.06 % requirement referenced in the "Test for Zero Stability."

Pre-Test Determinations (cont.):

7.4. Materials test. ..... T.1.

Maintenance and acceptance tolerances on the materials test, relative to the weight of the material, shall be 0.25 percent (1/400) of test load.

7.5. Repeatability test. ..... T.2.

Tolerance Values, Repeatability Tests. – The variation in the values obtained during the conduct of materials tests shall not be greater than 0.25 % (1/400).

Test:

SAFETY REMINDER

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

1. Zero-load tests.

If the belt has been idle 2 hours or more, run empty for 30 minutes if temperature is 5 °C (41 °F) or above (longer if temperature is less than 5 °C (41 °F) before starting the zero-load test. ..... N.3.1.

(a) Determination of Zero: .....
For belt-conveyor scales with electronic integrators, the test must be performed over a period of at least 3 minutes and with a whole number of complete belt revolutions. For belt-conveyor scales with mechanical integrators, the test shall be performed with no less than three complete revolutions or 10 minutes of operation, whichever is greater. ..... N.3.1.1.

(b) Test of Zero Stability:
A series of zero-load tests shall be carried out immediately before conducting the simulated load or materials test until the three consecutive zero-load tests each indicate an error which does not exceed ± 0.06 % of the totalized load at full scale capacity for the duration of the test. No adjustments can be made during the three consecutive zero-load test readings. ..... N.3.1.2.

Check For Consistency of the Conveyor Belt Along Its Entire Length.

During a zero-load test with any operational low-flow lock-out disabled, the absolute value of the difference between the maximum and minimum totalizer readings indicated on the totalizer during any complete revolution of the belt

	H-44 General Code and BCS Systems Code References
shall not exceed 0.12 % of the minimum test load.....	N.3.1.3.

Test (cont.):

Note: The end value of the zero-load test must meet the ± 0.06 % requirement referenced in the "Test for Zero Stability."

Any changes in the zero reference will result in the action taken listed in UR.3.2.(c) for testing between official tests and during official tests.

2. Material test.

2.1. At the start of the test, write down the starting totalizer reading. Pass material over weigh belt using either pre-weighed material with controlled delivery or weigh material delivered from the belt..... .N.3.2.

Record the maximum and minimum feed rates during the delivery of the materials. Calculate the average feed rate.

2.2 Number of test runs and flow rates. ..... .N.2., N.2.1.

Initial Tests:

A belt-conveyor scale system shall be verified with a minimum of two test runs at each of the following flow rates:

(a) normal use flow rate,

(b) 20 % of the maximum rated capacity, and

(c) an intermediate flow rate between these two points.

Test runs may also be conducted at any other rate of flow that may be used at the installation.

Or:

A minimum of four test runs may be conducted at only one flow rate if evidence is provided that the system is used at a single flow rate and that rate does not vary in either direction by an amount more than 10 % of the normal flow rate that can be developed at the installation for at least 80 % of the time.

Belt must be loaded so that the rate of flow indicator is maintained between 20% and 100% of rated capacity. ..... UR.2., UR.1.2.(l)

Permanent means shall be provided to produce an audio or visual signal when the rate of flow is equal to or less than 20 % and when the rate of flow is equal to or greater than 100 % of the rated capacity of the scale. Different feeders or different feed rates may require additional materials tests. S.1.5. (1/1/1986)

Tests (cont.):

Subsequent tests:..... N.2.2.

Subsequent testing shall include testing at the normal use flow rate and other flow rates used at the installation. The official with statutory authority may determine that testing only at the normal use flow rate is necessary for subsequent verifications if evidence is provided that the system is used to operate:

(a) at no less than 70 % of the maximum rated capacity for at least 80 % of the time (excluding time that the belt is unloaded), or

(b) with a normal use flow rate that does not vary by more than 10 % of the maximum rated capacity.

Example: If a belt-conveyor scale system has a maximum rated capacity of 200 tons per hour (tph), and the normal use flow rate is 150 tph (75 % of the maximum rated capacity), no testing at additional flow rates is required provided the flow rates remain above 140 tph for more than 80 % of the time. If the same device were operating with a normal use flow rate of 130 tph, it is operating at 65 % of the maximum rated capacity. Testing at flow rates in addition to the normal use flow rate would be required if the normal use flow rate varies by more than 20 tph (10 % of the maximum rated capacity).

2.3. Compare net weight of material passed over belt as shown by belt totalizer with net weight established by reference scale and determine error. Refer to the table in UR.3.2. to determine what action is necessary based on the error observed..... T.1.

Example: Calculate error and tolerance when 101.7 tons of pre-weighed material is passed over a 500 ton per hour belt scale and the final totalizer reading is 101.9 tons.

Belt totalizer reading: 101.9 tons (indicated net weight)
Pre-weighed material: 101.7 tons (weight determined on the reference scale)
Error = + 0.2 ton
% Error = (+ 0.2 tons/101.7 tons) × 100 = 0.197 percent
% Error = + 0.197% (complies or meets tolerance)

Tolerance: +/- 0.25 %

The above calculations may also be made using the following steps:

% Error = [(Indicated net weight – Reference weight)/Reference weight] × 100
% Error = [(101.9 – 101.7) / 101.7] × 100 = +0.197%

(Range of allowable totalizer readings 101.4 to 102.0 tons)

	H-44 General Code and BCS Systems Code References

Test (cont.):

3. Repeatability test. Any subsequent material testing should consist of at least 2 individual tests to determine repeatability of scale and must repeat within 0.25% on all tests. The results of all these tests shall be within tolerance limits and shall not be averaged.	T.2., N.3.2.
4. Simulated test. A simulated test, as recommended by the manufacturer, shall be performed within 12-hours after a material test has established scale accuracy. Record the established factor that relates the results of the simulated load tests to the results of the materials tests. Results of the simulated load test shall repeat within 0.1 percent.	N.3.3. N.3.3.(c) UR.3.1.(d) UR.3.1.(f)
5. Post-test inspection of the conveyor and the material handling system.	N.3.2. (a),(c),UR.2.5.

Walk through the complete system from load point to discharge, inspecting all hoppers, feeders, belts, and transfer chutes for spillage and build up of material.

Any spillage occurring during the material test should be noted and reported, however insignificant the spillage may seem.

Any material build up on the scale structure or belt should also be noted and reported.

If material build up or spillage that occurred during the material test is determined to be large enough to have biased the test and the actual weight cannot be determined from a traceable standard then the test is not valid.

This includes test material that may have been left in the containers during the unloading process.

2015 NIST EPO No. 16

Examination Procedure Outline for

Automatic Bulk Weighing Systems

It is recommended that this outline be followed for automatic bulk weighing systems (ABWS's); that is, weighing systems adapted to the automatic weighing of a commodity in successive drafts of predetermined amounts automatically recording the no-load and loaded weight values and accumulating the net weight of each draft. Requirements that apply only to scales marked with an accuracy class are indicated with an asterisk. Nonretroactive requirements are followed by the applicable date in parentheses.

This outline is comprised of four separate parts plus three supplements. The title and a description of the information contained in each of those parts and supplements are as follows:

1. EPO No.16 Examination Procedure Outline for Automatic Bulk Weighing Systems – This document contains the outline of NIST Handbook 44 references for examining automatic bulk weighing systems.
2. EPO No. 16 Appendix A Description of Test Methods – This document describes three different test methods that may be used to conduct a performance test on an ABWS and provides guidance on which method to apply.
3. EPO No. 16 Appendix B High-Level Steps to Performing the Increasing-Load Test Using the Substitution or Alternative Substitution Test Method - This EPO recognizes two acceptable types of substitution test loads used in testing, those that are exact and those that are not. Appendix B describes the high level steps to performing the increasing load test on an ABWS using either type of substitution test loads.
    a. EPO No. 16 Appendix B (Supplement 1) Applying the High-Level Steps of the Substitution and Alternative Substitution Test Method - This document is a supplement to Appendix B and provides detailed instructions on applying each of the high-level steps that are identified in that appendix.
    b. EPO No. 16 Appendix B (Supplement 2) Determining Scale Error When Applying the Substitution Test Method – This document is also a supplement to Appendix B and further clarifies how scale error is determined from results obtained using exact substitution test loads. This supplement also provides an indication of how results of a test using exact substitution test loads may be recorded.
    c. EPO No. 16 Appendix B (Supplement 3) Determining Scale Error When Applying the Alternative Substitution Test Method – This document is also a supplement to Appendix C and further clarifies how scale error is determined from results obtained during testing using substitution test loads that are not exact. This supplement also provides an indication of how results of a test using substitution test loads that are not exact may be recorded.
4. EPO No. 16 Appendix C Definitions – This document provides definitions of terms that have special meaning when used in any of the various parts of the EPO.

The Grain Inspection Packers and Stockyards Administration (GIPSA) is provided the authority to regulate ABWS's used in the official weighing of grain under Section 7B (a) of the United States Grain Standards Act (Act). When performing certification testing on equipment used in the official weighing of grain as provided under the Act, the most current version of the GIPSA Weighing Handbook should be consulted. The GIPSA Weighing Handbook can be obtained by contacting GIPSA using the following contact information:

GIPSA Administrator
Stop 3601, Room 2055-South Building
1400 Independence Avenue, SW
Washington, DC 20250-3601
(202) 720-0219
http://www.gipsa.usda.gov

Note that some of the test procedures outlined in the NIST EPO for ABWS's may differ significantly from those in the GIPSA Weighing Handbook. For this reason, when considering using any of the test procedures included in this EPO to perform an official examination of an ABWS as part of the GIPSA scale testing program, you might wish to consult GIPSA beforehand to confirm their acceptance of those procedures prior to using them.

SAFETY NOTES

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

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

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

Electrical Hazards

First Aid Kit

Lifting

Location

also:

Wet and Slick Conditions

Chemicals. Petroleum Products and Hazardous Materials

Obstructions

Personal Protection Equipment

e.g., Safety Shoes

Support – for Scale and Test weights

Transportation of Equipment

Inspection:

SAFETY REMINDER!!!

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

H-44 General Code and ABWS Code References

1. Accessibility for inspection, testing, and sealing..... G-UR.2.3.
2. Zero or no-load reference indication ..... S.1.1., S.1.1.1., G-S.5.2.2.(d) (1/1/86)

Zero-load adjustment ..... S.2.1.[1]
Manual zero-setting mechanism ..... S.2.1.1.
Semiautomatic zero-setting mechanism ..... S.2.1.2.

3. General Considerations
Selection of equipment ..... G-UR.1.1., G-UR.1.2.
Number of scale divisions (n) - systems used to weigh grain UR.1.1 (1/1/84)
Number of scale divisions (n) - systems used to weigh commodities other than grain UR.1.2. (1/1/87)
Installation ..... G-UR.2.1.
Obstructions between indicating/recording element and weighing element ..... G-UR.2.2.
Protection from environmental factors ..... UR.2.1.
Foundation, supports, and clearance ..... UR.2.2.
Weighing sequence ..... S.1.4.
Recording sequence ..... S.1.5.
Provisions for sealing ..... G-S.8. (1/1/90), G-UR.4.5., S.1.6.
Verification (testing) standards ..... N.2.

4. Marking
a) General Code marking requirements – applicable to all equipment except as noted in G-S.1.
Identification ..... G-S.1.
Name, initials, or trademark of manufacturer or distributor ..... Retroactive
Model identifier ..... Retroactive
Model identifier prefix ..... (1/1/03)
Acceptable abbreviations for "model" and "number" ..... (1/1/03)
Nonrepetitive serial number ..... (1/1/68)
Serial number prefix ..... (1/1/86)
Acceptable abbreviations for "serial" and "number" ..... (1/1/01)

Current software version or revision identifier (for not-built-for-purpose, software based devices) ..... (1/1/04)
Version or revision identifier preface and acceptable abbreviations for the "version", "revision", and "number" ..... (1/1/07)
NTEP CC number or CC addendum number and prefix (for devices that have an NTEP CC) ..... (1/1/03)
Location of marking information for not built-for-purpose, software-based devices G-S.1.1. (1/1/04)
Remanufacturer information, as appropriate ..... G-S.1.2.
Name, initials, or trademark of the last remanufacturer or distributor ..... (1/1/02)
Model designation if different from original model designation ..... (1/1/02)
Lettering ..... G-S.7.
Operational controls, indications, and features ..... G-S.6.(1/1/77)
Visibility of identification ..... G-UR.2.1.1.
Interchange or reversal of parts ..... G-S.4.

Inspection (cont.):

b) ABWS Code marking requirements - (in addition to General Code marking requirements)
Capacity and value of the scale division ..... S.5.1.
Temperature limits (unless the temperature range is -10 ^{0}C to 40 ^{0}C (14 ^{0}F to 104 ^{0}F) S.5.3 (1/1/86)
Accuracy class[2] S.5.4. (1/1/86)

[1] An automatic zero-setting mechanism is a prohibited feature on an automatic bulk weighing system.

weighing elements ..... S.5.2.

In addition to the marking requirements outlined in 4 a) and 4 b) of this EPO, the main elements (i.e., the indicating element, weighing element, and load cells) of an ABWS, when not contained in a single enclosure for the entire scale, shall be marked in accordance with Scales Code Table S.6.3.a and explained in the accompanying notes S.6.3.b. except when such marking conflicts with that required by the ABWS Code. In all cases of conflict, the marking requirements contained in the ABWS Code, which are outlined in their entirety in 4 b) of this EPO, supersede those in the Scales Code. The Scales Code marking requirements applicable to the separable main elements of a scale are outlined in c) through e) below.

H-44 Scales Code References (Required Markings for Separable Main Elements)

c) Scales Code marking requirements – applicable to indicating element not permanently attached to weighing and load-receiving element or covered by a separate CC ..... Table S.6.3.a.
- Accuracy Class ..... (1/1/86)
- Nominal Capacity ..... Retroactive
- Value of Scale Division ..... (1/1/83)
- Value of the verification scale division (e) if different than the value of the scale division (d) ..... (1/1/86)
- Special application ..... (1/1/86)
- Maximum number of scale divisions (n_{max}) ..... (1/1/88)

d) Scales Code marking requirements – applicable to weighing and load-receiving element not permanently attached to an indicating element or covered by a separate CC ..... Table S.6.3.a.
- Accuracy class ..... (1/1/88)
- Nominal capacity ..... Retroactive
- Temperature limits (if range on the NTEP CC is narrower than and within -10 ^{0}C to 40 ^{0}C (14 ^{0}F to 104 ^{0}F) ..... (1/1/86)
- Special application ..... (1/1/86)
- Maximum number of scale divisions (n_{max}) ..... (1/1/88)

- Minimum verification scale division for which device complies with the requirements (e_{min} or d) ..... (1/1/88)

e) Scales Code marking requirements – applicable to load cell with Certificate of Conformance ..... Table S.6.3.a.

Note: Requires information on a data plate attached to the load cell or in an accompanying document. If a document is provided, the serial number shall appear on the load cell and in the document ..... (1/1/88)
- Manufacturer's name or trademark, model designation, and identifying symbols for the model and serial numbers as required by paragraph G-S.1. shall also be marked on both the load cell and in any accompanying documents ..... (1/1/91)
- Accuracy class ..... (1/1/88)

Inspection (cont.):

- Temperature limits (if range on the NTEP CC is narrower than and within -10 ^{0}C to 40 ^{0}C (14 ^{0}F to 104 ^{0}F) ..... (1/1/86)
- "S" or "M" for single or multiple cell applications ..... (1/1/88)
- Direction of loading, if not obvious ..... (1/1/88)
- Minimum dead load, maximum capacity, safe load limit, and load cell

[2] Systems manufactured as of January 1, 1986 that are used to weigh grain shall be marked Class III. Systems used to weigh materials other than grain manufactured as of January 1, 1986 are permitted to be marked either Class III or Class III L.

verification interval, v_{min} ..... (1/1/88)

H-44 General Code and ABWS Code References

5. Indicating and Recording Elements
   - Appropriateness of design ..... G-S.5., (except G-S.5.2.1.)
   - Value of the scale division (d) S.1.2. (1/1/86)
   - Digital rounding ..... G-S.5.2.2.(c)

6. Weighing Elements
   - Antifriction ..... S.4.1.
   - Adjustable components ..... S.4.2.
   - Multiple load-receiving elements ..... S.4.3.
   - Venting ..... S.4.4.

7. Interlocks and Gate Control
   - Interlocks ..... S.3.2.
     - Overfill Sensor ..... S.3.3. (a)
       - Systems equipped with a lower garner or surge bin ..... S.3.3. (b) (1/1/98)
   - Gate position ..... S.3.1.

8. Maintenance, Use, and Environmental Factors
   - Facilitation of fraud ..... G-S.2.
   - Operation ..... G-UR.3.1.
   - Position of equipment ..... G-UR.3.3.
   - Maintenance of equipment ..... G-UR.4.1.
   - Abnormal performance ..... G-UR.4.2.
   - Use of adjustments ..... G-UR.4.3.
   - Loading requirements
     - Minimum draft (systems used to weigh grain) ..... UR.3.1.
     - Minimum draft (systems used to weigh commodities other than grain) UR.3.2. (1/1/87)
   - System modification ..... UR.4.

9. Assistance in testing ..... G-UR.4.4.

Pretest Determinations

Each application of an ABWS is unique with its own special capacity requirements, location specifications, types of material handled, environmental conditions, etc. Consequently, each ABWS is usually custom-designed to some extent by the manufacturer to conform to a purchaser's particular application, thus, resulting in each installation being somewhat different from the next. The variations in design present some obstacles to overcome by those responsible for testing these devices. Most ABWS's require the use of special equipment and the need for special assistance in order to conduct a performance test. An on-site visit prior to scheduling an official test of an ABWS is recommended in order to determine the best means of conducting the test, verifying the availability of any special equipment that might be needed for testing, and make known to the owner or operator any special assistance that will likely be needed on the scheduled date of test.

1. Select the appropriate test method to apply when conducting the increasing-load test after reviewing the various test method descriptions outlined in Appendix A of this EPO ..... N.1.2.

   Automatic bulk weighing systems shall be tested to <u>at least used capacity</u>, (i.e. the maximum single-draft load weighed during commercial operation) by performing an increasing-load test using a combination of test weights and bulk material.[3] For initial verifications, it is recommended that ABWS's be tested to <u>scale capacity</u> providing it is practical and safe to do so.

   If substitution or strain-load tests are to be performed, verify there is a sufficient amount of bulk material available on site to enable testing to the desired test-load amount.

2. Minimum test weights ..... N.1.1.

   To minimize uncertainty in the test results, it is recommended that a greater amount of test weights than the minimum required by ABWS Code paragraph N.1.1. be used during testing providing they are available and can be applied safely to the load-receiving element in a manner that does not produce binding or off-center loading.[4] Ideally, when the increasing-load test is to be performed using substitution or strain-load test methods, test weights in amount of at least 25% of scale capacity should be used. Thus, when applying the substitution test method, not more than 3 substitutions plus the addition of the test weights will be needed to achieve a maximum test load equal to scale capacity. For strain-load tests, use of the additional test weights (i.e., in an amount totaling at least 25% of scale capacity) provides necessary verification over a sufficient weighing range of the scale to assure that any errors revealed during testing reflect inaccuracy in the performance of the scale.

   For additional information on substitution and strain-load testing, refer to Appendix A and Appendix B of this EPO.

Pretest Determinations (cont.):

[3] Although not mentioned in paragraph N.1.2. of the ABWS Code, test weight alone may also be used to perform the increasing-load test (i.e., providing it can be applied safely and distributed evenly onto the weighing element) and provides the least amount of uncertainty in test results.

[4] The performance test of an ABWS to used capacity (or scale capacity, as the case may be) commonly involves the use of one or more substitution test loads and/or strain-loads. Several factors limit the accuracy of many repeated substitution or strain-load tests. Some of these factors are creep, change in zero balance, environmental conditions that might exist during testing, etc. Using a greater amount of test weight than the minimum required reduces the number of substitution test loads and/or strain loads necessary to achieve maximum test load and also reduces the amount of uncertainty in test results.

3. Verify the availability of any special equipment or accessories that will be needed to perform the test. If hooks, chains, cables, etc. are to be used to suspend test weights from the load-receiving element, ensure that such equipment is of sufficient strength to safely withstand the force of all loads to be applied during testing and that the position of such equipment after attachment facilitates the even distribution of test weights to be applied. ..... G-UR.4.4.

4. Tolerance application ..... T.1.
   - Acceptance/maintenance ..... G-T.1., G-T.2.
   - Errors of underregistration and overregistration ..... G-T.3., T.1.1.
   - Intermediate values ..... G-T.4.
   - Increasing-load tests ..... T.1.2.
     - For substitution tests, tolerances apply equally to the substitution test load and test weights
     - For strain-load tests, tolerances apply only to the test weights or substitution test loads
   - Decreasing-load tests (required on devices used to weigh out) ..... T.1.3.

5. Tolerance values
   - Tests involving digital indications or representations ..... T.1.4.
   - Minimum tolerance ..... T.2.
     - Minimum tolerance for systems used to weigh construction materials ..... T.2.1.
   - Basic acceptance tolerance ..... T.3.1.
   - Basic maintenance tolerance
     - Systems used to weigh grain ..... T.3.2.
     - Systems used to weigh commodities other than grain ..... T.3.3.
   - Repeatability ..... T.5.

6. Verify that the system operator has a clear indication of the position of the gates leading directly to and from the weigh hopper ..... S.3.1.

