**Introduction** The purpose of this document is to establish recommended criteria relevant to the general calibration of scales and balances in the following areas:

A. Calibration tolerances
B. Calibration intervals
C. Uniform method for determining calibration test points

**Scope** The recommendations contained within this procedure are applicable to all scales and balances exclusive of micro and super microbalances or as required by the user. The intent of this procedure is to provide recommended general uniform calibration criteria for those scales and balances utilized in weighing applications for which calibration is required within XYZ for which the recommended general uniform calibration criteria is determined to be inappropriate should be handled on an individual case-by-case basis, with the affected calibration coordinator/user providing the required calibration criteria.

**Responsibilities**

A. Instrument Owner/User

1. To initiate action for placing a new scale/balance on the Calibration Program, or to revise the calibration status of a scale/balance already on the program by properly completing a Calibration Request Form and submitting the form to the responsible Divisional Calibration Coordinator.
2. To provide notification to the responsible Divisional Calibration Coordinator in the event that a scale/balance is to be used for a specific application for which general specifications are inappropriate.

**Responsibilities** (continued)

B. Divisional Calibration Coordinator

1. Review the Calibration Request Form received from owner/user for completeness and validity of included information.
2. To include, on the Calibration Request Form, calibration test points, tolerance, calibration intervals where those recommendations contained in this policy are determined to be inappropriate for the specific scale/balance application.

C. Corporate Metrology

1. For scales and balances utilized for general purpose weighing applications, establish recommended calibration test points, tolerances, and calibration intervals, or uniform methodologies for determining same.

2. To assure calibration measurement traceability to the National Institute of Standards and Technology (NIST) through applicable mass reference standards.

3. To maintain, on file, calibration records of each calibrated scale/balance and to provide records for review by authorized persons as required.

D. Calibration Agency

1. To calibrate applicable scales and balances determined to be used for general purpose weighing applications in accordance with the recommended criteria set forth in this policy unless otherwise directed by the responsible Divisional Calibration Coordinator.
2. To calibrate applicable scales and balances in accordance with approved written procedures defining proper calibration techniques and accuracies.

**Procedure** The calibration program is to ensure that all measuring equipment has been tested at appropriate test points and intervals to ensure that it will be within the accuracy limits required by its application. Careful consideration is to be given to the selection and establishment of calibration test points, tolerances, and calibration intervals. To provide standardization and uniformity for scales and balances used for GENERAL PURPOSE weighing applications, the following recommended calibration criteria have been developed.

A. Test Tolerance

The general tolerance to be applied to all scales and balances used for GENERAL
PURPOSE weighing applications is:

±0.1% of reading, or ±5 counts, whichever is the greater.

Due to the manner in which a balance indicates a reading, some consideration must be given to the usable range over which the above specification holds. In general, a digital balance is described in terms of the number of digits that are displayed to the right of the decimal point. For example a balance may be described as a 4-place analytical balance if the display is such that readability is to 0.0001g. At its limit, the tolerance on the balance in this example is +/-0.0005g. However it is important that the +/-0.1% of reading tolerance still be in effect at this limit.

N = the number of digits displayed to the right of the decimal point.

Then the resolution is $10^{-N}$ . The floor specification is then $5 \times 10^{-N}$. Finally the lowest reading ($R_L$) at which the +/-0.1%reading tolerance may be obtained with regards to the floor specification in grams is:

$R_L = 5 \times 10^{-N} / 0.001$.

For example, given a 4 place balance, the lowest reading at which a tolerance of +/-0.1% of reading may be obtained is:

$R_L = 5 \times 10^{-4} / 0.001 = 0.5g = 500mg$ Therefore, the minimum quantity that can be measured to achieve ±0.1% of reading is determined by the following algorithm: $R_L = 5 \times 10^{-N} /0.001$; where $R_L$ = minimum load to achieve ±0.1% of reading, N is the resolution of the balance.

The accuracy, or specified tolerance of a scale or balance is made up of many contributing factors. Therefore, many manufacturers do not provide an absolute uncertainty, or tolerance statement. Instead they usually provide individual specifications for items such as linearity, reproducibility, side-load error, etc., and leave it up to the individual user to determine the total uncertainty of the scale/balance.

While the listed recommended general tolerance may be larger than some manufacturer specifications, it is felt to be sufficiently accurate for most GENERAL PURPOSE applications.

B. Calibration Interval

In general, the initial calibration interval of six months should be used for all scales and balances utilized in GENERAL PURPOSE weighing applications.

This initial calibration interval is set to ensure continued measurement accuracies with due regards to product impact and calibration costs. The ensuing historical calibration data will be accumulated and periodically analyzed to optimize the intervals. Based on data results, the interval may be shortened or lengthened as deemed appropriate.

