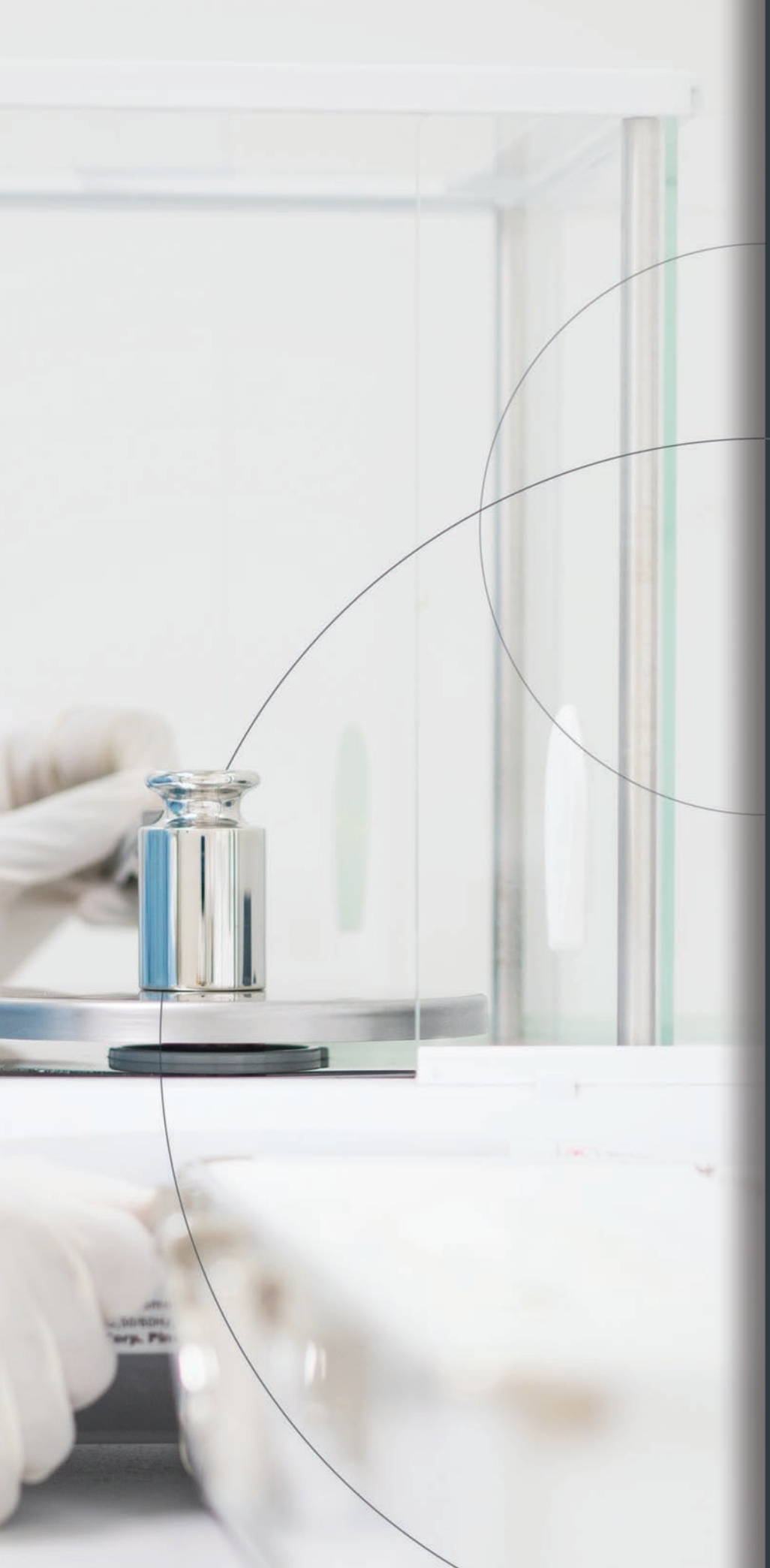


TABLE OF CONTENTS

234 Precision Mass Reference Standards and Calibration Weights

236 Weight Classification, International Laboratory Weights and Precision Mass Standards

238 Weight Classification, U.S. Laboratory Weights and Precision Mass Standards

240 Metric Weight Tolerances

241 Weight Classification, U.S. Field Standard

242 Weight Tolerance, Metric

243 Weight Tolerance, Avoirdupois

244 Weight Tolerance, Avoirdupois Ounces

245 Weight Tolerance, Troy Ounces

246 Weight Tolerance, Pennyweight and Grain

247 Weight Tolerance, Carats, Apothecary Scruples

248 Weight Tolerances for Historical NIST Handbook 105-1 (1990)

249 Conversion Factors for Units of Measure

250 Weight Cleaning Procedures

252 Environmental Impacts on Precise Measurements

254 Weights, Balances and Uncertainty

258 Properties of Magnetism in Mass Standards

261 Balance Verification Using Calibrated Weights

264 Glossary of Terms

266 A New Era of Measurement with the Redefined Kilogram

267 Historical Class F Calibration Weights

268 Trademarks

269 Terms and Conditions

271 Warranty and Limitation of Liability

275 Ingress Protection (IP) Ratings

275 Conversions

276 Shipping Information

Precision Mass Reference Standards and Calibration Weights

The following pages of this catalog contain all the information you'll need to place your mass standard or calibration weight order. If you're new to the specialized field of metrological weights, the selection process can be broken into five simple steps:

1. Determine the regulatory standard that applies to your application. The international standard (OIML) is summarized on page 236; the U.S. standard (ASTM E617) is summarized on page 238; the U.S. commercial standard for Legal for Trade applications (NIST Handbook 105-1) is summarized on page 241.
2. Determine the accuracy class appropriate for your application by reviewing the accuracy and tolerance information below and starting on page 240, as well as your internal ISO documentation and any applicable manufacturer's instructions.
3. Determine the type of laboratory documentation you require using the information gathered from steps 1 and 2.
4. Using the information from steps 1-3, select the weight or weight set and appropriate laboratory documentation for your application.