7. Discrimination – digital automatic indicating scales ..... T.6.

8. Perform a visual inspection of the weighing and load-receiving element:

   a) Verify that the lever system or load cells, the load-receiving element, and any permanently installed test weights are adequately protected from environmental factors, such as wind, weather, and RFI. If permanently installed test weights are available, confirm they are being properly maintained, are of suitable condition for use in testing (e.g., clean, free of a significant amount of surface rust, etc.) and that the date of last certification complies with any jurisdictional policy concerning certification frequency, if one exists ..... UR.2.1.

   b) Confirm there is adequate clearance provided around all live parts to the extent that no contacts may result before or during operation of the system. If the load-receiving element is a hopper, pay particular attention to the clearance around the hopper and any fill, vent, or discharge mechanism(s) or any housing surrounding the hopper, if the hopper is enclosed. Also, confirm that any accessory equipment, whether permanently or temporarily installed, is positioned correctly and fastened securely such that the position of the equipment cannot shift to the extent that contacts may result before or during operation of the system. ..... UR.2.2.

Pretest Determinations (cont.):

c) Verify the relationship of the load cell verification interval value to the value of the scale division ..... Scales Code References S.5.4. (1/1/94) and T.N. 8.1*

The value of v_{min} marked on the load cell(s) is used to determine compliance with T.N.8.1. of the Scales Code. To be considered compliant, the value of v_{min} marked on the load cell must be less than or equal to the value of the scale division (d) divided by the square root of the number of load cells used in the scale (for full electronic scales). For scales with lever systems v_{min} must be less than or equal to the value of (d) divided by the square root of the number of load cells used in the system times the value of the scale multiple. The formulas for both full electronic scales and those with lever systems may be stated as follows:

a) $v_{min} \leq \frac{d}{\sqrt{N}}$ *for full electronic scales*

b) $v_{min} \leq \frac{d}{\sqrt{N}\, x\, (scale\ multiple)}$ *for scales with a lever system*

9. Verify that the weighing system is equipped with adequate venting and if venting exhausts to the outside atmosphere ensure there are no obstructions in the vent ducts or their protective covers or screens which could restrict air flow. If venting is facilitated by air aspiration, open an inspection door, if possible, to verify movement of air (suction or exhaust) with system in operation..... S.4.4.

10. Inspect several recently completed scale tickets, including tickets completed at different dates and by different device users, if possible. Verify each of the following:

- each recorded gross weight value (except the final partial draft) on a ticket, representing the gross weight of a single draft load, exceeds the minimum permissible draft size.
  - Minimum draft size (systems used to weigh grain) ..... UR.3.1.
  - Minimum draft size (systems used to weigh commodities other than grain)..... UR.3.2. (01/01/87)
- all values recorded are properly identified (e.g., gross, tare, net, lb, kg, etc),
  - Values defined ..... G-S.5.2.4., G-S.5.2.5.
- the total weight recorded on each ticket representing the entire bulk load is equal to the result of subtracting the sum of all corresponding individual draft tare values from the sum of all the individual draft gross weights that are recorded on the same ticket for same complete bulk load.
  - Indicating and recording elements (General) G-S.5.1

Test Notes

1. Verify correct weighing and recording sequence ..... S.1.4.
   - If the system is used to receive (weigh in), the no-load reference value shall be determined and recorded only at the beginning of each weighing cycle.
   - If the system is used to deliver (weigh out), the no-load reference value shall be determined and recorded only at the end of each weighing cycle.

2. Observe the automatic operation of the device and verify that at the start and end of each weigh cycle in automatic mode, tare and gross weight values are displayed until such time that each is recorded. ..... S.1.5.

3. Verify that an interlock provides for each of the following (if practical): ..... S.3.2.

   - Product cannot be cycled and weighed if the recording element is disconnected or subjected to a power loss.
   - The recording element cannot print a weight if either of the gates leading directly to or from the weigh hopper is open.
   - A "low paper" sensor, when provided, is activated.
   - The system operates only in the proper sequence in all modes of operation.
   - When an overfill alarm is activated, the system indicates and records an overfill condition.

4. Verify the weigh hopper is equipped with an overfill sensor, which when activated, causes each of the following to occur: ..... S.3.3.(a)
   - The feed gate to close
   - An alarm to activate
   - Weighing to be inhibited until the overfill condition has been corrected

5. If system is equipped with a lower garner or surge bin, verify that it too is equipped with an overfill sensor, which when activated, causes each of the following to occur: ..... S.3.3.(b) (01/01/98)
   - The gate of the weigh hopper to remain open
   - An alarm to activate
   - Weighing to be inhibited until the overfill condition has been corrected

6. Check repeatability of, and agreement between, indications throughout test ..... G-S.5.2.2.(a), G-S.5.2.2.(b), G-S.5.4.

7. Print a ticket at each test load comparing the value indicated with the value recorded. ..... G-S.5.2.2.

8. Recheck zero-load balance or no-load reference each time test load is removed ..... N.1.4.

9. Verify the effectiveness of motion detect
   a. Semi-automatic zero setting mechanism (if so equipped) ..... S.2.1.2.
   b. Recording element ..... S.2.2.

   Note: Indications should not oscillate significantly or update slowly to the extent that erroneous values can be recorded by the printer during any weighing operation.

Test

1. Discrimination test at zero load (to be performed when results will not be affected by environmental conditions) N.1.5. (01/01/86)

2. Increasing-load test (apply multiple test loads to achieve a maximum test load equal to at least used capacity of the system using the appropriate test method that was selected from the "Pretest" section of this EPO ..... N.1.1., N.1.2.

   Note: To reduce the amount of uncertainty in test results, error weights denominated in 0.1 d must be used whenever the increasing-load test is performed using substitution or strain-load test methods on an ABWS with digital indication. Detailed instructions on using error weights to perform the increasing load test using substitution or strain-load test methods are located in Appendix B of this EPO.

3. Discrimination test at maximum test load (to be performed when results will not be affected by environmental conditions) N.1.5. (01/01/86)

3. Over-capacity test (if practical) ..... S.1.3.

4. Decreasing-load test (systems used to weigh-out) ..... N.1.3.

5. Zero balance or no-load reference value change ..... N.1.4.

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Appendix A

Description of Test Methods

The Automatic Bulk Weighing Systems (ABWS) code of NIST Handbook 44 requires an increasing-load test to be performed up to the used capacity of the weighing system. It also requires the test be performed using test weights equal to at least 10 percent of the capacity of the system:

- on any automatic bulk-weighing systems installed after January 1, 1984 that's used to weigh grain, and
- all automatic bulk weighing systems installed after January 1, 1986, regardless of the type of product weighed.

Considering that only 10 percent of the capacity of a system in test weight is required and that most systems are typically used to weigh much heavier loads than the amount equivalent to 10 percent of system capacity, the typical increasing-load test performed on an ABWS usually necessitates the use of substitution and/or strain loads to achieve the required maximum test load amount specified. This is not to infer that substitution and/or strain loads are required to enable a proper test of an ABWS, but rather, they are usually necessary in order to achieve the required maximum test load, especially when performing the test using the least amount of test weight required.

As a general rule, it is recommended that the performance test of an ABWS be performed using as much test weight as can safely be applied onto or suspended beneath the load-receiving element of the scale in a manner that does not produce binding or off-center loading or necessitates an abnormal amount of labor. There are a number of significant benefits to using more test weight than the minimum amount required to include:

- faster completion of a test,
- a reduced amount of uncertainty in the test results,
- a reduction in labor associated with testing because fewer substitution test loads and strain loads will be needed, etc.

Recognizing that in some instances it may not be possible to safely apply more test weight than the required minimum amount specified; any one of the following three methods may be used to perform an increasing-load test on an ABWS:

1) ***Increasing-Load Test Using Only Test Weight***
2) ***Increasing-Load Test Using A Combination of Test Weight, Substitution Test Loads, and if needed, One or More Strain Loads***
3) ***Increasing-Load Test Using A Combination of Test Weight and One or More Strain Loads***

Proper selection of the best method to use for testing is dependent upon the amount of test weight available, the ease with which available test weight can be safely and properly applied to the load-receiving element of the scale, and whether substitution testing is appropriate. For substitution testing to be appropriate, the system operator must be able to control the loading of product onto the load-receiving element of the scale to the extent that substitution test loads may be created using bulk material entirely or a combination of bulk material and trim weights.[1]

Thus, the determination of whether or not substitution testing is appropriate is dependent upon how closely an operator is able to duplicate the indication of the test load using bulk material as a substitute. This determination shall be made on a case by case basis by the official conducting the test.

A brief description of each test method is included below and intended to serve as a guide for selecting the most appropriate method for testing automatic bulk weighing systems. Some procedures referenced in the descriptions are more fully explained in other appendices included with this EPO. Those appendices should be consulted when performing those procedures to ensure proper application.

Method 1: Increasing-load Test Using Only Test Weight: *This test method should be used whenever test weight in an amount equal to the maximum test load desired for a complete test (i.e., typically to scale capacity or used capacity) is available and can be safely applied onto or suspended beneath the load-receiving element of the scale in a manner that does not produce binding or off-center loading nor necessitate an abnormal amount of labor.*

Test at multiple points from zero-load to at least used capacity, including at least one point in each 1/3rd capacity range of the system. If preset values have been programmed into the system to control the amount of product comprised of an individual draft load for one or more commodities typically weighed, include a test at the lowest preset value or at least one point below and as close as practical to the lowest preset value and a test at the highest preset value or at least one point above and as close as practical to the highest preset value. If only one preset value has been programmed, test at that preset value or at least one point above and as close as practical to that value.

[1] When creating any new substitution test load from bulk material that has been loaded onto the load-receiving element of a scale, small amounts of weight, known as "trim weights," sometimes need to be applied to increase the weight of the substitution test load being created so that its displayed indication either:

- matches that of the previous test load for which it is intended to substitute, if using exact substitutions, or
- brought to within 5 divisions less than the indicated weight of the previous test load for which it is intended to substitute, if not using exact substitutions.

The use of exact substitutions and substitutions that are not exact during testing are fully explained in Appendix B of this EPO and its supplements.

Method 2: Increasing-load Test Using a Combination of Test Weight, Substitution Test Loads, and One or More Strain Loads (If Needed)*: This test method should be used in all instances in which the total value of the test weights to be applied during testing is less than the maximum test load desired for a complete test (i.e., typically to scale capacity or used capacity) and it has been determined that substitution testing can be performed. When using this test method, error weights must be used to:*

- *establish a starting reference at no load and at each of the starting references from which test weights are applied to substituted material (and strain loads, if used during testing),*
- *determine the precise amount of error at all applied test loads, and*
- *determine the amount of any no-load change once all test loads have been removed from the load-receiving element of the scale.*

All test weights and test loads applied during testing shall be distributed equally onto or suspended from the load-receiving element in a manner that does not produce binding or off-center loading.

Test at multiple points from zero-load to at least used capacity, including not less than one point in each 1/3rd capacity range of the system using test loads consisting of test weight and a combination of test weight and substituted bulk material. If preset values have been programmed into the system to control the amount of product comprised of an individual draft load for one or more commodities typically weighed, include a test at the lowest preset value or at least one point below and as close as practical to the lowest preset value and a test at the highest preset value or at least one point above and as close as practical to the highest preset value. If only one preset value has been programmed, test at that preset value or at least one point above and as close as practical to that preset value.

Note: This EPO recognizes two types of acceptable substitution test loads; those that are exact (which are used with the test method referred to in this EPO as the "Substitution Test Method") and those that are not (which are used with the test method referred to in this EPO as the "Alternative Substitution Test Method"). Both types are described more fully in Appendix B of this EPO and its supplements.

In consideration of both types, in order to qualify as a substitution test load, the weight of the load created for substitution must either:

- precisely match the weight of the test load for which it is intended to substitute (for exact substitution test loads), or
- weigh slightly less (i.e., weigh not more than 5 divisions less) than the indicated value of the test load for which it is intended to substitute after any trim weights have been applied (for substitution test loads that are not exact).

The procedures used to create each type of substitution test load during testing are

somewhat different as are the test procedures to be applied when using them to conduct an increasing-load test. One significant difference in the two types of substitution test methods is the means by which scale error is determined (or measured). For example:

- When using exact substitution test loads (substitution test method), scale error is determined for a series of test loads applied in an increasing manner from the same starting reference. No more than three substitution test loads may be developed from a particular starting reference in order to minimize the effect of scale creep (or drift), which can result when applied loads are left remaining on a scale for long periods of time; in this case, the time required to develop the substitution test loads and perform the tests. Consequently, depending upon the amount of test weight available for testing, it is sometimes necessary to use one or more strain loads to be able to verify performance of a scale in its upper weighing range, e.g., in its range of use, nominal scale capacity, etc.

- When using substitution test loads that are not exact (alternative test method), each substitution test load becomes the starting reference for the next applied test weight load. Thus, scale error is determined (or measured) from a new starting reference each time the test weight is applied (i.e., for each segment of the test). Creep (or drift) is usually not an issue because the time typically required to develop the substitution load and apply the test weight is of short duration. Consequently, the alternative test procedure can be applied in as many steps as needed to achieve a test to scale capacity (e.g., as many as nine substitution test loads may be used to test an ABWS if using test weight equal to only ten percent of scale capacity, etc.,), and strain loads are <u>not</u> needed.

Due to the differences in these procedures, it is recommended that either method be selected and used throughout the entire test of an ABWS.

For step by step instructions on performing an increasing-load test using substitution test loads refer to:

- Appendix B High-Level Steps to Performing the Increasing-Load Test Using the Substitution <u>or</u> Alternative Substitution Test Method; and
- Appendix B (Supplement 1) Applying the High-Level Steps of the Substitution <u>and</u> Alternative Substitution Test Method

To view recorded results (with descriptive notations included) of a hypothetical increasing-load test performed using exact substitution test loads, refer to Appendix B (Supplement 2) of this EPO.

To view recorded results (with descriptive notations included) of a hypothetical increasing-load test performed using substitution test loads that are not exact, refer to Appendix B (Supplement 3) of this EPO.

Method 3: Increasing-load Test Using a Combination of Test Weight and One or More Strain-loads*: This method should be used when the amount of test weight to be applied during testing is less than the maximum test load desired for a complete test (i.e., typically to scale capacity or used capacity) and it has been determined that substitution testing can not be performed with reasonable ease. It is recommended that when using this method, test weight of at least 25% of scale capacity be used to assure that errors disclosed during testing reflect inaccuracy in the performance of the scale. Ideally, a scale should be tested from a no-load reference to at least 25% of scale capacity using test weights entirely and that same amount of test weight should then be applied to one or more strain loads such that the scale's performance is tested over its entire range of use. To minimize the amount of uncertainty in test results, error weights must be used to establish all starting reference points from which to apply the test weights during testing and to determine the precise amount of error in the scale at all test loads.[2] All test weights and test loads shall be distributed equally onto or suspended from the load-receiving element in a manner that does not produce binding or off-center loading.*

Test at multiple points from a zero-load reference to at least used capacity, including not less than one point in each 1/3rd capacity range of the system using test weight and strain-load test methods. If preset values have been programmed into the system to control the amount of product comprised of an individual draft load for one or more commodities typically weighed, include testing at a point that is within 5% of the value of system capacity below the lowest programmed preset value and at a point that is within 5% of the value of system capacity above the highest programmed preset value. If only one preset value has been programmed, test at a point that is within 5% of the value of system capacity above that preset value. For strain-load tests, tolerances apply only to the known test load portion of the applied load.

[2] Although titled "High-Level Steps to Performing the Increasing-Load Test Using the Substitution or Alternative Substitution Test Method," high-level steps 1 through 3 of Appendix B and the detailed instructions corresponding to these steps provided in Appendix B (Supplement 1) explain how to properly use error weights to establish a proper starting reference and determine scale error when testing a scale with digital indication. Thus, in addition to these instructions applying to the substitution and alternative substitution test methods, they also apply to the strain-load method (i.e., Method 3) of testing an ABWS.

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Appendix B

High-Level Steps to Performing the Increasing-Load Test Using the Substitution or Alternative Substitution Test Method

Listed below are the high-level steps necessary to properly perform an increasing-load test on a scale with digital indication using the substitution or alternative substitution test method. For detailed instructions on how to perform each of these steps refer to Appendix B (Supplement 1) titled "Applying the High-Level Steps of the Substitution and Alternative Substitution Test Method." For additional clarification on determining the amount of scale error and evaluating the results of tests when using the substitution test method, refer to Appendix B (Supplement 2) titled "Determining Scale Error When Applying the Substitution Test Method." For additional clarification on determining the amount of scale error and evaluating the results of tests when using the alternative substitution test method, refer to Appendix B (Supplement 3) titled "Determining Scale Error When Applying the Alternative Substitution Test Method."

Step 1) ***Establish a proper reference at no load****:* With no load on the load-receiving element of the scale, add error weights equal to the value of 0.1 d to establish a proper reference at no load. Make note of the total value of the error weights on the scale; then remove the error weights.

Step 2) ***Apply the test weight and then use error weights to establish a proper reference:*** Apply the first test load consisting entirely of test weight. Then add error weights equal to the value of 0.1 d to adjust the weight of the load so that a proper reference is established between two adjacent increments. Make note of the total value of the error weights on the scale; then remove the error weights.

Step 3) ***Determine the amount of scale error:***
(a) Determine the amount of error in the scale for each test load applied using the error formula:

$$E_n = I_e - I_s - L + R_s - R_e$$

Where:

"E_n" *(Error)* represents the amount of error in the scale relative to the applied test weight portion of the total applied load;

"I_e" *(Indication ending)* represents the scale indication after the test weight has been applied and proper reference established;

"I_s" *(Indication start)* represents the scale indication before the test weight was applied;

"L" *(Load)* represents the value of the applied test weight excluding any substituted load;

"R_s" *(Reference start)* represents the value of the error weights on the load-receiving element that established proper reference prior to the test weight being applied; and

"R_e" *(Reference ending)* represents the value of the error weights on the load-receiving element that established proper reference after the test weight had been applied.

(b) Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Step 4) ***Remove the test weight and determine the amount of any no-load balance change:*** Remove the first test load and add error weights to return to the proper reference at no load. Any difference in error weights from Step 1 represents a change in the no-load balance reference. Discontinue testing if no-load balance is unstable or does not repeat to within the value of minimum tolerance each time a test load is applied and then removed.

If no change has occurred or the amount of change does not exceed minimum tolerance, testing may continue. However, in the latter case it will be necessary to make note of the value of the error weights needed to re-establish proper no-load reference. Once you've made note of the value of the error weights that establishes the no-load reference, remove the error weights from the scale.

Step 5) ***Create the first substitution test load:*** Create the first substitution test load by loading bulk material onto the load-receiving element of the scale.

Substitution Test
Apply trim weights, as necessary, to increase the weight of the first substitution test load to that which was first indicated when the test weight was first applied in Step 2.

Alternative Substitution Test
Apply trim weights, as necessary, to increase the weight of the first substitution test load so that it's indicated weight is slightly less than (i.e., no more than 5 divisions) the value indicated when the test weight was first applied in Step 2.

Then add error weights equal to the value of 0.1 d to establish a proper reference for the first substitution load. Make note of the total value of the error weights on the scale; then remove the error weights.

Step 6) ***Apply test weight to the first substitution test load and use error weights to establish a proper reference:*** Apply the test weight to the first substitution test load. Then add error weights equal to the value of 0.1 d to adjust the weight of the load so that a proper reference is established between two adjacent increments.

Step 7) ***Determine the amount of scale error:*** Determine the amount of error in the scale using the error formula provided in Step 3. Then remove the test weight, all error weights, and any trim weights that were added in Step 5 from the load-receiving element.

Step 8) ***Create the second substitution test load:*** Create the second substitution test load by loading bulk material onto the load-receiving element of the scale.

Substitution Test
Apply trim weights, as necessary; to increase the weight of the second substitution test load to that which was first indicated when the test weight was applied in step 6.

Alternative Substitution Test
Apply trim weights, as necessary, to increase the weight of the second substitution test load so that it's indicated weight is slightly less than (i.e., no more than 5 divisions) the value indicated when the test weight was first applied in Step 6.

Then add error weights equal to the value of 0.1 d to establish a proper reference for the second substituted load. Make note of the total value of the error weights on the scale; then remove the error weights.

Step 9) ***Apply test weight to the second substitution test load and use error weights to establish a proper reference:*** Apply the test weight to the second substitution test load. Then add error weights equal to the value of 0.1 d to adjust the weight of the load so that a proper reference is established between two adjacent increments.

Step 10) ***Determine the amount of scale error:*** Determine the amount of error in the scale with the test load applied using the error formula indicated in Step 3. Then remove the test weight, all error weights, and any trim weights that were added in Step 8 from the load-receiving element.

Step 11) ***Create the third substitution test load:*** Create the third substitution test load by loading bulk material onto the load-receiving element of the scale.

Substitution Test
Apply trim weights, as necessary; to increase the weight of the third substitution test load to that which was first indicated when the test weight was applied in step 9.

Alternative Substitution Test
Apply trim weights, as necessary, to increase the weight of the third substitution test load so that it's indicated weight is slightly less than (i.e., no more than 5 divisions) the value indicated when the test weight was first applied in Step 9.

Then add error weights equal to the value of 0.1 d to establish a proper reference for the third substituted load. Make note of the total value of the error weights on the scale; then remove the error weights.

Step 12) ***Apply test weight to the third substitution test load and use error weights to establish a proper reference:*** Apply the test weight to the third substitution test load. Then add error weights equal to the value of 0.1 d to adjust the weight of the load so that a proper reference is established between two adjacent increments.

Step 13) ***Determine the amount of scale error:*** Determine the amount of error in the scale using the error formula indicated in Step 3.

Substitution Test
Note: If after completion of three substitutions from the no-load reference, additional test loads are still needed to make possible a test to at least used capacity, it will be necessary to use a strain load to increase the loading of the scale to the appropriate area where additional testing is needed. Once the strain load has been created and proper reference established for the load, up to three substitution test loads can be created from that strain load using the same procedures outlined in this appendix.

Alternative Substitution Test
Note: If after completion of three substitutions from the no-load reference, additional test loads are still needed to make possible a test to at least used capacity, continue applying these same procedures, using as many additional substitution test loads as are needed, to complete the test.

