ASTM

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Standard Method of Testing
Top-Loading, Direct-Reading Laboratory Scales and Balances[1]

This standard is issued under the fixed designation E 898; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This method is designed to test commonly used laboratory scales that read the entire range of weight up to the capacity without manual operation. In essence, the entire reading range is on-scale and no manipulation of weights, riders, or dials is required; except some scales with optical reading devices may require the operation of a micrometer dial to interpolate the final one or two significant figures.

1. Scope

1.1 This method covers the determination of characteristics of top-loading, direct-reading laboratory scales and balances. Laboratory scales of the top-loading type may have capacities from a few grams up to several kilograms. Resolution may be from 1/1000 of capacity to 1/1 000 000 or more. This method can be used for any of these instruments and will serve to measure the most important characteristics that are of interest to the user. The characteristics to be measured include the following:

1.1.1 warm-up,

1.1.2 off center errors,

1.1.3 repeatability, reproducibility, and precision,

1.1.4 accuracy and linearity,

1.1.5 hysteresis,

1.1.6 settling time,

1.1.7 temperature effects,

1.1.8 vernier or micrometer calibration, and

1.1.9 resistance to external disturbances.

1.2 The types of scales that can be tested by this method are of stabilized pan design wherein the sample pan does not tilt out of a horizontal plane when the sample is placed anywhere on the pan surface. The pan is located generally above the measuring mechanism with no vertical obstruction, except for draft shields. Readings of weight may be obtained from an optical scale, from a digital display, or from a mechanical dial. Weighing mechanisms may be of the deflecting type, using gravity or a spring as the transducer, or may be a force-balance system wherein an electromagnetic, pneumatic, hydraulic, or other force is used to counterbalance the weight of the sample. Other force-measuring devices may be tested by this method as long as a sample placed on a receiving platform produces an indication that is substantially a linear function of the weight of the sample.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Method

2.1 Throughout this method, the instrument is used in the manner for which it is intended. One or more weights are used to test each of the characteristics, and the results are expressed in terms of the least count or ultimate readability of the display.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:* [2]

3.1.1 *accuracy*—the degree of agreement of the measurement with the true value of the quantity measured.

3.1.2 *capacity*—the maximum weight load specified by the manufacturer. In most instruments, the maximum possible reading will exceed the capacity by a small amount.

3.1.3 *full-scale calibration*—the indicated reading when a standard weight equal to the full scale indication of the scale is placed on the sample pan after the device has been correctly zeroed. Usually some means is provided by the manufacturer to adjust the full scale indication to match the weight of the standard.

3.1.4 *linearity*—the degree to which a graph of weight values indicated by a scale vs. the true values of the respective test weights approximates a straight line. For a quantitative statement of linearity errors, the concept of terminal-based non-linearity is recommended, such as, the maximum deviation of the calibration curve (average of the readings at increasing and decreasing test load, respectively) from a straight line

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drawn through the upper and lower endpoints of the calibration curve.

3.1.5 *off-center errors*—differences in indicated weight when a sample weight is shifted to various positions on the weighing area of the sample pan.

3.1.6 *hysteresis*—difference in weight values indicated at a given test load depending on whether the test load was arrived at by an increase or a decrease from the previous load on the scale.

3.1.7 *repeatability*—closeness of agreement of the indicated values for successive weighings of the same load, under essentially the same conditions, approaching from the same direction (such as, disregarding hysteresis).

3.1.8 *reproducibility*—closeness of agreement of the indicated values when weighings of the same load are made over a period of time under essentially the same conditions but not limited to the same direction of approach (such as, hysteresis errors are included).

3.1.9 *precision*—the smallest amount of weight difference between closely similar loads that a balance is capable of detecting. The limiting factor is either the size of the digital step of the indicator readout or the repeatability of the indicated values.

3.1.10 *standard deviation*—used as a quantitative figure of merit when making statements on the repeatability, reproducibility or precision of a balance.

3.1.11 *readability*—the value of the smallest unit of weight that can be read without estimation. In the case of digital instruments, the readability is the smallest increment of the least significant digit (for example, 1, 2 or 5). Optical scales may have a vernier or micrometer for subdividing the smallest scale division. In that case, the smallest graduation of the vernier or micrometer represents the readability.

3.1.12 *standard weight*—any weight whose mass is given. Since weights are not always available with documented corrections, weights defined by class may be used if the class chosen has sufficiently small limits and there is an understanding that errors perceived as being instrumental in nature could be attributed to incorrectly adjusted weights.

4. Significance and Use

4.1 This method will enable the user to develop information concerning the precision and accuracy of weighing instruments. In addition, results obtained using this method will permit the most advantageous use of the instrument. Weaknesses as well as strengths of the instrument should become apparent. It is not the intent of this method to compare similar instruments of different manufacture, but to enable the user to choose a suitable instrument.

5. Apparatus

5.1 *Manufacturer's Manual*.

5.2 *Standard Weights*—A set of weights up to the capacity of the scale with sufficient subdivisions of weight so that increments of about 10 % of the capacity up to the capacity can be tested.

5.3 *Thermometer*, room temperature, with a resolution of at least 1 °C.

5.4 *Stop-Watch*, reading to ⅕ s.

6. Preparation

6.1 Make sure that the scale and weights are clean.

6.2 Place the standard weights near the instrument.

6.3 Place the thermometer on the bench in such a position that it can be read without being touched.

6.4 Allow the instrument and the weights to sit undisturbed for at least 2 h with the balance turned off. Monitor the temperature during this time to make sure that there is no more than approximately 2°C variation over the last hour before beginning the test.

6.5 Read the manufacturer's instructions carefully. During each step of the test procedure, the instrument should be used in the manner recommended by the manufacturer. Know the location of any switches, dials, or buttons as well as their functions.

7. Test Procedure

7.1 *Warm-up Test*:

7.1.1 If it is required in the normal operation of the scale to turn it "on" as an operation separate from weighing, perform that operation simultaneously with the starting of the stop-watch.

7.1.2 If a zeroing operation is required, do it promptly. Record the temperature.

7.1.3 At the end of 1 min, read and record the indication with the pan empty.

7.1.4 At the center of the sample pan place a standard weight nearly equal to but not exceeding 98 % of the capacity of the scale. If the scale allows no weight readings above the stated nominal capacity, then this test should be performed with standard weights equal to 90 % of capacity. When the indication is steady, record the indication and remove the weight from the pan.

7.1.5 At the end of 5 min, repeat steps 7.1.3 and 7.1.4 without rezeroing.

7.1.6 At the end of 30 min, repeat again.

7.1.7 At the end of 1 h, repeat again. Record the temperature.

7.1.8 Compute for each measurement as follows:

$$k_t = W/(I_w - I_o) \qquad (1)$$

where:
I_w = indication with the standard weight on the pan,
I_o = indication with pan empty,
W = known or assumed value of the standard weight, and
k_t = calibration factor for time t.

7.1.9 Plot the values of k_t against the time (1 min, 5 min, 30 min, and 60 min). The time at which k_t apparently no longer drifts in one direction can be assumed to be the warm-up time required.

7.1.10 If there is a user-adjustable full-scale calibration procedure recommended by the manufacturer, this adjustment should be made after the warm-up time determined in 7.1.9.

7.1.11 If the calibration cannot be adjusted by the user, the factor k_t can be used as a multiplier for an indicated weight to correct to true weight.

7.1.12 Plot I_o as a function of time to determine the zero drift. For individual measurements of weight, the zero can be monitored or corrected prior to a weighing. However, if the