UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

USBR 1012-89

PROCEDURE FOR

CALIBRATING BALANCES OR SCALES

INTRODUCTION

This procedure is under the jurisdiction of the Geotechnical Services Branch, Code D-3760, Research and Laboratory Services Division, Denver Office, Denver, Colorado. The procedure is issued under the fixed designation USBR 1012. The number immediately following the designation indicates the year of acceptance or the year of last revision.

1. Scope

1.1 This designation outlines the procedure for calibrating balances or scales used for standard laboratory testing.

1.2 This procedure is used to determine the calibration of a balance or scale over its full capacity range. The method described is used to periodically check laboratory balances or scales. If stringent calibration tolerances are required, this procedure should not be used; the apparatus should be inspected and calibrated by an appropriate certifying agency.

2. Applicable Documents

2.1 *USBR Procedure*:
USBR 3900 Standard Definitions of Terms and Symbols Relating to Soil Mechanics

2.2 *ASTM Standard*:
E 617 Standard Specification for Laboratory Weights and Precision Mass Standards

2.3 *National Bureau of Standards.*–Handbook 44 [1][1].

3. Summary of Method

3.1 Calibrated masses are placed on a balance or scale. The known mass value is compared to the balance or scale reading. The percent error is calculated, and the acceptability of the balance or scale is determined.

4. Significance and Use

4.1 Mass determinations are performed as part of virtually every laboratory soil testing procedure. Accurate mass determinations are required to ensure reliable laboratory test results. The following balances or scales are commonly used in soils laboratories: portable platform scale, fan scale, two-pan balance, and electronic balance.

4.2 It is recommended that each laboratory maintain a service contract with a company certified to perform maintenance and calibration on all scales or balances used by the laboratory. The contract should provide for annual inspection, and calibration if necessary.

4.3 If it is not feasible to maintain such a contract, the calibration checks should be performed by laboratory personnel. These should be performed annually, or more frequently if it is suspected that any scales or balances are not operating properly. Certified personnel should perform any necessary adjustments.

5. Terminology

5.1 Definitions are in accordance with USBR 3900.

5.2 Terms not included in USBR 3900 specific to this designation are:

5.2.1 *Error.*–The arithmetic difference between the mass of the precision mass standard and the balance or scale reading obtained for that standard.

5.2.2 *Percent Error.*–The ratio expressed as a percent of (1) the error calculated for a given precision mass standard, to (2) the mass of the precision mass standard.

5.2.3 *Tolerance.*–The acceptable mass deviation (error) within which a balance or scale is acceptable for most soil laboratory applications.

6. Apparatus

6.1 *Precision Mass Standards.*–Precision mass standards used for calibration of balances or scales must be of known accuracy. If suitable testing facilities for the calibration of these masses are not available locally, masses calibrated by the National Institute of Standards and Technology (formerly National Bureau of Standards) are available on request from the Bureau's Denver Office, code D-3730. Calibrated masses required for this procedure are to be such that the balance or scale may be loaded in increments equal to one-fourth, one-half, three-fourths, and total capacity of the balance or scale.

7. Precautions

7.1 *Safety Precautions*:

7.1.1 Ensure that electronic scales or balances are properly grounded and that power cords are not frayed or cut.

7.1.2 Inspect the portable scales to ensure proper mounting on the platform and that the platform and frame are constructed so as to provide sufficient strength and rigidity to prevent collapse when the scale or balance is in use.

[1] Number in brackets refers to the reference.

7.2 *Technical Precautions.*–Tables and floors on which the balances or scales are placed must not deflect.

8. Calibration and Standardization

8.1 Verify that the precision mass standards used for comparison readings are currently calibrated and meet the standards outlined in ASTM E 617. If the calibration is outdated, the precision mass standards should be calibrated before they are used for this procedure.

9. Conditioning

9.1 Perform this calibration procedure in an area that is isolated from heat sources, air currents, and vibrations. It is recommended that this calibration be performed in an environment which is as close to 68 °F (20 °C) as possible.

9.2 The balance or scale and the precision mass standards are to be placed in the environment in which they are to be calibrated for a period of at least 24 hours prior to calibration.

10. Procedure

10.1 All data are to be recorded on the "Balance or Scale Calibration" form as shown on figure 1.

10.2 Check the balance or scale to ensure that it is level and isolated from heat sources, air currents, and/or vibrations.