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Appendix B (Supplement 1)

Applying the High-Level Steps of the Substitution and Alternative Substitution Test Method

This supplement to Appendix B provides detailed instructions on how to apply each of the high level steps necessary to perform a proper increasing-load test on a scale with digital indication using the substitution or alternative substitution test method. The procedures contained in this supplement are intended to be applied in the order that they appear.

Establishing a proper reference at no-load (high-level step 1)

a. At no load, apply error weights to the load-receiving element in increments equal to 0.1 d until the displayed indication just begins to flicker to the next higher increment. If the displayed indication is already flickering before adding any error weights, it will be necessary to add enough error weights in increments equal to 0.1 d to go beyond the existing zone of uncertainty to a point just above the lower edge of the next higher one.
b. Remove an error weight equal to 0.1 d from the load-receiving element to confirm that the indication returns to a constant display of the lower increment. If the indication returns to a constant display of the lower increment when the 0.1 d is removed, add back 0.1 d to cause the indication to once again flicker to the next higher increment. **A proper reference is established when the indication is flickering between two consecutive increments and removal of an error weight equal to 0.1 d from the load-receiving element causes the constant display of the lower increment.** Thus, the proper reference to establish is a point just above the lower edge of the zone of uncertainty between two consecutive scale increments. The illustration on the next page depicts the area within the zone of uncertainty where the proper reference should be established.
c. Once a proper reference at no-load has been established, record the values of the two increments that are flickering and the total value of error weights on the load-receiving element of the scale; then remove the error weights.

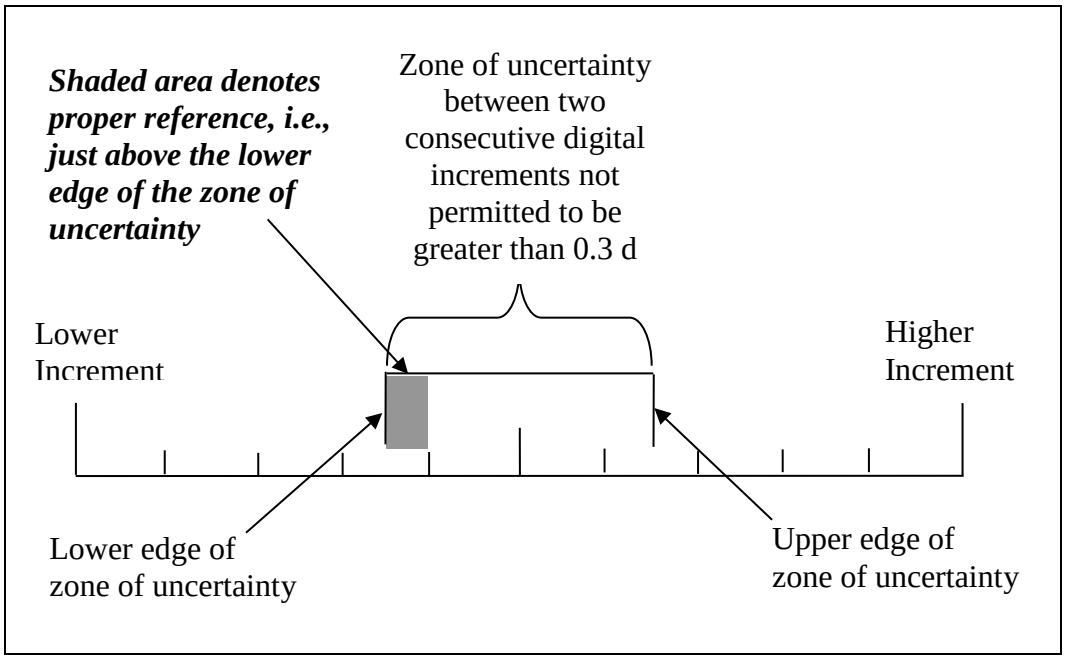

Illustration Depicting Proper Reference

Applying the test weight and establishing proper reference (high-level step 2)

d. Apply the first test load consisting entirely of test weight to the load-receiving element and observe the displayed indication.
e. Add error weights to the load-receiving element in increments equal to 0.1 d to establish a proper reference with the test load applied. For example, if the scale is indicating a constant 3 000 lb after the test weight has been applied, add error weights in increments equal to 0.1 d to establish proper reference at a point just above the lower edge of the zone of uncertainty between 3 000 lb and the next higher increment. Record the total value of the error weights on the scale; then remove the error weights.

Determining the amount of error in the scale at first test load (high-level step 3)

f. Determine the amount of "step" error in the scale at the first test load by inserting the appropriate corresponding values obtained from testing into the following error formula and solving the equation:

$$E_n = I_e - I_s - L + R_s - R_e$$

Where:

"E_n" *(Error)* represents the amount of error in the scale relative to the applied test weight portion of the total applied test load;

"I_e" *(Indication ending)* represents the scale indication after the test weight has been applied and proper reference established;

"I_s" *(Indication start)* represents the scale indication before the test weight was applied;

"L" *(Load)* represents the value of the applied test weight excluding any substituted load;

"R_s" *(Reference start)* represents the value of the error weights on the load-receiving element that established proper reference prior to the test weight being applied; and

"R_e" *(Reference ending)* represents the value of the error weights on the load-receiving element that established proper reference after the test weight had been applied.

Determining appropriate values for "I_e" and "I_s" in the error formula: Because the scale indication flickers between two consecutive increments when proper reference has been established, an average of the two increments should be inserted in the error formula for each of the two components "I_e" and"I_s." For example, if the scale indication at no load is flickering between 10 lb and 20 lb after a proper reference has been established, the average of 10 lb and 20 lb should be determined and inserted in the error formula. The average of 10 and 20 is calculated as follows:

$$\frac{(10+20)}{2} = \frac{30}{2} = 15$$

Thus, the value to be applied in the formula for I_s is 15 lb.

If the scale indication, with a 3 000 lb test load applied, is flickering between 3 010 lb and 3 020 lb after a proper reference has been established, the average of 3 010 and 3 020 is calculated as follows:

$$\frac{(3\,010+3\,020)}{2} = \frac{6\,030}{2} = 3\,015$$

Thus, the value to be applied in the formula for "I_e" should be 3 015 lb.

Applying the Error Formula:
The following example test results, which include references to the different variables in the error formula, are provided to show how error is to be calculated from results of having applied an initial test weight load of 3000 lb to an ABWS equipped with a scale division value equal to 10 lb:

Scale indication at start of the test with no load applied: 10 lb (this value is not used in the error formula but represents the no-load indication of the scale at the start of the test)

Amount of error weight added at no load to achieve proper reference: 6 lb (R_s)

Scale indication at no load and proper reference established: 10 lb flickering 20 lb (I_s = 15 lb and is determined by averaging the two alternating values as explained above in "Determining appropriate values for "I_e" and "I_s" in the error formula")

Amount of test weight applied: 3 000 lb (L)

Scale indication with test load applied: 3 010 lb (this value also is not used in the formula and represents the scale indication after the test weight has first been applied)

Amount of error weight added with test weight applied to achieve proper reference: 9 lb (R_e)

Scale indication with first test load applied and proper reference established: 3 010 lb flickering 3 020 lb (I_e = 3 015 lb and is also determined by averaging the two alternating values as explained above in "Determining appropriate values for "I_e" and "I_s" in the error formula")

To determine the amount of error in the scale at the first test weight load insert the appropriate values from the example steps above into their proper position in the formula and solve as follows:

Error formula: $E_n = I_e - I_s - L + R_s - R_e$

Corresponding values inserted from the example steps:

$$E_n = 3\,015 - 15 \text{ lb} - 3\,000 \text{ lb} + 6 \text{ lb} - 9 \text{ lb}$$

Solve equation to determine amount and direction of scale error at the first test weight load:

$$E_n = -3 \text{ lb}$$

Note: The first two tables included in Appendix B (Supplements 2 and 3) provide indication of how an official might record each of these steps.

Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Verifying return to no-load reference (high-level step 4)

g. Remove the first test load and add error weights on the load-receiving element to reach the no-load reference between the same two consecutive increments made note of in step b. Then subtract the total value of error weights needed to reach the no-load reference from the total value required to establish the initial no-load reference (i.e., the amount made note of in step b.). The result provides the direction and the amount of change in the return to no-load condition. If the amount of change exceeds applicable tolerance, testing should not proceed until the cause of the change has been determined and corrected.

   If no change has occurred or the amount of change does not exceed applicable tolerance, testing may continue. However, in the latter case it will be necessary to make note of the value of the error weights needed to re-establish proper no-load reference. If no change has occurred, the value of the error weights made note of in step b. establishes the no-load reference. Once you've recorded the total value of the error weights that establishes the no-load reference, remove the error weights from the scale.

Creating the first substitution test load (high-level step 5)

h.

Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element in an amount to cause the indicator to display as nearly as possible, but not to exceed, the value that was displayed after the first test load was applied in step d.

At a location on the load-receiving element separate from the error weights, apply trim weights as needed, and in whatever amount necessary, to increase the displayed indication to that which was first indicated when the test weight was applied in step d. Then add error weights to the load-receiving element in increments equal to 0.1 d to establish proper reference between the same two increments as was established in step e. (i.e., the indication flickering between the same two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established between the same two consecutive increments, it can be assumed that the weight of the applied load (i.e., the first substitution test load) is the same as that of the field standard test weight for which it now substitutes. Thus, it can also be assumed that the error in the scale with either load (i.e., the test weight or first substitution load) applied is also the same.

Record the total value of the error weights on the scale; then remove them.

Alternative Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element

in the amount necessary to cause the scale to indicate a value that is within five scale divisions of the value that was displayed after the first test load was applied in step d. **To qualify as a substitution test load, the weight of the bulk material must provide a displayed indication that is slightly less, but in no case more than five divisions less, than the indicated weight of the test load for which it is intended to substitute (i.e., the value indicated in step d.).**

Note: Depending upon how close an operator is able to stop the flow of material onto the load-receiving element relative to the weight targeted (i.e., the value indicated in step d), it may be necessary to add trim weights to increase the weight of the bulk material so that its displayed indication is within five divisions of the target weight.

Add error weights in increments equal to 0.1 d to establish a proper reference (i.e., the indication flickering between two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established, record the values of the two increments that are flickering, as well as the total value of the error weights on the scale; then remove the error weights.

Applying the test weight to the first substitution test load, establishing proper reference, and determining scale error (high-level steps 6 and 7)

i. Reapply the test weight to the load-receiving element of the scale and observe the displayed indication.
j. With the test weight and first substitution test load now applied, add error weights in increments equal to 0.1 d to re-establish a proper reference.
k. Determine the amount of error in the scale with the test weight and first substitution test load applied by inserting the appropriate corresponding values obtained from testing into the following error formula and solving the equation:

$$E_n = I_e - I_s - L + R_s - R_e$$

Note: As per the instructions in step f., an average of the two increments that are flickering should be inserted in the error formula for each of the two components "I_e" and"I_s."

Once the total amount of error has been determined, remove from the load-receiving element the test weight portion of the test load, all error weights, and any trim weights that were previously added.

Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Creating the second substitution test load (high-level step 8)

l.

Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element in an amount to cause the indicator to display as nearly as possible, but not to exceed, the value that was displayed after the test weight was applied in step i.

At a location on the load-receiving element separate from the error weights, apply trim weights as needed, and in whatever amount necessary, to increase the displayed indication to that which was first indicated when the test weight was applied in step i. Then add error weights to the load-receiving element in increments equal to 0.1 d to establish proper reference between the same two increments as was established in step j. (i.e., the indication flickering between the same two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established between the same two consecutive increments, it can be assumed that the weight of the applied load (i.e., the second substitution test load) is the same as that of the combination of test weight and first substitution test load for which it now substitutes. Thus, it can also be assumed that the error in the scale with either test load (i.e., the second substitution test load or the combination of the first substitution test load and test weight) applied is also the same.

Record the total value of the error weights on the scale; then remove them.

Alternative Substitution Test
Instruct the system operator to load bulk material onto the load-receiving element in the amount necessary to cause the scale to indicate a value that is within five scale divisions of the value that was displayed after the first test load was applied in step i. **To qualify as a substitution test load, the weight of the bulk material must provide a displayed indication that is slightly less, but in no case more than five divisions less, than the indicated weight of the test load for which it is intended to substitute (i.e., the value indicated in step i.).**

Note: Depending upon how close an operator is able to stop the flow of material onto the load-receiving element relative to the weight targeted (i.e., the value indicated in step i), it may be necessary to add trim weights to increase the weight of the bulk material so that its displayed indication is within five divisions of the target weight.

Add error weights in increments equal to 0.1 d to establish a proper reference (i.e., the indication flickering between two consecutive increments and the removal of 0.1 d causing a constant display of the lower increment). Once proper reference has been established, record the values of the two increments that are flickering, as well as the total value of the error weights on the scale; then remove the error weights.

Applying the test weight to the second substitution test load, establishing proper reference, and determining scale error (high-level steps 9 and 10)

n. Reapply the test weight to the load-receiving element of the scale and observe the displayed indication.
o. With the test weight and second substitution test load now applied, add error weights in increments equal to 0.1 d to re-establish a proper reference.
p. Determine the amount of error in the scale with the test weight and second substitution test load applied by inserting the appropriate corresponding values obtained from testing into the same error formula provided in the previous steps and solving the equation.

Sum the cumulative errors (ΣE_n) for all steps of the substitutions.

Once the amount of error has been determined, remove from the load-receiving element the test weight portion of the test load, all error weights, and any trim weights that were previously added.

Creating the third substitution test load (high-level step 11)

q. Apply the same procedures that were used to create the second substitution test load to create the third substitution test load except that the weight to be targeted for substitution is that which was first indicated when the test weight was applied in step n.

Applying the test weight to the third substitution test load, establishing proper reference, and determining scale error (high-level steps 12 and 13)

r. Repeat steps n. through step p. replacing the term "second substitution test load" with the term "third substitution test load" to complete the third substitution test and determine the amount of error in the scale using the error formula.

Substitution Test
Note: If after completion of three substitutions from the no-load reference, additional test loads are still needed to make possible a test to at least used capacity, it will be necessary to use a strain load to increase the loading of the scale to the appropriate area where additional testing is needed. Once the strain load has been created and proper reference established for the load, up to three substitution test loads can be created from that strain load using the same procedures outlined in this appendix.

Alternative Substitution Test
Note: If after completion of three substitutions from the no-load reference, additional

test loads are still needed to make possible a test to at least used capacity, continue applying these same procedures, using as many additional substitution test loads as are needed, to complete the test.

EPO No. 16

Appendix B (Supplement 2)

Determining Scale Error When Applying the Substitution Test Method

This supplement is intended to further clarify how scale error is determined from hypothetical results, made up to imitate those that might be recorded by an official who applied the various steps of the substitution test method to perform an increasing-load test on a scale with digital indication. The results of having applied each step of the test are shown with sufficient notation to make clear how the substitution test loads were created and scale error determined from using error weights. Shading is used to differentiate between values associated with the most current step from those of previous steps.

Types of Error:

When using the substitution test method, there are two types of errors you will need to consider:

1) The error associated with each step of the increasing-load test in which test weight is applied from a proper starting reference. These are referred to herein as "step errors." You will see these errors recorded in the column of the example tables titled: "Error (E_n)"
2) The error associated with the cumulative results of one or more steps in which test weight is applied during of the increasing-load test. These errors are referred to herein as "cumulative errors." Cumulative errors are determined by summing the results of consecutive increasing-load steps. You will see these errors recorded in the column of the example tables titled: "Error ($\sum E_n$)"

Tolerance Application:

The tolerances apply to the total cumulative test load for the successive increasing-load tests.

Establish a proper reference at no load (high-level step 1)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			

Apply the test weight, establish proper reference, and determine the total amount of scale error (high level steps 2 and 3)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1

The following formula is used to determine the amount of error (i.e., step error) in the scale at the first applied test weight load:

$$E_n = I_e - I_s - L + R_s - R_e$$

Where:

"E_n" *(Error)* represents the amount of error in the scale relative to the applied test weight portion of the total applied test load;

"I_e" *(Indication ending)* represents the scale indication after the test weight has been applied and proper reference established;

"I_s" *(Indication start)* represents the scale indication before the test weight was applied;

"L" *(Load)* represents the value of the applied test weight excluding any substituted load;

"R_s" *(Reference start)* represents the value of the error weights on the load-receiving element that established proper reference prior to the test weight being applied; and

"R_e" *(Reference ending)* represents the value of the error weights on the load-receiving element that established proper reference after the test weight had been applied.

Thus, from the values recorded in the Table above:

"I_e" is equal to 3 015
"I_s" is equal to 15
"L" is equal to 3 000
"R_s" is equal to 6
"R_e" is equal to 9

To determine the amount of error in the scale, insert the appropriate corresponding values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values (from Table above) inserted into the formula:

$$E_n = 3\,015 - 15 - 3\,000 + 6 - 9$$

Completed formula calculation step 1: Error = - 3

Evaluating the Results:

Since only test weights have been applied thus far during testing, the cumulative results are the same as the error for Step 1.

Verify return to no-load reference (high-level step 4)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		

Create the first substitution test load and establish proper reference (high-level step 5)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20	-3	-3	

Apply test weight to first substitution test load, establish proper reference, and determine the total amount of scale error (high-level steps 6 and 7)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20	-3	-3	
Increase	3 000	3 000	5	9	6 010/20	-4	-7	Step 2

To determine the amount of error in the scale corresponding to the test weight portion of the test load (i.e., step error), insert the appropriate values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values from the table above illustrating the results of high-level steps 6 and 7 inserted into the formula:

$$E_n = 6\ 015 - 3\ 015 - 3\ 000 + 5 - 9$$

Completed formula calculation step 2: Error = - 4

Evaluating the Results:

Tolerances apply to the cumulative results of the first two increasing-load steps which is - 7 pounds.

In order for the example scale to meet applicable tolerances the cumulative results (error) of the two increasing-load steps completed thus far, must also be within tolerance. That is, the sum of the error recorded in each of the increasing-load steps completed thus far in relation to the sum of the test weight applied in each of those same steps must be within tolerance. In the two increasing-load steps completed thus far, the cumulative error is - 7 pounds and the sum of the test weight applied is 6 000 pounds.

Create the second substitution test load and establish proper reference (high-level step 8)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20		-3	
Increase	3 000	3 000	5	9	6 010/20	-4	-7	Step 2
2nd Sub.		6 000		3	6 010/20		-7	

Apply test weight to the second substitution test load, establish proper reference, and determine the total amount of scale error (high-level steps 9 and 10)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20		-3	
Increase	3 000	3 000	5	9	6 010/20	-4	-7	Step 2
2nd Sub.		6 000		3	6 010/20		-7	
Increase	3 000	6 000	3	4	9 000/10	-11	-18	Step 3

To determine the amount of error in the scale corresponding to the test weight portion of the test load (i.e., step error), insert the appropriate corresponding values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values from the table above illustrating the results of high-level steps 9 and 10 inserted into the formula:

$$E_n = 9\,005 - 6\,015 - 3\,000 + 3 - 4$$

Completed formula calculation step 3: Error = - 11

Evaluating the Results:

> Tolerances apply to the error corresponding to the cumulative results of having applied the test weight three times (i.e., once in each of the three consecutive increasing-load steps). The cumulative error corresponding to the three increasing-load steps completed thus far is - 18 pounds.

In order for the example scale to meet applicable tolerances the cumulative results (errors) of all increasing-load steps completed thus far, must also be within tolerance. That is, the sum of the error recorded in each of the increasing-load steps completed thus far in relation to the sum of the test weight applied in each of those same steps must be within tolerance. In the three increasing-load steps completed thus far, the cumulative error is - 18 pounds and the sum of the test weight applied in each of those same steps is 9 000 pounds.

Create the third substitution test load and establish proper reference (high-level step 11)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20		-3	
Increase	3 000	3 000	5	9	6 010/20	-4	-7	Step 2
2nd Sub.		6 000		3	6 010/20		-7	
Increase	3 000	6 000	3	4	9 000/10	-11	-18	Step 3
3rd Sub.		9 000		7	9 000/10		-18	

Apply the test weight to the third substitution load, establish proper reference, and determine the total amount of scale error (high-level steps 12 and 13)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20		-3	
Increase	3 000	3 000	5	9	6 010/20	-4	-7	Step 2
2nd Sub.		6 000		3	6 010/20		-7	
Increase	3 000	6 000	3	4	9 000/10	-11	-18	Step 3
3rd Sub.		9 000		7	9 000/10		-18	
Increase	3 000	9 000	7	5	11 980/90	-18	-36	Step 4

To determine the amount of error in the scale corresponding to the test weight portion of the test load (i.e., step error), insert the appropriate corresponding values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values from the table above illustrating the results of high-level steps 12 and 13 inserted into the formula:

$$E_n = 11\ 985 - 9\ 005 - 3\ 000 + 7 - 5$$

Completed formula calculation step 4: Error = - 18

Evaluating the Results:

> Tolerances apply to the error corresponding to the cumulative results of having applied the test weight four times (i.e., once in each of the four consecutive increasing-load steps). The cumulative error corresponding to the four increasing-load steps completed thus far is - 36 pounds.

In order for the example scale to meet applicable tolerances the cumulative results (errors) of all increasing-load steps completed thus far, must also be within tolerance. That is, the sum of the error recorded in each individual increasing-load step completed thus far, in relation to the sum of the test weight applied in each of those same steps. In the four increasing-load steps completed thus far, the cumulative error of - 36 pounds and the sum of the test weight applied in each of those same steps is 12 000 pounds.

Additional Testing to Achieve Maximum Test Load (If Necessary)

If maximum test load has not been achieved after the test weights are applied to the third substitution test load, remove the test weight and conduct a strain load to make possible additional testing. Up to three additional substitution tests may be conducted after proper reference has been established at any strain-load. The unshaded portion of the table below shows example results of a single strain-load and two substitution tests that were necessary to achieve a maximum test load to used capacity.