5. If your weights will require Legal for Trade certification prior to placing them in service, decide if you would like the certification to be handled by Rice Lake Weighing Systems' metrology labs - Wisconsin or California - accredited by the National Voluntary Laboratory Accreditation Program (NVLAP), or sent to your state lab. For more information on the certification process of NVLAP-accredited labs see page 2.

Accuracy Classes

Current Standard and Test Weight Accuracy Classes			Historical Classes	
Typical Use	**OIML[1]**	**ASTM E617[2]**	**NIST 105-1[3]**	**NBS CIR. 547[3]**
Certificate of Weight Calibration (Accredited) Is Recommended for...				
Primary Laboratory Reference Standard High precision standards for calibration of weights and special precision analytical balances accuracy Classes I and II (class number depending on precision).	E1	00		
	E2			
		0 and 1		M and S
Certificate of Weight Calibration (Non-accredited) Is Recommended for...				
High Accuracy Balances Working standard for precision analytical work, built-in weights and external weights used to calibrate moderate precision balances.	F1	2		
		3		S1
	F2			
Statement of Accuracy Is Acceptable for...				
Industrial Scales and Balances Accuracy Class III industrial scales, dial scales, trip balances, platform scales. Also used for accuracy Class IIIL and IIII, and weights used to calibrate scales in Legal for Trade applications.		4		P
	M1	5		Q
	M2	6	F	T
	M3	7		

[1] For more information on OIML Weight Classifications, see page 236

[2] For more information on ASTM Weight Classification, see page 238 (ASTM E617)

[3] Listed for reference only. NBS Cir. 547 has been superseded by ASTM E617 classifications

NOTE: All NIST Class F Weights placed into service prior to January 1, 2020

Precision Mass Reference Standards and Calibration Weights

Accuracy Classes, NIST Handbook 44

Class	Value of the Verification Scale Division (d or e[1])	Number of Scale[4] Divisions (n)	
		Minimum	Maximum
SI Units			
I	Equal to or greater than 1 mg	50,000	-
II	1 to 50 mg, inclusive	100	100,000
	Equal to or greater than 100 mg	5,000	100,000
III[2, 5]	0.1 to 2 g, inclusive	100	10,000
	Equal to or greater than 5 g	500	10,000
III L[3]	Equal to or greater than 2 kg	2,000	10,000
IIII	Equal to or greater than 5 g	100	1,200
U.S. Customary Units			
III[5]	0.0002 to 0.005 lb, inclusive	100	10,000
	0.005 to 0.125 oz inclusive	100	10,000
	Equal to or greater than 0.01 lb	500	10,000
	Equal to or greater than 0.25 oz	500	10,000
III L[3]	Equal to or greater than 5 lb	2,000	10,000
IIII	Greater than 0.01 lb	100	1,200
	Greater than 0.25 oz	100	1,200