10.3 *Mechanical Balances or Scales*:

10.3.1 Balance the beam with no mass applied.

10.3.2 Place precision mass standards corresponding to 25, 50, 75, and 100 percent of the capacity of the balance or scale on the beam or pan.

10.3.3 Record the mass of the precision mass standard applied and the balance or scale reading for each mass.

10.3.4 Calculate error for each mass measurement.

10.3.5 Calculate percent error for each mass measurement.

10.4 *Electronic Balances or Scales*:

10.4.1 Plug the power cord into a power supply compatible to the power requirements of the electronic balance or scale.

NOTE 1.–A warmup period may be required for some electronic balances or scales.

10.4.2 Tare the balance or scale and check for a zero balance reading. Record the balance or scale reading as shown on figure 1.

10.4.3 Place precision mass standards corresponding to 25, 50, 75, and 100 percent capacity of the balance or scale on the beam or pan.

10.4.4 Record the mass of the precision mass standard applied and the balance or scale reading for each mass measurement.

10.4.5 Calculate error for each mass measurement.

10.4.6 Calculate percent error for each mass measurement.

11. Calculations

11.1 Calculate error for each mass measurement.

$$(4) = (2) - (3) \qquad (1)$$

where:

(4) = error, g or lbm
(2) = mass of precision mass standard, g or lbm
(3) = balance or scale reading, g or lbm

11.2 Calculate percent error for each mass measurement.

$$(5) = 100\,\frac{(4)}{(2)} \qquad (2)$$

where:

(5) = percent error
(4) = error, g or lbm
(2) = mass of precision mass standard, g or lbm
100 = convert from decimal to percent

12. Interpretation of Results

12.1 The following tables (1 and 2) are to be used to determine the acceptability of a balance or scale for most soil laboratory applications. If the computed error, for any precision mass standard placed on the calibrated balance or scale, is outside the acceptable tolerances—given in these tables—the balance or scale should be adjusted by certified personnel. These tables have been adapted in part from the National Bureau of Standards Handbook 44.

13. Report

13.1 The report is to consist of a completed and checked "Balance or Scale Calibration" form (fig. 1).

13.2 All calculations are to show a checkmark.

14. Reference

[1] National Bureau of Standards, Handbook 44, "*Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*," U.S. Department of Commerce, Washington, D.C., 1983.

Table 1.–Basic tolerances for balances or scales, inch-pound units.

Test mass From	Test mass To, but not including	Maximum allowable error, tolerance ±
Pounds		*Pounds*
0	1	0.002
1	2	.004
2	4	.008
4	7	.012
7	10	.016
10	15	.020
15	20	.023
20	30	.031
30	40	.039
40	50	.047
50	75	.062
75	100	.094
100	150	.125
150	200	.188
200	300	.250
300	400	.375
400	600	.500
600	800	.750
800	1000	.875
1000 and over		0.1 percent of test mass

Table 2.–Basic tolerances for balances or scales, SI units.

Test mass From	Test mass To, but not including	Maximum allowable error, tolerance ±
Grams		*Milligrams*
0	10	15
10	20	50
20	40	100
40	60	150
60	100	250
100	150	350
150	200	500
200	300	650
300	400	800
		Grams
400	500	1.0
500	750	1.5
750	1000	2.0
Kilograms		
1	2	4.0
2	3	5.5
3	5	7.5
5	10	11.0
10	15	15.0
15	20	19.0
20	30	25.0
30	40	35.0
40	50	45.0
50 kilograms and over		0.1 percent of test mass

7-2310 (9-85) Bureau of Reclamation	BALANCE OR SCALE CALIBRATION	Designation USBR 1012 - 89

Manufacturer Example Model No. SI Serial No. 100A

Type of balance or scale: Mechanical ☐ Electrical ☒ Other ____

Nominal capacity 3,000 grams Sensitivity 0.01 grams

Zero-balance reading 0.00 grams Date of calibration of precision mass standards 1/8/89

Calibration performed by Example Date 2/15/89

Calibration checked by Example Date 2/15/89

Trial (1)	Mass of precision mass standard (2) ☒ grams ☐ pounds	Balance or scale reading (3)	Error (4) = (2) − (3)	% Error (5) = $\frac{(4)}{(2)}$ x 100
1	0	0.00	0	0
2	750	750.73	−0.73	−0.10
3	1500	1500.99	−0.99	−0.07
4	2250	2250.89	−0.89	−0.04
5	3000	2999.96	0.04	0.001

REMARKS

Balance is acceptable.

GPO 848 - 600

Figure 1. – Balance or scale calibration — example.