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		3 000		5	3 010/20		-3	
Increase	3 000	3 000	5	9	6 010/20	-4	-7	Step 2
2nd Sub.		6 000		3	6 010/20		-7	
Increase	3 000	6 000	3	4	9 000/10	-11	-18	Step 3
3rd Sub.		9 000		7	9 000/10		-18	
Increase	3 000	9 000	7	5	11 980/90	-18	-36	Step 4
Strain Load				5	18 300/10	N/A	N/A	
	3 000		5	8	21 300/10	-3	-3	Step 1
1st Sub.		3 000		2	21 300/10		-3	
Increase	3 000	3 000	2	6	24 300/10	-4	-7	Step 2
2nd Sub.		6 000		8	24 300/10		-7	
Increase	3 000	6 000	8	8	27 290/00	-10	-17	Step 3

Tolerance application for increasing-load tests conducted from strain loads: With a strain load applied and proper reference established, the scale's indication and the amount of error weight used to establish the proper reference provides a new starting point for additional increasing-load tests. For those additional tests, tolerances apply to the total cumulative test load for successive increasing load tests applied from the strain load, including substitution tests.

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Appendix (Supplement 3)

Determining Scale Error When Applying the Alternative Substitution Test Method

This supplement is intended to further clarify how scale error is determined from hypothetical results, made up to imitate those that might be recorded by an official who applied the various steps of the alternative substitution test method to perform an increasing-load test on a scale with digital indication. The results of having applied each step of the test are shown with sufficient notation to make clear how the substitution test loads were created and scale error determined from using error weights. Shading is used to differentiate between values associated with the most current step from those of previous steps.

Types of Error:

When using the alternative substitution test method, there are two types of errors you will need to consider:

1) The error associated with each step of the increasing-load test in which test weight is applied from a proper starting reference. These are referred to herein as "step errors." You will see these errors recorded in the column of the example tables titled: "Error (E_n)"
2) The error associated with the cumulative results of one or more steps in which test weight is applied during of the increasing-load test. These errors are referred to herein as "cumulative errors." Cumulative errors are determined by summing the results of consecutive increasing-load steps . You will see these errors recorded in the column of the example tables titled: "Error ($\sum E_n$)"

Tolerance Application:

Tolerances apply to both types of error as follows:

1) Step Errors: Tolerances apply to the error corresponding to the test weight portion of each test load applied during the increasing-load test, including test loads comprised of substituted material and test weight.
2) Cumulative Errors: Tolerances apply to the error corresponding to the cumulative results of two or more consecutive increasing-load steps in which test weight is applied from a proper starting reference established at no load and each substitution load therefrom.

Establish a proper reference at no load (high-level step 1)

Test Description	Test Weight	Substituted Bulk	Starting Reference	Ending Reference	Scale Indication	Error (E_n)	Error ($\sum E_n$)	

	(L)	Material	(R_s)	(R_e)	(I_x)			
Zero load	0	0		6	10/20			

Apply the test weight load, establish proper reference, and determine the total amount of scale error (high level steps 2 and 3)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1

The following formula is used to determine the amount of error (i.e., step error) in the scale at the first applied test weight load:

$$E_n = I_e - I_s - L + R_s - R_e$$

Where:

"E_n" *(Error)* represents the amount of error in the scale relative to the applied test weight portion of the total applied test load;

"I_e" *(Indication ending)* represents the scale indication after the test weight has been applied and proper reference established;

"I_s" *(Indication start)* represents the scale indication before the test weight was applied;

"L" *(Load)* represents the value of the applied test weight excluding any substituted load;

"R_s" *(Reference start)* represents the value of the error weights on the load-receiving element that established proper reference prior to the test weight being applied; and

"R_e" *(Reference ending)* represents the value of the error weights on the load-receiving element that established proper reference after the test weight had been applied.

Thus, from the values recorded in the Table above:

"I_e" is equal to 3 015
"I_s" is equal to 15
"L" is equal to 3 000
"R_s" is equal to 6
"R_e" is equal to 9

To determine the amount of error in the scale, insert the appropriate corresponding values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values (from Table above) inserted into the formula:

$$E_n = 3\,015 - 15 - 3\,000 + 6 - 9$$

Completed formula calculation : Error = - 3

Evaluating the Results:

Since only test weights have been applied thus far during testing, the cumulative results are the same as the error for Step 1.

Verify return to no-load reference (high-level step 4)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1*		

* Note from the shaded area that error weight in the amount of 6 pounds was initially balanced in to create proper reference at zero load. However, after the test weights were applied and then removed to verify zero return, 7 pounds of error weight was needed to duplicate proper reference, thus resulting in a - 1 pound balance change.

Create the first substitution test load and establish proper reference (high-level step 5)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		2 980		1	2 980/90			

Apply test weight to first substitution test load, establish proper reference, and determine the total amount of scale error (high-level steps 6 and 7)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		2 980		1	2 980/90			
Increase	3 000	2 985	1	6	5 980/90	-5	-8	Step 2

To determine the amount of error in the scale corresponding to the test weight portion of the test load (i.e., step error), insert the appropriate values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values from the table above illustrating the results of high-level steps 6 and 7 inserted into the formula:

$$E_n = 5\ 985 - 2\ 985 - 3\ 000 + 1 - 6$$

Completed formula calculation : Error = - 5

Evaluating the Results:

Tolerances apply to:

1) the error corresponding to the test weight portion (i.e., 3 000 pounds) of the applied load for this particular increasing-load step; and
2) the error corresponding to the cumulative results of having applied the test weight twice; the first of which, resulted in a - 3 pound error, and the second of which, resulted in a - 5 pound error. Thus, the cumulative error corresponding to the first two increasing-load steps is - 8 pounds.

In order for the example scale to meet applicable tolerances:

1) the result (error) associated with the addition of the test weight in each step of the increasing-load test (identified in the table as "Increase") must be within applicable tolerance in relation to the test weight amount applied in each of those steps; and
2) the cumulative results (error) of the two increasing-load steps completed thus far, must also be within tolerance. That is, the sum of the error recorded in each of the increasing-load steps completed thus far in relation to the sum of the test weight applied in each of those same steps must be within tolerance. In the two increasing-load steps completed thus far, the cumulative error is - 8 pounds and the sum of the test weight applied is 6 000 pounds.

Create the second substitution test load and establish proper reference (high-level tep 8)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		2 980		1	2 980/90			
Increase	3 000	2 985	1	6	5 980/90	-5	-8	Step 2
2nd Sub.		5 950		9	5 950/60			

Apply test weight to the second substitution test load, establish proper reference, and determine the total amount of scale error (high-level steps 9 and 10)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		2 980		1	2 980/90			
Increase	3 000	2 985	1	6	5 980/90	-5	-8	Step 2
2nd Sub.		5 950		9	5 950/60			
Increase	3 000	5 955	9	8	8 950/60	+1	-7	Step 3

To determine the amount of error in the scale corresponding to the test weight portion of the test load (i.e., step error), insert the appropriate corresponding values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values from the table above illustrating the results of high-level steps 9 and 10 inserted into the formula:

$$E_n = 8\,955 - 5\,955 - 3\,000 + 9 - 8$$

Completed formula calculation : Error = + 1

Evaluating the Results:

Tolerances apply to:

1) the error corresponding to the test weight portion (i.e., 3 000 pounds) of the total applied load for this particular step; and
2) the error corresponding to the cumulative results of having applied the test weight three times (i.e., once in each of the three consecutive increasing-load steps). The cumulative error corresponding to the three increasing-load steps completed thus far is - 7 pounds.

In order for the example scale to meet applicable tolerances:

1) the result (error) associated with the addition of the test weight in each step of the increasing-load test (identified in the table as “Increase”) must be within

applicable tolerance in relation to the test weight amount applied in each of those steps; and

2) the cumulative results (errors) of all increasing-load steps completed thus far, must also be within tolerance. That is, the sum of the error recorded in each of the increasing-load steps completed thus far in relation to the sum of the test weight applied in each of those same steps must be within tolerance. In the three increasing-load steps completed thus far, the cumulative error is - 7 pounds and the sum of the test weight applied in each of those same steps is 9 000 pounds.

Create the third substitution test load and establish proper reference (high-level step 11)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		2 980		1	2 980/90			
Increase	3 000	2 985	1	6	5 980/90	-5	-8	Step 2
2nd Sub.		5 950		9	5 950/60			
Increase	3 000	5 955	9	8	8 950/60	+1	-7	Step 3
3rd Sub.		8 950		3	8 950/60			

Apply the test weight to the third substitution load, establish proper reference, and determine the total amount of scale error (high-level steps 12 and 13)

Test Description	Test Weight (L)	Substituted Bulk Material	Starting Reference (R_s)	Ending Reference (R_e)	Scale Indication (I_x)	Error (E_n)	Error ($\sum E_n$)	
Zero load	0	0		6	10/20			
Increase	3 000		6	9	3 010/20	-3	-3	Step 1
Zero Return	0	0	6	7	10/20	-1		
1st Sub.		2 980		1	2 980/90			
Increase	3 000	2 985	1	6	5 980/90	-5	-8	Step 2
2nd Sub.		5 950		9	5 950/60			
Increase	3 000	5 955	9	8	8 950/60	+1	-7	Step 3
3rd Sub.		8 950		3	8 950/60			
Increase	3 000	8 955	3	8	11 950/60	-5	-12	Step 4

To determine the amount of error in the scale corresponding to the test weight portion of the test load (i.e., step error), insert the appropriate corresponding values obtained during testing into the formula and solve the equation as follows:

$$E_n = I_e - I_s - L + R_s - R_e$$

Actual test result values from the table above illustrating the results of high-level steps 12 and 13 inserted into the formula:

$$E_n = 11\,955 - 8\,955 - 3\,000 + 3 - 8$$

Completed formula calculation : Error = - 5

Evaluating the Results:

Tolerances apply to:

1) the error corresponding to the test weight portion (i.e., 3 000 pounds) of the total applied load for this particular step; and
2) the error corresponding to the cumulative results of having applied the test weight four times (i.e., once in each of the four consecutive increasing-load steps). The cumulative error corresponding to the four increasing-load steps completed thus far is - 12 pounds.

In order for the example scale to meet applicable tolerances:

1) the result (error) of each individual step of the increasing-load test (identified in the table as "Increase") must be within applicable tolerance in relation to the test weight amount applied in that particular step; and
2) the cumulative results (errors) of all increasing-load steps completed thus far, must also be within tolerance. That is, the sum of the error recorded in each individual increasing-load step completed thus far, in relation to the sum of the test weight applied in each of those same steps. In the four increasing-load steps completed thus far, the cumulative error of - 12 pounds and the sum of the test weight applied in each of those same steps is 12 000 pounds.

Recording the Results of Additional Testing (If Necessary)

Note: If maximum test load has not been achieved after the test weights are applied to the third substitution test load, it will be necessary to develop additional substitution test loads and apply the test weights to those test loads as many additional times as needed to complete the test. These additional tests are to be performed in the same manner as those before them and the results recorded the same way.

EPO No. 16

Appendix C

Definitions

When using in this EPO, the following terms have the special meaning indicated.

Error weights: Physical standards, typically denominated in increments equal to $1/10^{th}$ or $1/4^{th}$ the value of the minimum scale division (d), that are used to define the indication on a digital scale to a value smaller than the minimum scale division.

Test load: The term "test load" refers to the test weight or a combination of test weight and substituted material of known weight; its mass previously quantified using the scale under test, which is applied to the load-receiving element of an ABWS for the purpose of verifying device accuracy.

Test weight: The term "test weight" refers to physical standards that meet the specifications and tolerances in the NIST 105-1 series standards (or other suitable and designated standards) and are traceable to the reference or working standards through comparisons using acceptable laboratory procedures.

Trim weights: Weight of known or unknown value, which is applied to or removed from the load-receiving element of a scale to increase or decrease the weight of a load being created for substitution to the extent that its displayed indication comes into close enough proximity of the test load for which it is intended to substitute to make possible its final development as a substitution test load.

Note: On occasion, trim weights may also be used to coarsely adjust the weight of a strain load so that its displayed value is one that is more convenient to use in testing. For example, 20 lb of trim weights may be added to the load-receiving element of a scale during testing to change the indicated weight of a strain load from 9980 to 10,000 lb, thus making it easier to calculate applicable tolerances, etc.

Used capacity: The largest load weighed commercially (i.e., for use in a commercial transaction) by any operator of the device.

2015 NIST EPO No. 21

Examination Procedure Outline for

Retail Motor-Fuel Dispensers
Single, Dual, and Multi-Product
(Except Blenders)

It is recommended that this outline be followed as minimum criteria for examining conventional, single and dual product, power-operated retail dispensers --"gasoline pumps," analog or digital, and consoles. This outline may also be used for multi-product dispensers that share a single hose, but not including those that dispense blended products, which are addressed in EPO No. 22. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

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

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment
e.g., safety shoes, safety aprons, gloves, barrier cream, etc. if deemed necessary.

Static Discharge

Safety Cones/Warning Signs

Switch Loading

Traffic

Transportation of Equipment

See Also: Wet/Slick Conditions, Chemicals, Petroleum Products, and Hazardous Materials, Obstructions

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Learn the nature of hazardous products used at, or near, the inspection site.**
- **Obtain and read copies of MSDS's.**
- **Know the emergency procedures and location and operation of fire extinguishers and emergency shut-offs.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use caution when moving in wet, slippery areas.**
- **Open both sides of the dispenser to allow fumes to dissipate before proceeding with the inspection.**
- **If leaks, spills, or exposed wiring cause hazardous testing conditions, it is recommended that the testing be discontinued until the unsafe conditions are corrected.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

Inspection:

	H-44 General Code and Liquid-Measuring Devices Code References
1. Selection	
Selection and Suitability	G-S.3., G-UR.1.1., G-UR.1.2. G-UR.1.3., UR.3.3.
Installation	G-S.2., G-UR.2.1., G-UR.2.2., UR.2.1., UR.2.2., UR.2.4.
Position of Equipment	G-UR.3.3.
Accessibility	G-UR.2.3.
Assistance	G-UR.4.4.
Use and Maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.3.5.
Computing Capability	UR.3.3.
2. Indicating and recording elements	
Design	S.1.1.
Units	S.1.2.1., S.1.2.3.(a), S.1.2.3.(c)
Readability	G-S.5., G-S.6. (1/1/77), G-S.7., S.1.4., S.1.5.
Values of Intervals	G-S.5.3., G-S.5.3.1.

	H-44 General Code and Liquid-Measuring Devices Code References
Inspection (cont.):	
Indication of delivery	S.1.6.1. (portions NR 1/1/06)
Money-value divisions	
Analog	S.1.6.5.1.
Digital	S.1.6.5.2.
Auxiliary indications	S.1.6.5.3. (1/1/85)
Unit Price and product identity	S.1.6.4.1.(a), S.1.6.4.2., UR.3.2., UR.3.3.
Multiple unit price dispensers	S.1.6.4.1.(b) (1/1/91), S.1.6.4.1. (b)(2), S.1.6.5.(a) (1/1/91), S.1.6.5.4.(a) (1/1/91), S.1.6.5.4.(b), UR.3.3.
Quantity and total price display – except aviation refueling	S.1.6.5.5. (1/1/94)
Quantity and total price display – aviation refueling	S.1.6.5.6. (1/1/08)
Advancement and return to zero	S.1.3., S.1.6.3., UR.3.1.
Recorded representations.	
General.	G-S.5.6.
Point of sale systems.	S.1.6.7. (1/1/86)
Post-delivery discounts.	S.1.6.8., UR.3.3.
Provision for sealing	G-S.8. (1/1/90), G-UR.4.5., S.2.2., Table S.2.2. (1/1/95)
Sealing multiple measuring elements with a common provision for sealing	G-S.8.1. (1/1/10)
3. Marking	G-S.1., G-S.1.1.(1/1/04), G-S.1.2. (1/1/02), G-UR.2.1.1., G-UR.3.4., S.4.1., S.4.4.1. (1/1/85), S.4.4.2. (1/1/03)
4. Measuring elements.	
Air eliminator vent, if self-contained dispenser	S.2.1.
Security seal on adjusting mechanism	G-UR.4.5.
5. Discharge hose-retail	S.3.1., S.3.2., S.3.3., S.3.5., S.3.6., S.3.7.

	H-44 General Code and Liquid-Measuring Devices Code References

Inspection (cont.):

Length – General	UR.1.1.1.
Length and Protection – Marinas and Airports	UR.1.1.2.

6. Totalizers S.5. (1/1/95)

Pretest Determinations:

1. Tolerances

Applicable requirements	G-T., T.1.
Basic values	T.2., Table T.2
Repeatability	T.3.

2. Product storage identification ..... UR.2.5.
3. Test Liquid ..... N.1.1.

   Verify that the liquid available for testing is appropriate.
4. Test Draft Size ..... N.3.4.

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from splashed product.**
- **Do not leave an activated dispenser unattended!**
- **Ground the test measure or prover properly and only use a <u>metal</u> funnel when returning product to storage.**

Test Notes:

1. If the test measure or prover is dry, it must be prepared for use by first "wetting" it. To wet the test measure or prover, fill it to capacity and empty it following proper drain procedures.

2. Level the test measure or prover. When the test measure or prover is full of liquid, re-check its level to ensure that the weight of the product has not affected the level condition.

	H-44 General Code and Liquid-Measuring Devices Code References

Pretest Determinations (cont.)

3. Take care to minimize changes in volume of the test liquid due to temperature changes and evaporation losses. ..... N.2.

4. Hand held test measures require a 30 s (± 5 s) pour followed by a 10 s drain, with the measure held at a 10 to15 degree angle from vertical. ..... N.4.4.1.

   Bottom drain provers require a 30 s drain after the main flow ceases. ..... N.4.4.2.

   See NIST HB 105-3, Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, 2010, Section 7.

5. To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. S.5. (1/1/95)

6. After each test draft:

   a. Print a ticket if the device is so equipped and verify required information is provided on the receipt. ..... G-S.5.6., G-S.5.6.1., UR.3.4.

   b. Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy..... G-S.5.6.

   c. For transactions conducted with point-of-sale systems or devices activated by debit cards, credit cards, and/or cash, verify that required information is printed on the receipt. S.1.6.7. (1/1/86)

   d. Verify that required information is on the receipt and that a receipt is provided in applications where post-delivery discounts are offered..... S.1.6.8., UR.3.3.

   e. Check price computations on all indicators (including consoles) and on recorded representations. ..... S.1.6.5.(a) (1/1/91)

      Digital equipment ..... G-S.5.5.

      Analog equipment..... S.1.6.5.(b), Table 1., N.4.3.2.

   f. Check for agreement of quantity values between indicated and recorded representations. ..... G-S.5.2.2.,S.1.6.6.(a)(1), S.1.6.6.(a)(2) (1/1/88), S.1.6.6.(b)

	H-44 General Code and Liquid-Measuring Devices Code References

Test Notes (cont.):

7. Verify, after a delivery is completed, that the quantity and total price are displayed for at least five minutes or until the next transaction is initiated by a customer. ..... S.1.6.5.5. (1/1/94), S.1.6.5.6. (1/1/08) (aviation)

SAFETY REMINDER!!!

- **Use proper lifting techniques when lifting a test measure!!!**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic when moving between dispenser and storage tanks.**
- **Avoid switch loading! Test devices dispensing low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline and ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high-vapor pressure products.**

Test:

1. **Normal Test** – full flow, basic tolerance. ..... N.4.1., T.2., Table T.2

   For this and subsequent Normal Tests, verify that the maximum discharge rate of the installation does not exceed the marked maximum. ..... S.4.4.1. (1/1/85), UR.2.2.

   For this and subsequent tests, verify that other conditions of use do not exceed marked or manufacturer-specified limitations. ..... G-UR.3., S.4.1.

   At the beginning of the first delivery, check for suppressed values. S.1.6.1. (1/1/06)

   For this and subsequent tests, re-check the level of the test measure or prover once it is full of liquid and before reading the indication to ensure that the weight of the product has not affected the level condition.

   If the result of the first test is at or near the tolerance limit, repeat this test. ..... N.4.1.2., T.3.
   If necessary, conduct a Repeatability Test as outlined in Step 3 below.

	H-44 General Code and Liquid-Measuring Devices Code References

Test (cont.):

2. **Special –** slow flow, basic tolerance. ..... N.4.2., N.4.2.2., T.2., Table T.2.

   If the result of the first test is at or near the tolerance limit, repeat this test. If necessary, conduct a Repeatability Test as outlined in Step 3 below. N.4.1.2., T.3.

   Petroleum Product Sampling[1]

3. **Repeatability Test.** ..... N.2., N.3.4., N.4.1.2., T.3.

   If necessary, conduct a repeatability test. A repeatability test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size.

4. **RFI/EMI Test** (electronic equipment only)..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.

   This testing is typically done only if a problem is suspected or during the inspection of a new installation.
   Radio Frequency Interference (RFI)
   Electromagnetic Interference (EMI)

5. **Anti-Drain Test** - Check the effectiveness of the anti-drain means ..... S.3.7.

6. **Zero-Setback Interlock** - Check the effectiveness of the zero-setback interlock..... S.2.5.

   On equipment with remote pumping systems, activate one dispenser and check all others operated by the same pump to make certain they will not operate without activating the individual starting levers.

7. **Power Loss Test**..... S.1.6.2.1. (1/1/83), S.1.6.2.2. (1/1/83)

   Before conducting a power loss test, first check with your supervisor to determine your jurisdiction's policy on the conditions under which this test is to be conducted.