Table 3 - Parameters for Accuracy Classes - Handbook 44

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

[2] A Class III scale marked "For prescription weighing only" may have a verification scale division (e) not less than 0.01g. (Added 1986) (Amended 2003)

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

[4] On a multiple range or multi-interval scale, the number of divisions for each range independently shall not exceed the maximum specified for the accuracy class. The number of scale divisions, n, for each weighing range is determined by dividing the scale capacity for each range by the verification scale division, e, for each range. On a scale system with multiple load receiving elements and multiple indications, each element considered shall not independently exceed the maximum specified for the accuracy class. If the system has a summing indicator, the nmax for the summed indication shall not exceed the maximum specified for the accuracy class. (Added 1997)

[5] The minimum number of scale divisions for a Class III hopper scale used for weighing grain shall be 2,000. [Nonretroactive as of January 1, 1986] (Amended 1986, 1987, 1997, 1998, 1999, 2003 and 2004)

Weight Classification, International Laboratory Weights and Precision Mass Standards

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY RECOMMENDATIONS OIML R111

OIML Weight Classification and Selection

OIML is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by national metrological services or related organizations of member states.

Main categories of OIML publications:

- International Recommendations (OIML R), which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML member states shall implement these recommendations to the greatest possible extent.
- International Documents (OIML D), which are informative in nature and intended to improve the work of metrological services.
- International Recommendations and International Documents are published in French (F) and English (E), and are subject to revision.
- OIML publications may be obtained from the organization's headquarters:

  Bureau International de Metrologie Legale 11
  Rue Turgot - 75009 Paris, France
  Telephone: 33 (1) 48 78 12 82 and 42 85 27 11
  Fax: 33 (1) 42 82 17 27
  Telex: 234 444 SVP SERV F ATTN. OIML
  www.OIML.org

General Information on Weight Classes: E1, E2, F1, F2, M1, M2

This recommendation contains the principle physical characteristics and metrological requirements for weights which are used:

- For the verification of weighing instruments
- For the verification of weights of a lower class of accuracy

The nominal values of mass of the weights covered by this recommendation range from 1 milligram (mg) to 50 kilograms (kg).

This recommendation applies to weights in classes of accuracy as follows: E1, E2, F1, F2, M1, M2 and M3.

Weights used for the verification of weighing instruments

The classes of accuracy of the weights used for the verification of weighing instruments shall be specified in the appropriate International Recommendations relating to these instruments.

Weights used for the verification of weights of a lower class of accuracy

E1 Weights intended to ensure traceability between national mass standards (with values derived from the International Prototype of the kilogram. The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be 6.626 070 15 × 10−34 when expressed in the unit J s, which is equal to kg m2 s−1, where the metre and the second are defined in terms of c and Δ vCs.) and weights of Class E2 and lower. Class E1 weights or sets of weights shall always be accompanied by a calibration certificate.

E2 Weights intended to be used for the initial verification of weights of Class F1. They may be used as Class E1 weights if they comply with the requirements for surface roughness and magnetic susceptibility of Class E1 weights and if their calibration certificate gives the appropriate data. Class E2 weights or sets of weights shall always be accompanied by a calibration certificate.

F1 Weights intended to be used for the initial verification of weights of Class F2.

F2 Weights intended to be used for the initial verification of weights of Class M1 and possibly M2. M1 weights intended to be used for the initial verification of weights of Class M2.

F1, F2 Weights used with instruments of accuracy Class I.

F2 Weights intended to be used for important commercial transactions (e.g. gold and precious stones) on weighing instruments of accuracy Class II.

M1 Weights intended to be used with weighing instruments of accuracy Class II.

M2 Weights intended to be used in normal commercial transactions and on weighing instruments of accuracy Class III.

M3 Weights intended to be used on weighing instruments of accuracy Classes III and IV.

The accuracy of weights used with weighing instruments shall be chosen in accordance with the requirements of OIML R 76 "Nonautomatic weighing instruments."

Excerpts from the Standard Specification for Laboratory Weights and Precision Mass Standards as Regulated by the Organization Internationale De Metrologie Legale (OIML): 2004 Edition (E) Publication OIML R 111-1

This specification covers various classes of weights and mass standards used in laboratories, and weights used for field standards and commercial measurement.

Construction

Class E1 and E2 Weights

Class E1 and E2 weights shall be solid and have no cavity open to the atmosphere. They shall have an integral construction, i.e., consist of a single piece of material.