**Procedure** (continued)

C. Calibration Test Points

Unfortunately, unlike a tolerance or an interval, there is no single set of calibration test points that can be applied to all makes and models of scales and balances used for GENERAL PURPOSE applications.

In the absence of a single set of test points, the following guideline for establishing test points has been developed. Unless otherwise directed, this guideline will be used by the calibration agency in establishing calibration test points for all scales and balances used for GENERAL PURPOSE applications.

1. Zero-load Test As previously stated, there is no single set of calibration test points for all scales/balances; however, there is one single test that is applicable to all. This is the zero-load test.

The primary purpose for performing a zero-load test is to ensure that the balance/scale weighing mechanism indicates zero with no load applied. This is necessary, as the weighing process in which the balance/scale is to be used is a differential process rather than an absolute process.

Present practice is to perform a zero-load test prior to calibration in which the scale is set (if necessary) to read zero before further test points are attempted. Linearity of the scale is then verified by calibration at representative test points across the balance/scale range.

Technically it is felt that forcing the scale to read zero with no load applied, and then verifying that it is within the established tolerance limits at the test points, provides a verification that the scale is linear across its entire range.

**Procedure** (continued)

It is recommended that this zero-load test be accomplished for each balance/scale prior to making any weight accuracy tests.

2. Scales – Mechanical

In addition to a zero-load test, the mechanical scale reading face (chart), additional capacity (weighbeams, counterpoise weights), and shift (corner) accuracy will be tested as follows:

a) The scale reading face (chart) accuracy will be tested by weight testing at a minimum of four pre-selected points. The selected points must be representative of the full-scale range.
b) All scale weighbeams will be checked at half and full scale capacity.
c) Scale counterpoise weights will be checked in groups to allow for a minimum of calibration checks, while still assuring the accuracy of the weight.
d) A scale shift (corner) test will be accomplished by placing a weight(s) equal to or greater than half the scale capacity in the center of each quadrant of the scale platform.

3. Scale - Electronic Digital Display

In addition to a zero-load test, testing of the scale digital display and shift (corner) accuracy will be performed as follows:

a) The scale digital display accuracy will be tested by selecting a minimum of four points for weight testing. The selected points must be representative of the full-scale range.
b) A scale shift (corner) test will be accomplished by placing a weight(s) equal to or greater than half the scale capacity in the center of each quadrant of the scale platform.

**Procedure** (continued)

4. Balances – Mechanical (Single pan substitution weighing)

In addition to a zero-load test, the balance optical range, and internal weight set accuracy will be tested as follows:

a) The balance optical weighing range will be checked at a minimum of two points, mid and full-scale capacity.
b) The balance internal weights will be checked in combination such that not more than two unknown internal weights will be used at any test point.

5. Balances – Electronic Digital Display

In addition to a zero-load test, the balance digital range, and internal weight set accuracy will be tested as follows:

a) The balance digital weighing range will be checked at a minimum of four points selected to cover the full range

**Definitions**

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Balance/Scale</td><td>A measuring instrument used to determine the mass of a sample, by measuring the force which is exerted by the sample on its support within the gravitational field of the earth.<br><br>Note: The definition is the same for both scale and balance; however, generally speaking, and for the purpose of this policy, a balance is the term applied to those measuring instruments having an application class as defined by NIST Handbook 44, of I or II. Scale is the term applied to those measuring instruments having an application class of III, III L, or III.<br><br>NIST Handbook 44 class designations, or type of device for weighing applications is as follows:<br><br>
<table>
<tr><td>Class</td><td>Weighing Application</td><td>Measuring Inst. Type</td></tr>
<tr><td>I</td><td>Precision Laboratory Weighing</td><td>analytical balance</td></tr>
<tr><td>II</td><td>Laboratory weighing</td><td>precision balance</td></tr>
<tr><td>III</td><td>Commercial weighing</td><td>commercial scale</td></tr>
<tr><td>III L</td><td>Vehicle, axle-load livestock, & railway</td><td>track scale</td></tr>
<tr><td>III I</td><td>Highway weight enforcement, wheel- load weighers</td><td>portable axel-load weighing scale</td></tr>
</table>
</td></tr>
<tr><td>Analytical Balance</td><td>A balance with a readability of 4 places; i.e., 0.1 mg resolution.</td></tr>
<tr><td>Micro Balance</td><td>A balance with readability of 6 places; i.e., 1 µg resolution.</td></tr>
<tr><td>Super Micro Balance</td><td>A balance with readability of 7 places; i.e., A balance with readability of 7 places; i.e.,</td></tr>
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