[1] When taking gasoline samples from single hose multi-product dispensers, the samples should be collected either immediately following an observed sale of the particular grade or product to be sampled or after sufficient product has been purged from the hose to ensure the sample is representative of the grade or product being sampled. Guidelines for taking samples for octane verification are found in NIST Handbook 130, "Uniform Laws and Regulations in the Areas of Legal Metrology and Engine Fuel Quality,"Interpretations and Guidelines, Section 2.6.16. Minimum Fuel Flush for Octane Verification, and are stated as follows: **"A minimum of 1.2 L (0.3 gal) of motor fuel shall be flushed from a dispenser before taking a sample for octane verification. The flush shall be returned to the storage tank containing the lowest octane."**

	H-44 General Code and Liquid-Measuring Devices Code References

Post-Test Tasks:

1. **Security Means**
   a. Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed. ..... G-UR.4.5., S.2.2.
   b. Record audit trail information if the device is equipped with an audit trail. ..... S.2.2. (1/1/95), Table S.2.2. (1/1/95)

2. Record the total quantity of product dispensed during testing on the official report.

SAFETY REMINDER!!!

– **Avoid switch loading! Test devices dispensing low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline and ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high-vapor pressure products.**

3. After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. ..... G-UR.4.1., G-UR.4.3.

4. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

SAFETY REMINDER!!!

– **Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.**

2015 NIST EPO No. 22

Examination Procedure Outline for

Retail Motor-Fuel Dispensers
Blended Products

It is recommended that this outline be followed as minimum criteria for examining conventional blended product, power-operated retail dispensers – "gasoline pumps," analog or digital, and consoles. For non-blending single, dual, and multi-product dispensers, see EPO No. 21. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the NIST EPO Safety Annex (Safety Considerations and Glossary of Safety Key Phrases) should be duplicated and included with this outline.

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

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

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location

Safety Data Sheets (SDS)

Nature of Product

Personal Protection Equipment
e.g., safety shoes, safety aprons, gloves, barrier cream, etc. if deemed necessary

Static Discharge

Safety Cones/Warning Signs

Switch Loading

Traffic

Transportation of Equipment

See Also: Wet/Slick Conditions, Chemicals, Petroleum Products, and Hazardous Materials, Obstructions

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Learn the nature of hazardous products used at, or near, the inspection site.**
- **Obtain and read copies of SDS's.**
- **Know the emergency procedures, location, and operation of fire extinguishers and emergency shut-offs.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use caution when moving in wet, slippery areas.**
- **Open both sides of the dispenser to allow fumes to dissipate before proceeding with the inspection of the dispenser.**
- **If leaks, spills, or exposed wiring cause hazardous testing conditions, it is recommended that the testing be discontinued until the unsafe conditions are corrected.**
- **Use personal protection equipment appropriate for the inspection site.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

Inspection:

	H-44 General Code and Liquid-Measuring Devices Code References
1. Selection.	
Selection and Suitability	G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3., UR.3.3.
Installation	G-S.2., G-UR.2.1., G-UR.2.2., UR.2.1., UR.2.2., UR.2.4.
Position of Equipment	G-UR.3.3.
Accessibility	G-UR.2.3.
Assistance	G-UR.4.4.
Use and Maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.3.5.
Computing Capability	UR.3.3.
2. Indicating and recording elements.	
Design	S.1.1.
Units	S.1.2.1., S.1.2.3.(a), S.1.2.3.(c)

	H-44 General Code and Liquid-Measuring Devices Code References

Inspection (cont.):

Readability	G-S.5., G-S.6.(1/1/77), G-S.7., S.1.4., S.1.5.
Values of Intervals	G-S.5.3., G-S.5.3.1.
Indication of delivery	S.1.6.1. (portions NR 1/1/06)
Money-value divisions	
Analog	S.1.6.5.1.
Digital	S.1.6.5.2.
Auxiliary indications	S.1.6.5.3. (1/1/85)
Unit Price and product identity	S.1.6.4.1.(a), S.1.6.4.2., UR.3.2., UR.3.3.
Multiple unit price dispensers	S.1.6.4.1.(b)(1) (1/1/91), S.1.6.4.1.(b)(2), S.1.6.5.(a) (1/1/91), S.1.6.5.4.(a) (1/1/91), S.1.6.5.4.(b), UR.3.3.
Quantity and total price display – except aviation refueling	S.1.6.5.5. (1/1/94)
Quantity and total price display – aviation refueling	S.1.6.5.6. (1/1/08)
Advancement and return to zero	S.1.3., S.1.6.3., UR.3.1.
Recorded representations.	
General.	G-S.5.6.
Point of sale systems.	S.1.6.7. (1/1/86)
Post-delivery discounts.	S.1.6.8., UR.3.3.
Provision for sealing.	G-S.8. (1/1/90), G-UR.4.5., S.2.2., Table S.2.2. (1/1/95)
Sealing multiple measuring elements with a common provision for sealing.	G-S.8.1. (1/1/10)

3. Marking.

General.	G-S.1.
Location, Not-Built-For Purpose, Software-Based Devices	G-S.1.1.(1/1/04)
Devices or Main Elements Remanufactured as of January 1, 2002.	G-S.1.2.
Visibility of required markings after installation.	G-UR.2.1.1.
Location of Marking Information, Retail Motor-Fuel Dispensers.	S.4.4.2. (1/1/03)
Money-Operated Devices, Responsibility.	G-UR.3.4.

	H-44 General Code and Liquid-Measuring Devices Code References

Inspection (cont.):

Limitation on Use.	S.4.1.
Discharge Rates.	S.4.4.1. (1/1/85)
4. Measuring elements.	
Air eliminator vent, if self-contained dispenser.	S.2.1.
Security seal on adjusting mechanism.	G-UR.4.5.
5. Discharge hose-retail.	S.3.1., S.3.2., S.3.3., S.3.5., S.3.6., S.3.7.
Length – General.	U.R.1.1.1.
Length and Protection – Marinas and Airports.	U.R.1.1.2.
6. Totalizers.	S.5. (1/1/95)

Pretest Determinations:

1. Tolerances.	
Applicable requirements.	G-T., T.1.
Basic values.	T.2., Table T.2.
Repeatability.	T.3.
2. Product storage identification.	UR.2.5.
3. Test Liquid.	N.1.1.
Verify that the liquid available for testing is appropriate.	
4. Test Draft Size.	N.3.4.

H-44 General Code and Liquid-Measuring Devices Code References

Pretest Determinations (cont.):

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from splashed product.**
- **Do not leave an activated dispenser unattended!**
- **Ground the test measure or prover properly and only use a metal funnel when returning product to storage.**

Test Notes:

1. If the test measure or prover is dry, it must be prepared for use by first "wetting" it. To wet the test measure or prover, fill it to capacity and empty it following proper drain procedures

2. Level the test measure or prover. When the test measure or prover is full of liquid, re-check its level to ensure that the weight of the product has not affected the level condition.

3. Take care to minimize changes in volume of the test liquid due to temperature changes and evaporation losses. ..... N.2.

4. Hand held test measures require a 30 s ($\pm$ 5 s) pour followed by a 10 s drain, with the measure held at a 10 to 15 degree angle from vertical..... N.4.4.1.

   Bottom drain provers require a 30 s drain after the main flow ceases. ..... N.4.4.2.

   See NIST HB 105-3, Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards," 2010, Section 7.

5. To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. S.5. (1/1/95)

6. After each test draft:
   a. Print a ticket if the device is so equipped and verify required information is provided on the receipt. ..... G-S.5.6., G-S.5.6.1., UR.3.4.

	H-44 General Code and Liquid-Measuring Devices Code References

Test Notes (cont.)

b.	Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy.	G-S.5.6.
c.	For transactions conducted with point-of-sale systems or devices activated by debit cards, credit cards, and/or cash, verify that required information is printed on the receipt.	S.1.6.7. (1/1/86)
d.	Verify that required information is on the receipt and that a receipt is provided in applications where post-delivery discounts are offered.....	S.1.6.8., UR.3.3.
e.	Check price computations on all indicators (including consoles) and on recorded representations.....	S.1.6.5.(a) (1/1/91)
	Digital equipment.....	G-S.5.5.
	Analog equipment.	S.1.6.5.(b), Table 1., N.4.3.2.
f.	Check for agreement of quantity values between indicated and recorded representations.....	G-S.5.2.2., S.1.6.6.(a)(1), S.1.6.6.(a)(2) (1/1/88), S.1.6.6.(b)
7.	Verify, after a delivery is completed, that the quantity and total price are displayed for at least 5 minutes or until the next transaction is initiated by a customer.	S.1.6.5.5. (1/1/94), S.1.6.5.6. (1/1/08) (aviation)

SAFETY REMINDER!!!

- **Use proper lifting techniques when lifting a test measure!!!**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic when moving between dispenser and storage tanks.**
- **Avoid switch loading! Test devices dispensing low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline and ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high-vapor pressure products.**

	H-44 General Code and Liquid-Measuring Devices Code References

Test:

1. Lowest Grade – Normal and Special Tests.

Normal Test, Lowest Grade - Full Flow, Basic Tolerance.

Test with the **lowest grade** product, activating the dispenser such that the lowest grade product is dispensed.	N.2., N.3.4., N.4.1., T.2., Table T.2.
For this and subsequent Normal Tests, verify that the maximum discharge rate of the installation does not exceed the marked maximum.	S.4.4.1. (1/1/85), UR.2.2.
For this and subsequent tests, verify that other conditions of use do not exceed marked or manufacturer-specified limitations.	G-UR.3., S.4.1.
At the beginning of the first delivery, check for suppressed values.	S.1.6.1. (1/1/06)
For this and subsequent tests, re-check the level of the test measure or prover once it is full of liquid and before reading the indication to ensure that the weight of the product has not affected the level condition.	
If the result of this test is at or near the tolerance limit, repeat the test.	
If necessary, conduct a repeatability test as outlined in Step 5 below.	N.4.1.2.
Special Test, Lowest Grade - Slow Flow, Basic Tolerance.	N.4.2., N.4.2.2., T.2., Table T.2.

Petroleum Product Sampling[1] for Lowest Grade Octane Verification

2. Highest Grade – Normal and Special Tests.

Normal Test, Highest Grade – Full Flow, Basic Tolerance.

[1] When taking gasoline samples from single hose multi-product dispensers, the samples should be collected either immediately following an observed sale of the particular grade or product to be sampled, or after sufficient product has been purged from the hose to ensure the sample is representative of the grade or product being sampled. Guidelines for taking samples for octane verification are found in NIST Handbook 130, Interpretations and Guidelines, Section 2.6.16. Minimum Fuel Flush for Octane Verification and are stated as follows: **"A minimum of 1.2 L (0.3 gal) of motor fuel shall be flushed from a dispenser before taking a sample for octane verification. The flush shall be returned to the storage tank containing the lowest octane."**

	H-44 General Code and Liquid-Measuring Devices Code References

Test (cont.):

Test with the highest grade product, activating the dispenser such that the highest grade product is dispensed. ..... N.4.1., T.2., Table T.2.

If the result of this test is at or near the tolerance limit, repeat this test. If necessary, conduct a repeatability test as outlined in Step 5 below. ..... N.4.1.2., T.3.

Special Test, Highest Grade - Slow Flow, Basic Tolerance. ..... N.4.2., N.4.2.2., T.2., Table T.2.

Petroleum Product Sampling[1] for Highest Grade Octane Verification.

3. Special Test, Middle Grade - Slow Flow, Basic Tolerances.

Test the middle grade blended product. Activate the dispenser such that an intermediate blended product is dispensed. . ..... N.4.2., N.4.2.2., T.2., Table T.2.

If the result of this test is at or near the tolerance limit, repeat the test. If necessary, conduct a repeatability test as outlined in Step 5 below ..... N.4.1.2., T.3.

4. Special Test, Other Blends – Slow Flow, Basic Tolerances.

Conduct a slow flow test at the first blended grade above the lowest grade and at the first blended grade below the highest grade. ..... N.4.2., N.4.2.2., T.2., Table T.2.

If the result of this test is at or near the tolerance limit, repeat the test. If necessary, conduct a repeatability test as outlined in Step 5 below. ..... N.4.1.2., T.3.

Petroleum Product Sampling[1] for Blended Octane Verification

Return any blended product to the storage tank containing the <u>lowest</u> octane fuel.

	H-44 General Code and Liquid-Measuring Devices Code References

Test (cont.):

5. Repeatability Test.

If necessary, conduct a repeatability test. A repeatability test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size. ..... N.2., N.3.4., N.4.1.2., T.3.

6. Money-Value Computations and Recorded Representations.

Check money-value computations on all other blends. Select each of the remaining blends and dispense 1 liter/gallon to check that the computed price is mathematically correct. ..... G-S.5.5., S.1.6.5.

Print a ticket if device is so equipped and check price computations as outlined in "Test Notes." ..... G-S.5.2.2., S.1.6.6.(a), S.1.6.6.(b) (1/1/88)

7. RFI/EMI Test (electronic equipment only).

This testing is typically done only if a problem is suspected or during the inspection of a **new installation.**
Radio Frequency Interference (RFI)
Electromagnetic Interference (EMI)..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.

8. Anti-Drain Test - Check the effectiveness of the anti-drain means. S.3.7.

9. Zero-Setback Interlock.

Check the effectiveness of the zero-setback interlock. ..... S.2.5.(a), S.2.5.(b)

On equipment with remote pumping systems, activate one dispenser and check all others operated by the same pump to make certain they will not operate without activating the individual starting levers. ..... S.2.5.(c)

10. Power Loss Test.

	H-44 General Code and Liquid-Measuring Devices Code References

Test (cont.)

Ensure that information needed to complete transactions in progress at the time of a power loss can be determined for at least 15 minutes at the dispenser or customer-accessible console and that user information is retained in device memory..... S.1.6.2.1. (1/1/83), S.1.6.2.2. (1/1/83)

Before conducting a power loss test, first check with your supervisor to determine your jurisdiction's policy on the conditions under which this test is to be conducted.

Post-Test Tasks:

1. Security Means.

Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed. ..... G-UR.4.5., S.2.2.

Adequate provision shall be made for applying a physical security seal or providing for other approved means of security. ..... G-S.8, S.2.2., Table S.2.2. (1/1/95)

Audit Trail Information. If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. ..... S.2.2. (1/1/95), Table S.2.2. (1/1/95)

2. Record the total number of gallons of product dispensed during testing on the official report.

3. After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. ..... G-UR.4.1., G-UR.4.3.

4. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

H-44 General Code and Liquid-Measuring Devices Code References

Post-Test Tasks (cont.)

SAFETY REMINDERS!!!

- **Avoid switch loading! Test devices dispensing low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline and ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high-vapor pressure products.**
- **Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.**

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2015 EPO No. 23

NIST Examination Procedure Outline (EPO) for

Vehicle-Tank Meters (VTMs)
Power-Operated

It is recommended that this outline be followed as minimum criteria for examining all power-operated vehicle-tank meters – analog or digital. Nonretroactive requirements are followed by the applicable date in parentheses. Do not use this outline for testing vehicle-tank metering systems used to measure milk, LPG, cryogenics, or carbon dioxide. This EPO does not apply to gravity-discharge vehicle tank meters or vehicle-mounted mass flow meters. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

Prior to beginning any inspection, the inspector should read and be familiar with the EPO Safety Annex - "Safety Considerations and Glossary of Safety Key Phrases." The terms and key phrases in each safety reminder of this outline are found in the glossary of the EPO Safety Annex. The inspector should read and be familiar with the introductory section on safety found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Clothing

Electrical Hazards

Emergency Procedures

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location

Nature of Product

Personal Protection Equipment
e.g.,

Safety Shoes, Safety Aprons, Gloves, Eye Protection

Hard Hat, etc. if deemed necessary

Safety Cones/Warning Signs

Safety Data Sheets (SDS)

Static Discharge

Switch Loading

Traffic

Transportation of Equipment

also: **Wet/Slick Conditions, Chemicals, Hazardous Materials, Petroleum Products, and Obstructions**

SAFETY REMINDER

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the prover when it is filled with product - don't forget to chock the wheels of the prover.**
- **Learn the nature of hazardous products used at or near the inspection site – obtain and read copies of MSDS's.**
- **Know emergency procedures and location and operation of fire extinguisher and emergency shut-offs.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use caution in moving in wet, slippery areas and climbing on prover, storage tanks, and vehicles.**
- **Use personal protection equipment and clothing appropriate for the inspection site.**
- **If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected.**
- **Be sure that a first aid kit is available and that it is appropriate for the type of inspection activity.**

	H-44 General Code and VTM Code References
Inspection:	
1. General considerations	
Selection	G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
Installation.	G-S.2., G-UR.2.1., G-UR.2.2., UR.1.1.
Position of equipment	G-UR.3.3.
Accessibility.	G-UR.2.3.
Assistance	G-UR.4.4., G-UR.4.6
Use and maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.2.3., UR1.4.
Use of Automatic Temperature Compensator (ATC).	UR.2.5.
Invoices based on device readings with ATC.	UR.2.5.3.
Period of use (ATC).	UR.2.5.2.
2. Indicating and recording elements.	
Design.	S.1.1.1., S.2.4.
Units	S.1.1.2.(a), S.1.1.3.(b) and (c)
Readability.	G-S.5., G-S.6. (1/1/77), G-S.7., S.1.2., S.1.3.
Values of Intervals.	G-S.5.3.
Recorded representations.	
General.	G-S.5.6., S.1.4.2.
Required for vehicle-tank metering systems	UR.2.2., UR.2.3.
Exceptions for aviation fuel	UR.2.2.1.

	H-44 General Code and VTM Code References

Inspection (cont.)

Computing-type Devices.	
Display of unit price.	S.1.4.1, UR.1.2.
Money-value computations	S.1.4.3.
Gross and net indications with ATC.	
Advancements and return to zero.	S.2.5.3.
Provisions for sealing.	S.1.1.4., S.1.1.5., UR.2.1. G-S.8. (1/1/09), G-S.8.1. (1/1/10) G-UR.4.5.
Provisions for sealing ATC	S.2.2., Table S.2.2. S.2.5.4.
3. Marking.	
	G-S.1.
General.	G-S.1.1.(1/1/04)
Location, Not-Built-For Purpose, Software-Based Devices	G-S.1.2.
Devices or Main Elements Remanufactured as of January 1, 2002	G-UR.2.1.1.
Visibility of required markings after installation.	G-UR.3.4.
Money-Operated Devices, Responsibility	S.5.1.
Limitation on Use	S.5.2.
Discharge Rates	S.5.6.
Temperature Compensation for Refined Petroleum, if equipped with ATC	S.5.7.
Meter Size	
4. Measuring elements.	
Vapor elimination	S.2.1.
Security seal on adjusting mechanism	G-UR.4.5., S.2.2.
Devices equipped with ATC	S.2.5.1., S.2.5.2., S.2.5.3., S.2.5.5., UR.2.5.
Provisions for thermometer well.	S.2.6. (1/1/12)
5. Piping.	
Directional flow valves and discharge line and valves.	S.2.3., S.3.
Antidrain valve.	S.3.6.
Leaks.	G-UR.4.1.
Facilitation of fraud.	G-S.2.
6. Devices Equipped with ATC.	S.2.5., S.2.5.1.
Provisions for deactivating	S.2.5.2.
Gross and net indications	S.2.5.3.
Provision for sealing ATC	S.2.5.4.
Temperature determination	S.2.5.5.

Pretest Determinations:

1. Determine that the test fluid in the tank compartment is similar in character to the fluid to be measured.	N.1
2. Test draft size. Determine if the prover size is adequate	N.3.

	H-44 General Code and VTM Code References

Pretest Determinations (cont.):

3. Tolerances.

Applicable requirements ..... G-T., T.1.
Tolerance values ..... T.2., Table 1, Table 2
Repeatability ..... T.3.

Product Depletion ..... T.4.

For example:

Maximum flow rate marked on device: 100 gpm
Applicable tolerance: 0.6%

The amount delivered in one minute at the maximum flow rate marked on the meter =

1 minute x 100 gallons/minute =
100 gallons

Product Depletion Test Tolerance = 0.6% x 100 gallons = 0.6 gallons

Devices equipped with ATC ..... T.2.1.

4. Note totalizer reading.

Test Notes:

SAFTEY REMINDER!!!

- **Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, eye protection (to prevent injury from splashed product), and a hard hat (to prevent injury from overhangs and projections).**
- **Use proper grounding procedures. Be sure that the prover is equipped with an explosion proof motor.**
- **Carefully inspect electrical supply lines to test equipment for wear and damage; correct potentially hazardous conditions before use.**
- **Device operator should be present at all times during test – the operator (not the inspector) should operate the device under test.**
- **Never leave equipment unattended while it is in operation.**

1. Record totalizer(s) indication before and after each draft to determine proper operation.
2. If prover is dry, wet prover. Follow proper draining procedures. Allow a 30-second drain period each time the prover is emptied.
3. Level the test measure or prover. When the test measure or prover is full of liquid, re-check its level to ensure that the weight of the product has not affected the level condition.
4. Evaporation and volume change: exercise care so the product temperature is the same in the prover as at the meter ..... N.2.

	H-44 General Code and VTM Code References

Test Notes (cont.):

5. Temperature corrections are to be made for accuracy tests to account for any difference between the temperature of the liquid passing through the meter and the liquid in the prover. ..... N.5.

6. After each test draft:

   a. Print a ticket (if so equipped) ..... G-S.5.2.2., G-S.5.6.

   b. If computing type, check price computation on indicator and on recorded representations..... G-S.5.6., S.1.4.2., S.1.4.3., S.1.4.4.

   c. Check for agreement between indicators ..... G-S.5.2.2.

7. Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy. ..... G-S.5.6.

8. If the result of any test is at or near the tolerance limit, repeat that test. If necessary, conduct a repeatability test as outlined in Step 2 under "Tests: All Meters" below.

Tests:

SAFTEY REMINDER!!!