Class F1 and F2 Weights

Class F1 and F2 weights from 1 gram to 50 kilograms may be one or more pieces from the same material. Class F1 and F2 weights may contain an adjusting cavity; however, the volume of this cavity shall not exceed one-twentieth of the total volume of the weight, and the cavity shall be closed either by means of the lifting knob or by any other suitable device.

Calibration or Initial Verification

Certain categories of new weights may either be calibrated individually or be subject to initial verification, depending on their intended use and the national legislation of the country.

Calibration weights shall be accompanied by a certificate which gives at least the conventional mass of each weight, its expanded uncertainty and the value of the coverage factor *k* (see coverage factor *k*).

Class E1 weights shall always be accompanied by certificates.

The certificate for Class E1 weights shall mention at least the values of conventional mass, the expanded uncertainty and the coverage factor *k*, and the density or volume for each weight.

The certificate for Class E2 weights shall mention at least:

- The values of conventional mass of each weight and the expanded uncertainty and the coverage factor *k*, or
- The information required for Class E1 weights certificates (under the conditions of the above paragraph).

Recalibration or Periodic Verification

The categories of weights which are subject to calibration or initial verification should either be recalibrated or have a periodic verification. This makes it possible to verify that the weights maintain their metrological properties. Any weights found defective at the time of the periodic verification shall be discarded or readjusted.

Uncertainty of Measurement

Standard Uncertainty

Uncertainty of the result of a measurement expressed as an estimated standard deviation.

Combined Standard Uncertainty

Standard uncertainty of a measurement result. When that result is obtained from the values of a number of quantities, it is equal to the positive square root of the appropriate sum of the variances and covariances of these quantities. The variance of quantity is the square of its standard deviation.

Expanded Uncertainty

The expanded uncertainty U is obtained by multiplying the combined standard uncertainty by the coverage factor, *k*. $U = k \times uc$

Coverage factor *k* — level of confidence

In most cases, it is appropriate to use the factor $k = 2$.

For the normal distribution, the factor $k = 2$ signifies that the limits of expanded uncertainty apply when the confidence level is approximately 95.45%.

Excerpts from the Standard Specification for Laboratory Weights and Precision Mass Standards as Regulated by the Organization Internationale De Metrologie Legale (OIML): 2004 Edition (E) Publication OIML R 111-1

This specification covers various classes of weights and mass standards used in laboratories, and weights used for field standards and commercial measurement.

Weight Classification, U.S. Laboratory Weights and Precision Mass Standards

Weight Classification and Selection

Selection of type and class depends upon the application of the weights. For primary standards, stability and information about the values of the weights is more important than the closeness of the values to nominal. Weights to be used with balances of low precision do not require small tolerances nor need the choice of materials to be limited to those of high stability. The suggested application table should serve as a guide in selecting weights for specific applications.

Type

Weights are divided into two types based upon the design:

Type I

These weights are of one-piece construction and contain no added adjusting material. They should be specified when weights are to be used as standards of the highest order and where maximum stability is required. A precise measurement of density can be made only for one-piece weights.

Type II

Weights of this type can be of any appropriate design such as screw-knob, ring or sealed plug. Adjusting material can be used as long as it is of a material at least as stable as the base material and is contained in such a way that it will not become separated from the weight.

Physical Characteristics

Class 00 and 0 must be Type I, one-piece construction, and Classes 1–7 can be either Type I or II depending on the application. All weights must meet other design requirements for density, hardness, permitted surface area, surface finish, magnetic properties, corrosion resistance, surface protection and markings. Class selection depends upon the degree of stability required. Density limitations are important in minimizing the effects of air buoyancy in high precision measurements. Class 0 weights shall not bear any indication of nominal value.

Class

Tolerance limitations are described in Classes 00, 0, 1, 2, 3, 4, 5, 6 and 7, as shown in the weight tolerance tables. Classes with small numerical designations represent smaller tolerances. Classes 0, 1 and 2 are used primarily in metric but are also available in avoirdupois denominations. Classes 3, 4, 5, 6 and 7 include tolerances for metric, avoirdupois pound, avoirdupois ounce, troy ounce, pennyweight and grain weights. Class 1 through 7 tolerances are comparable to those in the obsolete NIST Circular 547, Section 1, with the following exception: Class 1 replaces the smaller tolerances of Classes M and S, while Class 2 replaces the larger tolerances of Classes M and S.