- **Avoid switch loading! Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline).**
- **If supply or return lines are not coupled at their discharge ends, they must be held in place continuously while product flows through the line.**
- **Use proper lifting techniques to lift and move equipment.**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic in the area.**

Tests: Non-Temperature-Compensated Meters

1. Normal test - full flow, basic tolerance ..... N.4.1., T.2.

2. Special test - slow flow, special tolerance ..... N.4.2, T.2.

3. Proceed to "Tests – All Meters."

Tests: Temperature-Compensated Meters

1. Normal test with compensator activated - full flow, normal tolerance. ..... N.4.1., N.4.1.3. T.2.1.

	H-44 General Code and VTM Code References
2. Deactivate temperature compensator and repeat normal test. Compare the compensated volume indicated or recorded to the actual delivered volume corrected to 15 °C (60 °F) ...	N.4.2., N.4.1.3. T.2.1.
3. Special test - slow flow, special tolerance	N.4.2., T.2.
4. Proceed to "Tests – All Meters."	

Tests: All Meters

1. Product Depletion Test ..... S.2.1., N.4.5, T.4.

a. Start test (normal flow rate) from a compartment containing less test fluid than one half the capacity of the prover and with pump in operation and pressure to the discharge nozzle.

b. Permit test to continue until lack of fluid supply causes meter register to stop completely for at least 10 seconds.

c. If the meter indication fails to stop completely for at least 10 seconds, continue to operate the system for 3 minutes.

d. With pump in operation, shut manifold valve (or disconnect whip-hose connection) from now empty compartment.

e. Finish the test by switching to another compartment with sufficient product to complete the test on a multi-compartment vehicle or by adding sufficient product to complete the test to a single compartment vehicle. When adding product to a single compartment vehicle, allow approximate time for any entrapped vapor to disperse before continuing the test.

f. Test drafts are to be of the same size and run at approximately the same flow rate.

2. Repeatability Test. ..... N.4.1.2., T.3.

If necessary, conduct a repeatability test. Test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size.

3. RFI/EMI Test (electronic equipment only) ..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.
This testing is typically done only if a problem is suspected or during the inspection of a new installation.
Radio Frequency Interference (RFI)
Electromagnetic Interference (EMI)

4. Check automatic stop mechanism. ..... G-UR.4.1.
The device should stop the flow within one-half the minimum interval indicated.

5. Check effectiveness of antidrain valve (with pump pressure off line). ..... S.3.6., N.4.3.

	H-44 General Code and VTM Code References

Post-Test Tasks:

1. Security Means.

   Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed. ..... G-UR.4.5.

   Adequate provision shall be made for applying a physical security seal or providing for other approved means of security. ..... G-S.8, S.2.2., Table S.2.2.(1/1/95)

   Audit Trail Information. If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. ..... G-S.8., S.2.2., Table S.2.2. (1/1/95)

2. Record the number of gallons of product dispensed during test on the official report. .....

SAFTEY REMINDER!!!

- **Avoid switch loading! Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline).**
- **Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.**

3. After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. ..... G-UR.4.1., G-UR.4.3.
4. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

2015 EPO No. 24

NIST Examination Procedure Outline for

Vehicle-Tank Meters (VTMs)
Gravity-Discharge

It is recommended that this outline be followed as minimum criteria for examining all gravity-discharge vehicle-tank meters – analog or digital. Nonretroactive requirements are followed by the applicable date in parentheses. Do not use this outline for testing vehicle-tank metering systems measuring milk, LPG, cryogenics, or carbon dioxide or for testing power-operated vehicle tank meters. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

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

Clothing

Electrical Hazards

Emergency Procedures

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location

Nature of Product

Personal Protection Equipment
e.g.,
Safety Shoes, Safety Aprons, Gloves, Eye Protection

Hard Hat, etc. if deemed necessary

Safety Cones/Warning Signs

Safety Data Sheets (SDS)

Static Discharge

Switch Loading

Traffic

Transportation of Equipment

also: **Wet/Slick Conditions, Chemicals, Hazardous Materials, Petroleum Products, and Obstructions**

H-44 General Code and Vehicle-Tank Meter Code References

Inspection:

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the prover when it is filled with product - don't forget to chock the wheels of the prover.**
- **Learn the nature of hazardous products used at or near the inspection site – obtain and read copies of MSDS's.**
- **Know emergency procedures and location and operation of fire extinguisher and emergency shut-offs.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use caution in moving in wet, slippery areas and climbing on prover, storage tanks, and vehicles.**
- **Use personal protection equipment and clothing appropriate for the inspection site.**
- **If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected.**
- **Be sure that a first aid kit is available and that it is appropriate for the type of inspection activity.**

1. General considerations.

Selection	G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3. UR.3.3.
Installation	G-S.2., G-UR.2.1., G-UR.2.2., UR.1.1.
Position of equipment	G-UR.3.3.
Accessibility	G-UR.2.3.
Assistance	G-UR.4.4., G-UR.4.6.
Use and maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.2.3., UR.1.4
Use of ATC	UR.2.5.1
Invoices based on device readings with Automatic Temperature	
Compensator (ATC)	UR.2.5.3.
Period of use (ATC)	UR.2.5.2.
Computing-capability	UR.3.3.

2. Indicating and recording elements.

Design	S.1.1.1.

	H-44 General Code and Vehicle-Tank Meter Code References

Inspection (cont.):

Units	S.1.1.2.(a) , S.1.1.3.(b) and (c)
Readability	G-S.5., G-S.6. (1/1/77), G-S.7., S.1.2., S.1.3.
Values of intervals	G-S.5.3.
Recorded representations.	
General	G-S.5.6., S.1.4.2.
Required for vehicle-tank metering systems	UR.2.2., UR.2.3.
Exceptions for aviation fuel	UR.2.2.1.
Computing-type devices.	
Display of unit price	S.1.4.1, UR.1.2.
Money-value computations	S.1.4.3.
Gross and net indications for devices with ATC	S.2.5.3.
Advancement and return to zero	S.1.1.4., S.1.1.5., UR.2.1.
Provision for sealing	G-S.8. (1/1/90), G-UR.4.5., S.2.2., Table S.2.2.
Provision for sealing ATC Systems	S.2.5.4.
3. Marking.	
General	G-S.1.
Location, Not-Built-For Purpose, Software-Based Devices	G-S.1.1.(1/1/04)
Devices or Main Elements Remanufactured as of January 1, 2002	G-S.1.2.
Visibility of required markings after installation	G-UR.2.1.1.
Money-Operated Devices, Responsibility	G-UR.3.4.
Limitation on Use	S.5.1.
Discharge Rates	S.5.2.
Temperature Compensation for Refined Petroleum, if equipped with ATC	S.5.6.
Meter Size	S.5.7.

	H-44 General Code and Vehicle-Tank Meter Code References

Inspection (cont.):

4. Measuring elements.
   - Vapor elimination ..... S.2.1.
   - Security seal on adjusting mechanism ..... G-UR.4.5., S.2.2.
   - Provisions for thermometer well S.2.6. (1/1/12)

5. Piping.
   - Directional flow valves and discharge line and valves ..... S.2.3., S.3.
   - Leaks ..... G-UR.4.1.
   - Facilitation of fraud ..... G-S.2.

6. Devices Equipped with ATC. ..... S.2.5., S.2.5.1.
   - Provisions for deactivating .....
   - Gross and net indications ..... S.2.5.2.
   - Provision for sealing ATC ..... S.2.5.3.
   - Temperature determination ..... S.2.5.4.
     S.2.5.5.

Pretest Determinations:

1. Test Equipment Set-up. Gravity discharge VTMs are designed to make deliveries to underground storage tanks; product is delivered to a tank that is entirely below the level of the truck tank. As such, when product is delivered from these systems the discharge end of the hose is approximately roadway level and the discharge hose is said to have a negative head to allow gravity to push product through the system.

   To approximate commercial operating conditions in the testing operations of these devices, the prover height must simulate road level height so that the end of the delivery line from the VTM corresponds to its position when inserted in the fill pipe of an underground storage tank at a filling station.

2. Determine that the test fluid in the tank compartment is similar in character to the fluid to be measured ..... N.1.

3. Determine that a compartment or compartments have a sufficient amount of product to conduct “high head” and “low head” tests (also referred to as full compartment and near empty compartments tests since the head pressure acting on the meter decreases as the compartment is drained).

4. Test draft size. Determine if the prover size is adequate ..... N.3.

5. Ensure that the prover inlet is lower than the meter outlet.

6. Tolerances.
   - Applicable requirements ..... G-T., T.1.
   - Tolerance values ..... T.2., Table 1, Table 2
   - Repeatability ..... T.3.
   - Devices equipped with ATC ..... T.2.1. (a), (b)

7. Note totalizer reading.

H-44 General Code and Vehicle-Tank Meter Code References

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, eye protection (to prevent injury from splashed product), and a hard hat (to prevent injury from overhangs and projections).**
- **Use proper grounding procedures. Be sure that prover is equipped with an explosion proof motor.**
- **Carefully inspect electrical supply lines to test equipment for wear and damage; correct potentially hazardous conditions before use.**
- **Device operator should be present at all times during test - the operator (not the inspector) should operate the device under test.**
- **Never leave equipment unattended while it is in operation.**

Test Notes:

1. Record totalizer (s) indication before and after each draft to determine proper operation.
2. If prover is dry, wet prover. Allow a 30-second drain period each time prover is emptied.
3. Level the test measure or prover. When the test measure or prover is full of liquid, re-check its level to ensure that the weight of the product has not affected the level condition.
4. Evaporation and volume change: exercise care so that the product temperature is the same in the prover as at the meter. N.2
5. Temperature corrections are to be made for accuracy tests to account for any difference between the temperature of the liquid passing through the meter and the liquid in the prover. ..... N.5.
6. After each test draft:
   a. Print a ticket (if so equipped). ..... G-S.5.2.2., G-S.5.6.
   b. If computing type, check price computation on indicator and on recorded representations. ..... G-S.5.6., S.1.4.2., S.1.4.3., S.1.4.4.
   c. Check for agreement between indicators..... G-S.5.2.2.
7. Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy. ..... G-S.5.6.
8. If the result of any test is at or near the tolerance limit, repeat that test. If necessary, conduct a repeatability test as outlined in Step 1 under “Tests: All Meters” below.

H-44 General Code and Vehicle-Tank Meter Code References

Tests:

SAFETY REMINDER!!!

- **If supply or return lines are not coupled at their discharge ends, they must be held in place continuously while product flows through the line.**
- **Use proper lifting techniques to lift and move equipment.**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic in the area.**

Tests: Non-Temperature-Compensated Meters

1. Normal test - - full flow (high head/full compartment), basic tolerance. ..... N.4.1., T.2.
2. Normal test - - full flow (medium head/one-half full compartment), basic tolerance. .. N.4.1., T.2.
3. Normal test - - full flow (low head/one and one-half times prover capacity in the compartment), basic tolerance. ..... N.4.1., T.2.
4. Proceed to "Tests – All Meters."

Tests: Temperature-Compensated Meters

1. 1Normal test with temperature compensator activated - full flow, normal tolerance. (Do not deactivate the temperature compensator.) ..... N.4.1., N.4.1.3. T.2.1.

2. Deactivate temperature compensator and repeat normal test. Compare the compensated volume indicated or recorded to the actual delivered volume corrected to 15 °C (60 °F) ..... N.4.1., N.4.1.3. T.2.1.
3. Proceed to "Tests – All Meters."

Tests: All Meters

1. Repeatability Test. ..... N.4.1.2., T.3.
   If necessary, conduct a repeatability test. Test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size.
2. RFI/EMI test (electronic equipment only) ..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.
   This testing is typically done only if a problem is suspected or during the inspection of a new installation.
   Radio Frequency Interference (RFI)
   Electromagnetic Interference (EMI)
3. Check automatic stop mechanism. ..... G-UR.4.1.
   The device should stop the flow within one-half the minimum interval indicated.

Post Test Tasks:

1. Security Means.

   Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed. ..... G-UR.4.5.

   Adequate provision shall be made for applying a physical security seal or providing for other approved means of security. ..... G-S.8, S.2.2., Table S.2.2.(1/1/95)

   If system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. ..... G-S.8., S.2.2., Table S.2.2. (1/1/95)

SAFETY REMINDER!!!

- **Avoid switch loading!**
- **Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline).**
- **Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes!**

2. Record on the official report the number of gallons of product dispensed during test.
3. After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. ..... G-UR.4.1., G-UR.4.3.
4. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

2015 EPO No. 25

NIST Examination Procedure Outline

Loading-Rack Meters

It is recommended that this outline be followed as minimum criteria for examining loading-rack meters used to measure petroleum products sold at wholesale. The outline may be applied to devices with or without Automatic Temperature Compensating Systems. Non-retroactive and retroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. The inspector should read and be familiar with the introductory section on safety "Safety Considerations" found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location

also: **Wet/Slick Conditions**
Chemicals, Petroleum Products, and Hazardous Materials

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment
e.g.,
Safety Shoes, Safety Aprons, Respirators, Gloves, Barrier Cream, etc., if deemed necessary.
Hard Hat -- for protection from overhang in rear of vehicle tank truck

Safety Cones/Warning Signs

Static Discharge

Support -- for prover

Switch Loading

Obstructions and Overhead Hazards

Safety First !!!

Check the inspection site carefully for safety hazards and take appropriate precautions.

Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the prover when it is filled with product -- don't forget to chock the wheels of the prover.

Learn the nature of hazardous products used at or near the inspection site--obtain and read copies of MSDS's.

Know emergency procedures and location and operation of fire extinguishers and emergency shut-offs.

Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.

Use caution moving around in wet, slippery areas and in climbing on prover, storage tanks, and vehicles.

Use personal protection equipment and clothing appropriate for the inspection site.

Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.

H-44 General Code and Liquid Measuring Devices Code References

Pretest Determinations:

1. Prover must have valid calibration certificate and security seals must be intact on sight gauge.
2. Prover capacity must be sufficient to hold the amount of product that would be delivered by the meter to be tested during 1 minute of flow at its maximum discharge rate and in no case be less than 200 liters (50 gallons)..... N.3.5.
3. Prover and system design must be compatible (top loading/bottom loading).
4. Thermometers are to be accurate to within:
   a. ± 0.5 °C, have a range of at least 0 °C to 50 °C, and be divided in increments of no greater than 0.5 °C for liquid-in-glass thermometers and 0.1 °C for digital thermometers or
   b. ± 1 °F, have a range of at least 0 °F to 120 °F, and be divided in increments of no greater than 1 °F for liquid-in-glass thermometers and 0.1 °F for digital thermometers.

   Thermometers may be of the partial immersion or digital type.
   (See NIST HB 105-6 for additional information)

	H-44 General Code and Liquid Measuring Devices Code References

Pretest Determinations (cont.):

5. Inspect prover's interior surface for dents, product clingage, rust, water, or other foreign material.

6. Prover sight glass must be clean and fittings must not leak.

7. Available test fluid must be of the same general physical characteristics as that of the liquid to be commercially measured by the device. N.1.1., N.1.2.

8. For top loading provers, the prover inlet must be lower than the outlet of the meter discharge line.

9. Determine applicable tolerance values:

Applicable requirements	G-T., T.1.
Basic values	T.2.
a. On normal tests:	
Acceptance tolerance –Asphalt meters > 50 °C	0.3 percent
Acceptance tolerance – Other products	0.2 percent
Maintenance tolerance	0.3 percent
b. Special tests tolerance	0.5 percent

Inspection:

1. Indicating and recording elements.

Design:

Device must be equipped with indicating elements and MAY be equipped with a recording element. S.1.1.

Units:

Units are to be in terms of liters, gallons, quarts, pints, fluid ounces, or binary-sub-multiples or decimal subdivisions of the liter or gallon. S.1.2., S.1.2.3.(b)

Readability: G-S.5., S.1.4., S.1.5.

Indicating and recording elements must be clear, definite, and easily read.

G-S.6. (1/1/77), G-S.7.

Required markings shall be distinct, easily readable, and of a permanent nature

	H-44 General Code and Liquid Measuring Devices Code References

Inspection (cont.):

1. Indicating and recording elements. (continued)

Values of intervals:

Values of the graduated intervals must be uniform throughout the series of indicating elements or, if equipped, recording elements..... G-S.5.3.

For devices indicating or recording in more than one unit, the values must be appropriately identified..... G-S.5.1.3.

Advancement and return to zero: ..... S.1.3.

Indicating and recording elements may only be advanced to zero by the mechanical operation of the device, UNLESS:

a. Advancement cannot be stopped until zero is reached, OR
b. The indicating elements are automatically obscured until the elements reach a correct zero position.

Travel of Indicator

Device shall be readily operable to deliver accurately any quantity from 200 L (50 gal) to the capacity of the device. If the most sensitive element utilizes an indicator and graduations, their relative movement corresponding to a delivery of 4 L (1 gal) shall be not less than 5 mm (0.20 in). ..... S.1.7.1.

Provision for sealing: G-S.8. (1/1/90), S.2.2.,

Provision must be made for sealing electronic adjustable components ..... Table S.2.2. (1/1/95)

For multiple measuring elements with a single provision for sealing, a change to the adjustment of any measuring element must be individually identified. G.S.8.1. (1/1/10)

A security seal must be affixed to any adjustment mechanism designed to be sealed. ..... G-UR.4.5.

G-S.5.6.

Recording elements, General. .....

	H-44 General Code and Liquid Measuring Devices Code References

Inspection (cont.):

2. Measuring elements.

Determine that system has an effective vapor or air eliminator (or other automatic means for preventing the passage of vapor and air through the meter) and that vent lines are suitably rigid. ..... S.2.1.

Verify that means are provided for determination of product temperature
- for devices without automatic temperature compensating systems..... S.2.6. (1/1/85)
- for devices with automatic temperature compensating systems..... S.2.7.4.

Determine that provision is made for applying security seals to the meter and to the automatic temperature compensating system, and that security seals are intact on both..... G-UR.4.5., S.2.2., S.2.7.3.

3. Marking.

Device is clearly and permanently marked for the purpose of identification. ..... G-S.1., G-S.1.1., G-S.1.2.

All switches, lights, displays, pushbuttons, and other operational controls and features must be clearly and definitely identified. G-S.6. (1/1/77)

The limitation on a device's use shall be clearly and permanently marked on any device intended to measure accurately: ..... S.4.1.

a. only products having particular properties,
b. only under specific installation conditions, or
c. only when used in conjunction with specific accessory equipment.

Designed minimum and maximum discharge rates must be clearly and permanently marked on meter. Minimum discharge rate shall not exceed 20 percent of the maximum discharge rate..... S.4.3.1.

For devices equipped with temperature compensation, the primary indicating elements, recording elements, and recorded representations shall be clearly and conspicuously marked to show that the volume has been adjusted to the volume at 15 °C (60 °F) ..... S.4.3.2.

	H-44 General Code and Liquid Measuring Devices Code References

Inspection (cont.):

4. Installation.

Device must be readily accessible for purposes of testing. Assistance shall be provided by the firm if needed. G-UR.2.3., G-UR.4.4

Examine discharge line and valves to insure that measured liquid cannot be diverted from the measuring chamber or discharge line and that any directional flow valves are automatic in operation. ..... S.2.3., S.3.1., S.3.2.

No leaks should exist in the system on the outlet side of the meter. ..... G-UR.4.1., S.3.1.

Note: If leaks are detected on the inlet side of the meter, a notation should be made on the inspection report and the firm should be made aware of the location of the leak for purposes of safety.

Examine the system and any associated equipment to insure that the assembly, installation, and construction do not facilitate fraud. ..... G-S.2.

The details of the installation must be proper and must not adversely affect system performance. The actual maximum discharge rate must not exceed that specified by the manufacturer. ..... G-UR.2.1., UR.2.1., UR.2.2.

The device shall be installed so that there is no obstruction between a primary indicating element or recording element and the measuring element. Otherwise, there shall be convenient and permanently installed means for direct oral or visual communication between an individual located at the primary element and an individual located at the measuring element ..... G-UR.2.2.

A device or system equipped with a primary indicating element and used in direct sales shall be positioned so that its indications may be accurately read and the measuring operation may be observed from some reasonable "customer" and "operator" position. The positioning shall be determined on a case-by-case basis, considering the individual circumstances, including the size and character of the indicating element. ..... G-UR.3.3.

5. Selection and use.

Device must be suitable for the service in which it is used with respect to the elements of design, including flow rate, computing capability, the details of its indicating and recording elements, and the value of its smallest unit and unit prices. Device must also be suitable for use in the environment in which it is installed. G-UR.1.1., G-UR.1.2

Device and any associated equipment are to be operated and maintained as intended by the manufacturer ..... G-UR.3.1., G-UR.4.1.

	H-44 General Code and Liquid Measuring Devices Code References

Inspection (cont.):

UR.3.6.1.1.

If a device is equipped with a mechanical automatic temperature compensator, it shall be connected, operable, and in use at all times.....

6. Devices equipped with automatic temperature compensating systems.

Provision must be made to deactivate the automatic temperature compensating system so that the meter may indicate and record, if equipped to record, in terms of the uncompensated volume..... S.2.7.2.

Thermometer well must be provided for determination of the temperature of the liquid S.2.7.4.

Primary indicating and recording elements on devices equipped with automatic temperature compensating systems shall be marked to show that the volume delivered has been adjusted to 15 °C (60 °F)..... S.4.3.2.

Wear appropriate personal protection equipment such as petroleum-resistant, non-skid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, eye protection (to prevent injury from splashed product), and a hard hat (to prevent injury from overhangs and projections on vehicle tank truck).

Use proper grounding procedures!

Device operator should be present at all times during testing.

Test Notes:

1. Check for the proper operation of the level indicators on the prover and level the prover.
2. Connect safety interlock and ground cable. If applicable, connect the vapor recovery hose.
3. Verify that all valves in the proving system are closed and that the prover pumping mechanism is functional.
4. Note the totalizer reading. Totalizer should be checked before and after each draft to determine its proper operation.

	H-44 General Code and Liquid Measuring Devices Code References

Test Notes (cont.):

5. Care should be exercised to insure that the temperature difference between product in the prover and in the meter is small. ..... N.2.

6. For top-loading provers, take precautions to minimize splashing and to maintain the spout fill in a consistent position.

7. Examine printed tickets and invoices:

   a. Print a ticket after each test draft, if device is so equipped. ..... G-S.5.6.
   b. For devices of the computing type:
      1) Check price computations on indicator and on printed indications ..... S.1.7.2.
      2) The total price, the total volume of the delivery, and the price per liter or gallon shall be shown, either printed by the device or in clear hand script, on any printed ticket issued by a device and containing any one of these values.
   c. Check that all indicated and recorded values for proper comparability. ..... UR.3.4.
   d. For systems equipped with automatic temperature compensation, check invoices to determine if: G-S.5.2.2.
      1) deliveries which are adjusted to 15 °C or 60 °F show that the volume has been adjusted to 15 °C or 60°F.....
      2) in the case of an electronic wholesale device equipped with an automatic temperature compensating system, the API gravity, specific gravity, or coefficient of expansion; product temperature; and gross reading are also indicated. ..... S.4.3.2.,UR.3.6.1.2.(a)
   e. For nonautomatic temperature compensation: ..... UR.3.6.1.2.(b)
      1) the volume of the product delivered is adjusted to the volume at 15 °C or 60 °F, verify that the product temperature is taken during delivery in: UR.3.6.2.1
         -the liquid chamber of the meter;
         -the meter inlet or discharge line adjacent to the meter, or
         -the compartment of the receiving vehicle at the time it is loaded.

      The accompanying invoice for these systems shall indicate that the product has been adjusted to a volume at 15 °C or 60 °F and shall state the product temperature used in making the adjustment. ..... UR.3.6.2.2.
   f. In addition to tickets printed during inspection and testing, several examples of actual used tickets are to be examined. This serves to verify the format of and information on actual printed tickets.

   g. Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy. ..... G-S.5.6.

Test Notes (cont.):

	H-44 General Code and Liquid Measuring Devices Code References

8. Period of Use for Temperature Compensation UR.3.6.3.

When fuel is bought or sold based on temperature-compensated volume, it shall be bought or sold on this basis over at least a 12-month consecutive period, unless otherwise agreed to in writing by both the buyer and seller.

9. Prover readings are to be determined by reading the bottom of the meniscus for transparent liquids, and the top of the meniscus for opaque liquids.

10. When monitoring drainage of the prover, one of the following methods should be followed depending on prover design. Precautions should be taken to insure that drainage procedure is followed in a consistent manner for each test.

    a. If the prover has a lower neck equipped with a drain sight glass, close the drain valve prior to the liquid level reaching the zero mark indicator. After 30 seconds drain time, open the small drain-off valve and lower the liquid level to the zero mark. (Do not adjust the liquid level again, even if continued drainage raises the liquid level above the zero mark before the test is started.)

    b. If the prover is not equipped with a lower sight glass, leave the drain valve open until continuous flow ceases and dripping commences. Close drain valve after 30 seconds.

11. Temperature readings are to be taken to the nearest 0.25 °C or 0.5 °F or for digital thermometers, to the nearest increment. Take the temperature of the test liquid in the prover immediately following each accuracy test. For provers equipped with more than one thermometer, the temperature of the test liquid is the mathematical average of the individual readings.

    A thermometer placed in the thermowell adjacent to the meter is to be used to determine meter temperature. Meter temperature is to be taken at 1/3 and 2/3 prover capacity during each delivery and averaged.

12. Automatic-stop-mechanism must stop flow within one-half the minimum interval indicated S.2.4.

Test Procedure:

Use proper lifting techniques to lift and move equipment!

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.

Be aware of vehicular and pedestrian traffic in the area.

1. Wet prover.

2. Empty prover. Allow a 30-second drain period each time the prover is emptied, using one of the methods outlined in the Test Notes. The amount of time between wetting the prover and the first test draft should be minimal.

3. Insert a meter ticket and set preset stop mechanism for the rated capacity of the prover.

   Reset the meter to zero.

4. Start the pump, then open the prover delivery valve.

   - If any test result is close to or outside of applicable tolerance, then repeat the test.
   - If two consecutive tests are found to exceed applicable tolerance values, discontinue accuracy test and proceed to next portion of EPO.

For Repair Personnel:

Three consecutive test runs should be performed to insure repeatability. The difference between the high and low readings of these three consecutive runs should not exceed 0.05 percent of the prover's certified volume.

If test results exceed applicable tolerance values, the meter should be adjusted at this point. Repair personnel should follow company policy regarding adjustment of meter; for meters equipped with a temperature compensator, it may be necessary to first deactivate the temperature compensator prior to making any adjustment.

A check for the performance of the temperature sensor should be performed at the end of each accuracy test. Utilize the section at the end of each worksheet to analyze the performance of the sensor. Should a variation of 1 °C or 2°F exist for two consecutive runs, the normal operating thermometer must be recalibrated against a National Institute of Standards and Technology traceable thermometer**.**

Test Procedure (cont.):

	H-44 General Code and Liquid Measuring Devices Code References
5. Accuracy Tests	
a. **Nontemperature-compensated meters.**	
Temperature corrections are to be made for accuracy tests to account for any difference between the temperature of the liquid passing through the meter and the liquid in the prover.	
1) Normal test--full flow**. .....**	N.5.
a) Fill prover in a manner simulating actual use and determine actual flow rate. Test should be run at the maximum discharge rate anticipated under the conditions of the installation. Actual rate of flow should be within manufacturer's ratings of minimum and maximum flow**. . .....**	N.4.1., N.4.1.1., N.4.1.2, T.2., Table T.2., T.3.
b) Verify that all valves are closed and that prover remains level. Examine prover piping to insure that there is no entrapment of air and that there are no leaks.	G-UR.3.1., UR.2.2.
c) Disconnect the bottom loading coupler or remove the loading spout from the liquid.	
d) Allow time for product settling and foam dissipation prior to taking prover reading.	
e) Read the thermometers as described in **Test Notes**, and record the reading to the nearest 0.25 °C or 0.5 °F.	
f. For an analog device, record ending meter reading to the nearest 0.1 gallon. For a digital-indicating device, record the meter indication to the smallest quantity division available, e.g., test mode indication. Check totalizer against actual amount dispensed.	
g) Disconnect vapor recovery hose and then drain prover.	N.4.4., N.4.4.2
h) Use appropriate worksheet to determine meter error.	
2) Special test--slow flow**.....**	N.4.2., N.4.2.4., T.2., Table T.2.
a) Reconnect vapor recovery hose, if applicable. b) Fill prover at or slightly above the slower of -the minimum discharge rate marked on the device; or -20% of the minimum discharge rate marked on the device. In no case shall the test be performed at a flow rate less than the minimum discharge rate marked on the device. **c)** Repeat steps (b) through (h) of part 5.a.(1) above.	

Test Procedure (cont.):

	H-44 General Code and Liquid Measuring Devices Code References

b. <u>Temperature compensated meters</u>.

For meters that indicate in "net" gallons. With temperature compensator activated:

1) Normal test--full flow (do not deactivate temperature compensating system)..... N.4.1., N.4.1.1., N.4.1.2., T.2., Table T.2., T.3.

a) Fill prover as described in part 5.a.(1) above.
b) Obtain temperature of product at meter at 1/3 and 2/3 prover capacity. Determine the average.
c) Follow remaining steps in part 5.a.(1) above, using the worksheet for compensated meters to determine meter error.

Deactivate temperature compensator:

2) Normal test--full flow..... N.4.1., N.4.1.1., N.4.1.2., T.2., Table T.2., T.3., T.4. (1/1/88)

Follow testing procedure described in part 5.a. (1) above for normal test, uncompensated meters, determine meter error using worksheet for uncompensated meters.

3) Special test--slow flow..... N.4.2., N.4.2.4., T.2., Table T.2.

Follow testing procedure described in part 5.a.(2) above for special test, uncompensated meters. Determine meter error using worksheet for uncompensated meters.

Reactivate temperature compensator.

c. <u>Temperature compensated meters</u>.

For meters that indicate or record in "gross" gallons (uncompensated) <u>and</u> "net" gallons (compensated).

1) Accuracy of "gross" gallons is to be determined following the test procedure for non-temperature compensated meters in part 5.a.(1) and (2) above to perform both normal and special tests.

2) Accuracy of "net" gallons is to be determined as follows:

a) For each normal test run in part 5.c.(1) above, obtain the temperature of product at meter at 1/3 and 2/3 capacity of prover and determine the average.

Test Procedure (cont.):

b) Follow remaining steps in 5.a.(1) using the worksheet for compensated meters to determine the error.

6. For automatic temperature compensating systems. The difference between the meter error for tests performed with and without the automatic temperature compensating system activated shall not exceed 0.2 percent for mechanical ATCS and 0.1 percent for electronic ATCS of the test draft. The results of each test shall be within applicable tolerances.

   For systems that indicate or record in both "gross" (uncompensated) and "net"(compensated) quantities, it is not necessary to run multiple tests. "Compensated" and "Uncompensated" test results can be calculated from a single test draft using the "gross" and "net" indications along with observed temperature information. ..... T.4.

Tests: All Meters

1. For a wet-hose system, check the effectiveness of the anti-drain valve. ..... S.3.7.
2. For a dry-hose system, check for complete drainage of the hose. ..... S.3.4.
3. Radio Frequency Interference (RFI)/Electromagnetic Interference (EMI) (only if a problem is suspected). Test using only equipment on site in the vicinity of the metering system, perform a test for radio frequency/electromagnetic interference.

   Results of this test must indicate that use of such equipment does not adversely affect performance of the metering system..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.

	H-44 General Code and Liquid Measuring Devices Code References

Post-Test Tasks:

1. Security Means.

   Check for the presence of security seals on the device. Document missing seals on the official report and apply new ones as needed. ..... G-UR.4.5.

   Adequate provision shall be made for applying a physical security seal or providing for other approved means of security. ..... G-S.8., S.2.2., Table S.2.2. (1/1/95)

   Audit Trail Information. If the system is equipped with an audit trail, note the event counter settings on the report form for future reference. If equipped with an event logger, print a copy of the event log and attach it to the report form for future reference. G-S.8., S.2.2., Table S.2.2. (1/1/95)

2. Following completion of a successful examination, attach a label or tag indicating the type of liquid used during the test. ..... N.1.2.

3. After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. ..... G-UR.4.1., G-UR.4.3.

4. Record the compliance action and disposition of the device on the report and explain the results to the device owner.

Use extreme caution when switch-loading product!
Test devices metering low-vapor pressure products (e.g., diesel fuel and kerosene) before testing devices metering high-vapor pressure products (e.g., gasoline and ethanol blends up to E85) with the same test measure or prover. Additional precautions may be necessary with other high-vapor pressure products.

Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.

2015 NIST EPO No. 26

Examination Procedure Outline for

Liquefied Petroleum Gas (LPG) Liquid-Measuring Systems

It is recommended that this outline be followed as minimum criteria for examining all LPG liquid-measuring systems. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

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

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location

also:

Wet/Slick Conditions
Chemicals, Petroleum Products, and Hazardous Materials

Nature of Product

Obstructions and Overhead Hazards

Personal Protection Equipment

e.g., Safety Shoes, Safety Aprons, Respirators, Gloves, Barrier Cream, etc., if deemed necessary.

Hard Hat -- for protection from overhang in rear of vehicle tank truck

Safety Cones/Warning Signs

Safety Data Sheets (SDS)

Static Discharge

Support -- for prover

Switch Loading

Traffic

Transportation of equipment

Inspection:

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions.**
- **Pay particular attention to the condition of the product storage tank and valves.**
- **Check to be certain that the ground surface of the inspection site is sufficiently strong and rigid to support the prover when it is filled with product. Don't forget to chock the wheels of the prover.**
- **Learn the nature of hazardous products used at or near the inspection site; obtain and read copies of MSDS.**
- **Know emergency procedures (particularly for this location) and the location and operation of fire extinguishers and emergency shut-offs.**
- **Be sure that a constant supply of water is available for cooling tanks in an emergency.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use caution moving around in wet, slippery areas and in climbing on prover, storage tanks, and vehicles.**
- **Use personal protection equipment and clothing appropriate for the inspection site.**
- **If exposed wiring or other factors cause hazardous testing conditions, it is recommended that the testing be discontinued until the unsafe conditions are corrected.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**

	H-44 General Code and LPG and Anhydrous Ammonia LMD Code References - 2015
1. General considerations	
Selection	G-S.3., G UR.1.1., G-UR.1.2., G-UR.1.3.
Use and maintenance	G UR.3.1., G UR.4.1., G-UR.4.2
Installation.	G-S.2., G-UR.2.1., G-UR.2.2., UR.1.1.
Accessibility.	G UR.2.3
Assistance	G-UR.4.4
Testing devices at a central location	G-UR.4.6.(a).

	H-44 General Code and LPG and Anhydrous Ammonia LMD Code References - 2015

Inspection (cont.):

2. Indicating and recording elements.

Design	S.1.1.
Travel of Indicator, wholesale devices.	S.1.6.1.
Readability	G-S.5., G-S.6.(1/1/77), G-S.7.
Unit Price and Product Identity – Stationary retail devices only.	G-UR.3.3., S.1.2., S.1.3. S.1.5.1.
Advancement and return to zero, all devices.	S.1.1.4., UR.2.1.
Indication of delivery, retail devices.	S.1.4.1.
Return to zero, retail devices.	S.1.4.2.
Recorded Representations	
General	G-S.5.6.
Required for vehicle-mounted systems.	S.1.1.1., S.1.4.2., UR.2.6.
Point-of-sale systems	S.1.5.3.
Provision for sealing	G-S.8. (1/1/90), G-UR.4.5.

3. Measuring Elements

Vapor elimination	S.2.1., S.2.4.
Security seals	G-UR.4.5., S.2.2., Table S.2.2., A.2.6.2.
Thermometer well	S.2.5.
Automatic temperature compensation	S.2.6., S.2.6.1., UR.2.4.

4. Marking requirements.

General	G-S.1.
Location, Not-Built-For Purpose, Software-Based Devices	G-S.1.1.(1/1/04)
Devices or Main Elements Remanufactured as of January 1, 2002	G-S.1.2.
Marking, Operational Controls, Indications, and Features; Lettering	G-S.6.(1/1/77), G-S.7.
Visibility of required markings after installation	G-UR.2.1.1.
Limitation of use.	S.4.1.
Discharge rate.	S.4.2.
Location of marking information, retail devices.	S.4.3.
Temperature compensated volume.	S.4.4.

5. Discharge line and valves.

Directional flow valve.	S.2.3.,
Maintenance of liquid state.	S.2.4.
Diversion of measured liquid.	S.3.1.,
Delivery hose	S.3.2., UR.1.2.
Fill of discharge.	UR.2.2.
Vapor-return line.	UR.2.3

6. Facilitation of fraud ..... G-S.2.

H-44 General Code and LPG and Anhydrous Ammonia LMD Code References - 2015

Pretest Determinations:

1. Determine that the test liquid is similar in character to the liquid to be measured commercially..... N.1.

2. Test Drafts. Test drafts shall be equal to at least the amount delivered by the device in 1 minute at its normal discharge rate. ..... N.3.

3. Tolerances
   - Applicable requirements..... G-T., T.1.
   - Tolerance values..... T.2., Table 2
   - Repeatability..... T.3.
   - Automatic temperature-compensating systems ..... T.4.

Test Notes:

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as static-resistant, nonskid safety shoes (to avoid potential ignition source and to prevent possible injury from slipping on slick surfaces), protective clothing, eye protection (to prevent injury from product), and a hard hat (to prevent injury from overhangs and projections on the prover and at the test site).**
- **Use proper grounding procedures!**
- **Be sure that the prover is equipped with an explosion-proof motor.**
- **Carefully inspect the electrical supply lines for the test equipment for wear or damage; correct potentially hazardous conditions before use**; protect lines from damage during use.
- **Remove fire extinguisher(s) from storage receptacle and set out for easy access.**
- **Use proper lifting techniques to lift and move equipment!**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic in the area.**

1. Wet the prover (fill to nominal capacity). Allow a 30 second drain period each time the prover is emptied. NIST HB 105-4

2. Exercise care to reduce to a minimum vaporization and volume change..... N.2.

3. Read the temperature and pressure of the product in the prover immediately following each test draft and make appropriate corrections to the test results to account for changes in volume between the meter and the prover due to temperature..... N.5.

	H-44 General Code and LPG and Anhydrous Ammonia LMD Code References - 2015

Test Notes (cont.):

4. Print a ticket/receipt after each test run (if so equipped)	G-S.5.2.2., G-S.5.6.
Vehicle-mounted systems shall be equipped with a ticket printer.	UR.2.5., UR.2.6.
If computing type, check price computation on indicator and on recorded representations	S.1.1.6.,
Check for agreement between indicators	G-S.5.2.2., S.1.1.5.
5. Verify that any options for obtaining a recorded representation are appropriate. The customer may be given the option of not receiving the recorded representation. If the system is equipped with the capability, the customer may also be given the option of receiving the recorded representation electronically in lieu of or in addition to a hard copy.	G-S.5.6.
6. If the device is of the computing type, check price computations	
Money-value computations on stationary retail devices	G-S.5.5., S.1.1.5., N.4.3.2. S.1.5.2.
7. To determine proper operation of totalizers, observe and record the totalizer indication before and after all test drafts.	

Test:

If the result of any test is at or near the tolerance, repeat the test. If necessary, conduct a repeatability test as outlined in "Repeatability Test" below.

Nontemperature-compensated meters

Read the temperature of the product at the meter at one-third and two-thirds prover capacity	N.5.
1. Normal test - full flow, normal tolerance	N.2., N.4.1., N.5., T.2.
2. Repeat the normal test.	
3. Special test - slow flow, special tolerance	N.2., N.5., T.2.
Motor-fuel devices	N.4.1.2.
Other retail devices	N.4.2.2.
Wholesale devices	N.4.2.3.

Test (cont.):

If the result of any test is close to or outside the applicable tolerance, repeat that test.

Repeatability Test ..... N.4.1.2., T.3.
If necessary, conduct a repeatability test. A repeatability test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size.

Temperature-compensated meters

1. Normal test - full flow, normal tolerance. (Do not deactivate the temperature compensator.)..... N.2., N.4.1., N.4.1.1., N.5., T.2.,

2. Deactivate the temperature compensator and repeat the normal test..... N.2., N.4.1.1., N.5., T.2., T.4.

3. Special test - slow flow, special tolerance..... N.2., N.4.2.1., N.5., T.2.
   Motor-fuel devices ..... N.4.1.2.
   Other retail devices..... N.4.2.2.
   Wholesale devices ..... N.4.2.3.

If the result of any test is close to or outside the applicable tolerance, repeat that test. N.4.1.2., T.3.

All Meters

Repeatability Test N.2., N.4.1.2., T.3.
If necessary, conduct a repeatability test. A repeatability test must include at least three consecutive test drafts. Test drafts must be conducted under approximately the same conditions (e.g., flow rate and temperature) and be of approximately the same draft size.

Reactivate the temperature compensator.

Post-Test Tasks:

Security seal and audit trail. ..... S.2.2., Table S.2.2., S.2.6.2.

- Apply security seals to secure the meter and temperature adjusting mechanisms.
- Also seal the register to the meter.
- Record audit trail information (if applicable) on the official report.

Note the final totalizer reading and record the number of gallons of product dispensed during the test on the official test report.

EPO No. 28

Examination Procedure Outline (EPO) for

Compressed Natural Gas (CNG)
Retail Motor-Fuel Dispensers

It is recommended that this outline be followed as minimum criteria for examining retail motor-fuel dispensers used to measure compressed natural gas. Non-retroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

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

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

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

Asphyxiation

Chemicals, Petroleum Products, and Hazardous Materials

Clothing

Electrical Hazards

Emergency Procedures

Fire Extinguisher

First Aid Kit

Grounding

High Pressure Gas

Ignition Sources

Lifting

Location

Material Safety Data Sheet (MSDS)

Nature of Product

Personal Protection Equipment

e.g., Eye Protections, Safety Shoes

Safety Cones/Warning Signs

Static Discharge

Traffic

Transportation of Equipment

Equipment List:

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

Scale

- Intrinsic safety - scale meets Underwriters Laboratory (UL) Area Classification Class 1 Division 2 Group D (scale equipment must be located outside of classified area which is five feet from the hose fueling connection to the dispenser)
- Capacity
- Appropriate division size
- Type of power source

See the Appendix to EPO 28 for information on Scale Selection Criteria and Verifying Scale Accuracy.

Mass Standards

- Class F

Test Cylinder

- Rating - must be equivalent to or greater than the service pressure marked on the device under test as required by the ANSI/IAS NGV 4.1/CSA 12.5 "NGV Dispensing Systems," Standard for Natural Gas Vehicle Dispensing Systems
- Compatible fittings
- Bleed valve
- Pressure gauge
- Drain hose
- Means for grounding the cylinder prior to connecting to dispensing equipment such as a quick connect ground strap

Note: Service pressure is the settled pressure at a uniform gas temperature of 21 ºC (70 ºF) and full gas content. It is the pressure for which the equipment has been constructed under normal conditions. This is different from the maximum working pressure.

Optional Equipment:

- Cart
- Test cylinder supports (chocks)
- Weather shield/wind screen (for the weighing operation)

	HB 44 General Code and Mass Flow Meters Code References

Pretest Determination:

1. Select a site to locate the scale in the vicinity of the dispenser that is level and protected from wind and weather. Ensure that the scale is given a sufficient warm-up time.

2. Determine the scale error.

   Sufficient test weights should be available to verify the gross load to be applied during testing. The scale should be sensitive to 0.03 % or less of the total net weight of the product in the test cylinder. The value of the scale division should not exceed one-tenth of the tolerance applied to the smallest net load delivered through the device.

3. Scale capacity must be sufficient to weigh the test cylinder, optional chocks, and cart when filled to capacity with product.

4. Tolerances.
   - Applicable requirements..... G-T.1., G.T.2., T.1.
     Applicable tolerances in NIST Handbook 44.
   - Basic values..... T.2.
     Applicable tolerance for CNG application.

HB 44 General Code and Mass Flow Meters Code References

Inspection:

SAFETY REMINDER!!!

- **Check the inspection site carefully for safety hazards and take appropriate precautions pay particular attention to the condition of the test tank high pressure fitting and hoses.**
- **Learn the nature of hazardous products used at or near the inspection site; obtain and read copies of Material Safety Data Sheet (MSDS).**
- **Know emergency procedures and the location and operation of fire extinguishers and emergency shut-off system.**
- **Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.**
- **Use personal protection equipment and clothing appropriate for the inspection site.**
- **Make sure there is adequate ventilation to permit fumes to dissipate before proceeding with the inspection of the dispenser.**
- **If the product is leaking (most CNG contains an odorant), or inadvertently released, or exposed wiring cause hazardous testing conditions it is recommended that the testing be immediately discontinued until the unsafe conditions are corrected.**
- **Be sure that a first aid kit is available and that the kit is appropriate for the type of inspection activity.**
- **Use proper grounding procedures!**
- **Use proper low resistance grounding strap with recommended minimum conductance rating and correct connections consistent with the device under test.** (See the National Electrical Code or your local Occupational Safety and Health Administration (OSHA) for these requirements.)

1. General considerations.

Selection. ..... Equipment suitable for service.	G-UR.1.1.
Installation ..... Installed in accordance with manufacturer's instructions and does not adversely affect operation nor impede communications between indicator/recorder.	G-UR.2.1., G-UR.2.2., UR.2.1.
Position of equipment ..... During direct sales, indications are readable from a reasonable customer and operator position.	G-UR.3.3.
Accessibility ..... Located or such facilities provided for access to permit inspection, testing, and sealing.	G-UR.2.3.
Assistance ..... If required, operator to provide assistance in testing.	G-UR.4.4.

Inspection (cont.):

Use and maintenance.	G-UR.3.1., G-UR.4.1.
Proper operation and maintenance of equipment.	
2. Marking	
Location	G-S.1., S.5.,
Visible markings of the following information:	G-UR.2.1.1.,
Pattern approval mark.	S.5.1. (1/1/03)
Name and address of manufacturer.	
Model designation.	
Model prefix	
Nonrepetitive serial number	(1/1/03)
Serial number prefix	(1/1/68)
Accuracy class	(1/1/86), (1/1/01)
Maximum and minimum flow rates (quantity/unit time).	(1/1/95)
Maximum working pressure.	
Applicable temperature range (if other than −10 °C to 40 °C).	
Minimum measured quantity.	
Product limitations, if applicable.	
Remanufacturer information as appropriate.	
Name and ID of manufacturer	
Model number if different from original model number	G-S.1.2. (1/1/02)
Gasoline volume equivalent conversion factor	G-S.1.2. (1/1/02)
Software version for not-built-for purpose software-based devices	S.5.2.
Software prefix	G-S.1.(d) (1/1/04)
Location	(1/1/07)
	G-S.1.1. (1/1/04)
3. Indicating and recording elements	
Design	S.1.3.4., S.6.
Shall have clear accurate indicator.	G-S.5.1., S.1.1.
Computing type[1]	
Units	S.1.2.
Quantity indications in GLE or GGE.	S.1.3.1.1.
Mass display for inspection and testing.	
Gasoline Liter Equivalent (GLE) for units based on mass in kilograms, 1 GLE = 0.678 kg CNG	
Dispenser $Display_{GLE}$ = Dispenser Mass $Display_{\mathbf{kg}}$/ (0.678 kg/GLE), or	
Gasoline Gallon Equivalent (GGE) for units based on mass in pounds, 1 GGE = 5.660 lb CNG	
Dispenser $Display_{GGE}$ = Dispenser Mass $Display_{\mathbf{lb}}$/(5.660 lb/GGE).	

[1] Indicates an exception to this requirement for dispensers used exclusively for fleet sales, other price contract sales and truck refueling.

	HB 44 General Code and Mass Flow Meters Code References
Inspection (cont.):	
Readability	
Appropriate and accurate indicator and recorder.	
Clear and identified operational controls and indicator.	G-S.5., G-S.6. (1/1/77), G-S.7.
Lettering is clear and tends not to become obliterated.	
Values of intervals.....	
Values of graduated intervals shall be uniform.	
Maximum value of quantity-value divisions	G-S.5.3.
For units indicating in GLE, value is not greater than 0.01 GLE.	
For units indicating in GGE, value is not greater than 0.001 GGE.	S.1.3.3.(b)
Mass division shall not be greater than 0.001 kg or 0.001 lb.	
Auxiliary indications.....	
All money value and quantity divisions are identical to those of the primary element.	S.2.6.1.
Unit price and product identity.	
Display on each side	
Post information in direct sale[2]	
Selection of unit price[2]	S.2.5.1., S.2.5.2. UR.3.1
Advancement and return to zero.	S.2.5.3. (1/1/98)
Return indication to zero.	
Does not return beyond zero position	
Reset not operable during delivery	
Return primary indicator to zero prior to delivery	S.2.1.
Provision for sealing	S.2.2. S.2.8. (1/1/98), UR.3.7.
Audit trail format	G-S.8. (1/1/90), G-UR.4.5.
Metrological integrity protected by means of security.	S.3.5. (1/1/95), (1/l/96), (1/1/01)
Affix a seal to adjustment mechanisms.	
Recorded representations, point of sale systems.	
Cash register interfaced with dispenser shall record:	S.2.7. (1/1/86)
Total volume.	
Unit price.	
Total computed price.	
Product identity.	
4. Measuring Elements	
Means of security on adjusting mechanism.....	
Audit trail format.....	S.3.5. (1/1/95), (1/1/96), (1/1/01)
Adequate security or sealing for:	S.3.5. (1/1/95), (1/1/96), (1/1/01)
Measurement element.	
Adjustable elements that affect accuracy.	
Zero adjustment mechanism.	

[2] Indicates an exception to this requirement for dispensers used exclusively for fleet sales, other price contract sales and truck refueling.

	HB 44 General Code and Mass Flow Meters Code References

Inspection (cont.):

Note: If device is equipped with an audit trail, note audit trail information (e.g., counter values) on the inspection report or for devices with an event logger, print and attach event log to the report for future reference and comparison.

Directional flow valves ..... S.4.3.
Prevent flow reversal if it adversely affects device.

5. Discharge hose. ..... S.4.1., S.4.4., UR.1.1.(1/1/98)

No means of product diversion from measuring element.
It is apparent if there are two or more delivery outlets.
Discharge valve may be installed on wet-hose type.
Other shutoffs on outlet side of meter are automatic or semiautomatic predetermined stop type or operable by a separate tool or sealed open by means of security.
Length UR.1.1. (1/1/98)
Pressurizing the discharge hose..... S.3.7.
Discharge hose shall automatically pressurize prior to registration of delivery.

6. Automatic Density Correction..... S.3.6.

Test Notes:

SAFETY REMINDER!!!

- **Wear appropriate personal protection equipment such as nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from discharged product or propelled objects.**
- **Be certain the scale is intrinsically safe!**
- **Scale meets Underwriters Laboratory (UL) Rating for the Hazardous Area Classification**
- **Area Classification Class 1 Division 2 Group D (Locate the test equipment location outside of classified area which is five feet from hose connection to the dispenser.)**
- **Do not leave an activated dispenser unattended!**
- **Ground test tank and scale properly during fueling and return of product.**

1. Connect grounding cables to equipment.

2. Determine the tare weight of the test tank and record.
   Repeat this process prior to the delivery of each test draft.

3. To determine proper operation of the totalizer, observe and record the totalizer indications before and after all test drafts..... S.7. (1/1/98)

	HB 44 General Code and Mass Flow Meters Code References

Test Notes (cont.)

4. After each test draft:
   a) Print ticket if device is so equipped..... G-S.5.6., UR.3.4.
      - All recorded values shall be digital.
      - Total-price, quantity, and unit price must be on the receipt.

   b) Check price computations on all indicators (including consoles) and on recorded representations[3] ..... G-S.5.5., S.2.6.
      - Mathematical agreement of associated quantity or indication to the nearest one cent.

   c) Check all indicated and recorded values for proper comparability ..... G-S.5.2.2., S.2.5.4.(a), S.2.5.4.(b) (1/1/98)

   d) Check design of digital indication to determine that:
      - Like values agree.
      - Values coincide with analog value to nearest minimum graduation.
      - Value rounds off to nearest minimum unit.

5. A digital zero indication shall display all places to the right and at least one place to the left of the decimal point. ..... G-S.5.2.2.(d) (1/1/86), S.1.3.4.

Tests:

SAFETY REMINDER!!!

- **Ground test tank and scale properly during fueling and return of product.**
- **Use proper lifting techniques when lifting test tank!**
- **Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.**
- **Be aware of vehicular and pedestrian traffic when moving between dispenser and product return area.**

1. Normal test. ..... S.3.7., N.3., N.4., N.6.1., T.2., T.3.

   Computer jump:
   - Remove nozzle from dispenser and connect to test cylinder. (Test cylinder pressure should not be greater than 200 psi to simulate an actual delivery.)
   - Turn nozzle valve from "OFF" position to "FILL" position.
   - Empty discharge hose.
     - Turn nozzle valve to "OFF" position.
     - Activate dispenser.
   - Observe dispenser indications, if computer jump occurs, take appropriate action.

[3] Indicates an exception to this requirement for dispensers used exclusively for fleet sales, other price contract sales and truck refueling.

Tests (cont.)

Note: A test cylinder is not necessary for the computer jump test on dispensers equipped with an autovent system. To test, turn dispenser on and observe the indication display for computer jump when the dispenser shuts off.

Minimum test procedures and draft sizes are as follows:

- Place empty test cylinder on the scale. (cylinder may be supported by chocks and stand.)
- Access mass display of the dispenser.
- Tare weight of the test cylinder, chocks, and stand
- Connect the nozzle to the test cylinder.
- Fill the test cylinder to **1/3 capacity** full at maximum flow rate.

SAFETY REMINDER!!!

– **Stop delivery manually if delivery hose pressure exceeds allowable safety limits.**

- Disconnect the nozzle from the test cylinder.
- Compare mass display to scale indication.
- Determine dispenser error ..... T.2.
- Leave product in test cylinder.
- Tare the weight of the test cylinder, chocks and stand.
- Connect the nozzle to the test cylinder.
- Begin the fill operation with product in the cylinder; fill cylinder to **2/3 capacity**[4] at maximum flow rate.

SAFETY REMINDER!!!

– **Stop delivery manually if delivery hose pressure exceeds allowable safety limits.**

- Disconnect the nozzle from the test cylinder.
- Compare mass display to scale indication.
- Determine dispenser error ..... T.2.
- Tare the weight of the test cylinder, chocks and stand.
- Connect the nozzle to the test cylinder.
- Begin the fill operation with product in the cylinder; fill the cylinder to **capacity** at maximum flow rate.

SAFETY REMINDER!!!

– **Stop delivery manually if delivery hose pressure exceeds allowable safety limits.**

- Disconnect the nozzle from the test cylinder.
- Compare mass display to scale indication.

[4] Based on the example of selecting a scale with a division size (d) of 0.02 kg, if 300 divisions (d) or 2.27 kilograms (5 pounds) is greater than 1/3 of the test cylinder capacity, then the test cylinder should be emptied to accommodate a delivery of at least 300 d or 2.27 kilograms (5 pounds) otherwise a larger tank is necessary.

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Test (cont.)

- Determine dispenser error ..... T.2.
- Return product to owner/operator of dispenser. ..... UR.3.8.
- Place empty test cylinder on scale
- Tare the weight of the test cylinder, chocks, and stand.
- Connect the nozzle to the test cylinder.
- Fill test cylinder **to capacity** at maximum flow rate.

> **SAFETY REMINDER!!!**
>
> – **Stop delivery manually if delivery hose pressure exceeds allowable safety limits.**

- Disconnect the nozzle from the test cylinder.
- Compare mass display to scale indication.
- Determine dispenser error ..... T.2.
- Return product to owner/operator of dispenser ..... UR.3.8.
- Repeating previous tests ..... T.3., N.6.1.1.
- Applicable tolerance for three or more consecutive tests at the same flow rate and draft size under controlled conditions.
- Return product to owner/operator of dispenser.
- If the meter minimum measured quantity (MMQ) is less than the smallest test draft, conduct a test with a test draft quantity equal to the MMQ value ..... N.4.

2. Check effectiveness of zero-set-back interlock ..... S.3.8., UR.3.6., UR.3.7.
   - No subsequent delivery is permitted until indicating and recording elements are returned to zero.
   - After delivery is complete, the dispenser starting lever (mechanism) is shut off, interlock is engaged, and discharge nozzle is placed in the designed hanging position. (**Note:** This does not apply to nozzle control.)
   - To check the effectiveness, first remove nozzle from hanging position.
   - Reset computer to zero and turn on dispenser.
   - Attempt to return the nozzle to its designed hanging position, carefully remove nozzle and connect it to the test tank and open valve. Move the dispenser starting lever (mechanism) to "ON" position and attempt to dispense product. (**Note:** This does not apply to nozzle control.)

Product should not flow without resetting the indications to zero.

3. Check the operation of the low-flow cut-off valve. ..... UR.2.3.

   - Valve stops registration when flow is below the low-flow cut-off value.
   - Valve shall not be set lower that the minimum flow rate.
   - Connect the nozzle to the empty test tank and dispense product. Slowly begin to close the valve on the test tank to the minimum flow rate.

4. Power loss test ..... S.2.4.1., S.2.4.2.
   - Check with your supervisor before requiring shutdown of power to the equipment under test.
   - For transactions in progress at power loss, information shall be retainable for 15 minutes.
   - Device memory shall retain quantity of product and total sales price during power loss.

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Tests (cont.):

5. Security seal
   - Apply wire security seal to secure adjusting mechanism (if applicable)..... G-UR.4.5., S.3.5.

   Note on the official report the total number of gasoline gallon equivalents of product dispensed during the test.
   - After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments. ..... G-UR.4.1., G-UR.4.3.

Compressed Natural Gas (CNG)

Retail Motor-Fuel Dispensers

Reference Scale
Selection Criteria and Accuracy Verification

Scale Selection Criteria[5]:

Steps should be taken to eliminate the uncertainty[6] associated with reading weight values on the reference scale (test standard). The size of the scale division (*d*) for the reference scale should be taken into account along with the size of the net load because the relationship between these two values significantly affects the degree of accuracy to which a device can be tested. The size of *d* for the reference scale should be considered as part of the process for establishing the minimum test draft size so the draft is of a sufficient size to adequately evaluate the performance of the device under test. The size of d for the reference scale also affects the rounding error associated with reading the reference scale's indications to the nearest division. Note that a weight classifier is not suitable for use as a reference scale using these test procedures.

A digital electronic reference scale will round indications to the nearest scale division, which introduces a potential error of one-half *d* for each weight determination. Using a scale with a higher resolution, error weights to increase the readability of weight values, or the use of a larger test draft can reduce the rounding error. A combination of these approaches might be used to reduce errors. Each scenario must be evaluated on a case-by-case basis to ensure that you have selected the right approach or combination of approaches.

Likewise, when a mechanical scale is used error weights must be used in order to determine the weight indications as accurately as possible.

Reference Scale Division Value

Applying these principles, the "rounding error" (caused by reading the indicated weight value to the nearest scale division) can be held to an acceptably small level if the value of the scale division does not exceed one-tenth of the tolerance applied to the smallest net load likely from the CNG dispenser. This also ensures that the cumulative errors that can occur when reading scale indications, along with other factors that contribute to uncertainty in the reference scale's performance, do not use up the entire tolerance allowed for the test standard. When tolerances for the CNG dispenser were established, the inaccuracies associated with the use of the test standard were taken into account.

If the size of the test draft or net load must be small due to the capacity limitations of the available test cylinder(s) or when dispenser accuracy is being verified at the minimum attainable flow rate, then a reference scale must be selected with an appropriate division size. Consider an example in which the acceptance tolerance of ± 1.5 % for an Accuracy Class 2.0 mass flow meter (MFM) application (CNG) applies; the combined weight of the empty tank and the metered CNG is 22 kg; where the tank weight is 20 kg; and the CNG product weight is 2 kg.

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[5]The scale selection criteria and minimum test draft size for mass flow meter technology are discussed in the 1987 Report of the Committee on Specifications and Tolerances, Item 330-2 Recognize Mass Units for Metering.

[6]NIST IR 6919 Recommended Guide for Determining and Reporting Uncertainties for Balances and Scales (available on the NIST WMD web site at (http://www.nist.gov/pml/wmd/pubs/upload/NISTIR6919.pdf) includes a comprehensive description of how to determine and address uncertainties in balances and scales.

The tolerance is applied to the smallest net load indicated on the device under test (MFM), which in this case is 2 kg. The scale division selected for the reference scale is based on one-tenth of the tolerance applied to the smallest test load delivered during the test of the CNG dispenser and is calculated as follows:

Reference scale division (d) $\leq$ Smallest Test Load × Tolerance for the device under test × 1/10
$\leq$ 2 kg × 0.015 × 0.1
$\leq$ 0.003 kg

Thus, the scale division for the reference scale should be no greater than 0.003 kg or 3 g. Since the Scales Code of NIST Handbook 44 requires that the value of a scale division (d) be expressed in units of 1, 2, or 5, the reference scale division in this example must be no greater than 2 g.

Consider a second example in which the device under test indicates in inch-pound units; acceptance tolerance of ± 1.5 % for an Accuracy Class 2.0 mass flow meter (MFM) application (CNG) applies; the combined weight of the empty tank and the metered CNG is 50 lb; the tank weight is 45 lb; and the CNG product weight is 5 lb. Using the same formula as above, the maximum scale division for the reference scale is calculated as follows:

Reference scale division (d) $\leq$ Smallest Test Load × Tolerance for the device under test × 1/10
$\leq$ 5 lb × 0.015 × 0.1
$\leq$ 0.0075 lb

Thus, the scale division for the reference scale should be no greater than 0.0075 lb. Since the Scales Code of NIST Handbook 44 requires that the value of a scale division (d) be expressed in units of 1, 2, or 5, the reference scale division must be no greater than 0.005 lb.

Minimum Test Draft Size

The scale division size will also affect the size of the test draft required to evaluate the meter. Consider two examples in which a CNG dispenser is to be tested:

In Example 1 the reference scale is equipped with a 5 g division. Error weights should be used to increase readability of the scale to the nearest 0.5 g. Each weight value is, thus ± 0.25 g, reading to the nearest 0.5 g, but since there are two weighings, one to determine the gross weight and the other to establish the tare weight, the potential for total rounding error doubles to 0.5 g. To limit the error for each weighing to one-tenth of the tolerance, the minimum test draft size is calculated as follows:

$$\frac{\text{Readability of scale using error weights (kg or lb) x 10}}{\text{Tolerance for device under test}} = \text{Minimum test draft size (kg or lb)}$$

If the acceptance tolerance of ± 1.5 % applies; the minimum test draft size for the above example is calculated as follows:

Example 1:

$$\frac{(0.5 \text{ g x } 10)}{(0.015)} = 333.33 \text{ g} = 0.333 \text{ kg}$$

Thus, if a scale with a 0.5 g (higher resolution) size is used, or a scale with 5 g division size and corresponding error weights to 0.5 g is used and a tolerance of ± 1.5 % is applied, the minimum test draft is recommended to be at least 0.333 kg.

Consider Example 2, where the reference scale is equipped with a 0.01 lb division. Error weights should be used to increase readability of the scale to the nearest 0.001 lb. Each weight value is thus ± 0.0005 lb, reading to the nearest

0.001 lb, but since there are two weighings, one to determine the gross weight and the other to establish the tare weight, the potential for total rounding error doubles to 0.001 lb. To limit the error for each weighing to one-tenth of the tolerance, the minimum test draft size is calculated as follows:

$$\frac{\text{Readability of scale using error weights (kg or lb) x 10}}{\text{Tolerance for device under test}} = \text{Minimum test draft size (kg or lb)}$$

If the acceptance tolerance of ± 1.5 % applies; the minimum test draft size for each of the above examples is calculated as follows:

Example 2:

$$\frac{(0.001 \text{ lb x } 10)}{(0.015)} = 0.667 \text{ lb}$$

Thus, if a scale with a 0.001 lb division (higher resolution) size is used, or a scale with 0.01 lb division size and corresponding error weights to 0.001 lb are used and a tolerance of ±1.5 % is applied, the minimum test draft is recommended to be at least 0.667 lb.

Large relative errors result when rounding weight values for small loads. In the above examples, the potential error that occurs when rounding weight values can be reduced by increasing the test draft size. Other considerations may apply when determining the minimum test draft size such as average customer delivery and meter size. If the scale available for testing has a relatively large division size then the size of the test draft must be increased accordingly. (Also see the Tests section NOTE in EPO 28 for additional guidelines on determining the minimum test draft size.)

Verifying Scale Accuracy:

The Fundamental Considerations of NIST Handbook 44, specifies that it is necessary to limit the total error in a standard used without corrections to less than one-third of the tolerance applied to the device under test. For example, if applying the acceptance tolerance of 1.5 % to a CNG dispenser, the reference scale (i.e., the standard used for the test) must be accurate to at least 0.5 %. Consequently, it is necessary to thoroughly test the reference scale, verify that its results are repeatable, correct for any errors determined during the scale test, and use the scale properly. This takes considerable time and care under field conditions.