Excerpts from the Standard Specification for Laboratory Weights and Precision Mass Standards: ASTM E617-23

This specification covers various classes of weights and mass standards used in laboratories, and weights used for field standards and commercial measurement are excluded, as NIST Handbook 105-1 and NIST Handbook 44 cover those classes of weights.

Application Table X1.1 ASTM E617-23

Class	Type	Application
0, 00 and 000	I	Primary laboratory reference standards
0	I	Reference standards used for calibrating Class 1 weights
0	I	Reference standards used for calibrating Class 2 weights
1	I	Reference standards used for calibrating Class 3 weights
1	II	Calibration weights used with calibration Class I balances
1	I or II	Built-in weights for high quality analytical balances
1 and 2	I or II	Calibration weights used with calibration Class II balances, laboratory weights for routine analytical work
2	I or II	Standards used for calibrating Class 4 weights
3	I or II	Standards used for calibrating Class 5 weights
4	I or II	Standards used for calibrating Class 6 weights
4,5 and 6	I or II	Calibration weights used with Class III, IIIL and IIII balances, dial scales, trip balances and platform scales
5 and 6	I or II	Student laboratory use
7	I or II	Rough weighing operations in physical and chemical laboratories such as force measuring apparatus

Term Abbreviations NIST Handbook 44, Appendix C

Units of Mass	
1 assay ton (AT)	29.167 grams
1 carat (c)	200 milligrams (exactly) / 3.086 grains
1 dram apothecaries (dr ap or ʒ)	60 grains (exactly) / 3.888 grams
1 dram avoirdupois (dr avdp)	27 11/32 (= 27.344) grains 1.772 grams
1 gamma (γ)	1 microgram (exactly)
1 grain (gr)	64.798 91 milligrams (exactly)
1 gram (g)	15.432 grains 0.035 ounce, avoirdupois
1 hundredweight, gross or long (gross cwt)	112 pounds (exactly) / 50.802 kilograms
1 hundredweight, gross or short (cwt or net cwt)	100 pounds (exactly) / 45.359 kilograms
1 kilogram (kg)	2.205 pounds
1 milligram (mg)	0.015 grain
1 ounce, avoirdupois (oz avdp)	437.5 grains (exactly) / 0.911 troy or apothecaries ounce / 28.350 grams
1 ounce, troy or apothecaries (oz t or oz ap or ℥)	480 grains (exactly) / 1.097 avoirdupois ounces / 31.103 grams
1 pennyweight (dwt)	1.555 grams
1 point	0.01 carat / 2 milligrams
1 pound, avoirdupois (lb avdp)	7,000 grains (exactly) / 1.215 troy or apothecaries pounds / 453.592 37 grams (exactly)
1 micropound (μlb) [the Greek letter mu in combination with the letters lb]	0.000 001 pound (exactly)
1 pound, troy or apothecaries (lb t or lb ap)	5,760 grains (exactly) / 0.823 avoirdupois pound / 373.242 grams
1 scruple (s ap or ℈)	20 grains (exactly) / 1.296 grams
1 ton, gross or long	2,240 pounds (exactly) / 1.12 net tons (exactly) / 1.016 metric tons
1 ton, metric (t)	2,204.623 pounds / 0.984 gross ton / 1.102 net tons
1 ton, net or short (tn)21	2,000 pounds (exactly) / 0.893 gross ton / 0.907 metric ton

Metric Weight Tolerances

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY RECOMMENDATIONS OIML R111

Tolerance for weights of denominations between those listed can be determined as follows:

- If the unit of measure is non-metric, convert the nominal value to a metric unit
- For weights that are between those listed, the tolerance for the next lower weight shall be applied

OIML R111-1 2004

Nominal Size	Class E1	Class E2	Class F1	Class F2	Class M1	Class M2	Class M3
	mg	mg	mg	mg	mg	mg	mg
5 000 kg			25,0000	80,000	250,000	800,000	2,500,000
2 000 kg			10,000	30,000	100,000	300,000	1,000,000
1 000 kg		1,600	5,000	16,000	50,000	160,000	500,000
500 kg		800	2,500	8,000	25,000	80,000	250,000
200 kg		300	1,000	3,000	10,000	30,000	100,000
100 kg		160	500	1,600	5,000	16,000	50,000
50 kg	25	80	250	800	2,500	8,000	25,000
20 kg	10	30	100	300	1,000	3,000	10,000
10 kg	5.0	16	50	160	500	1,600	5,000
5 kg	2.5	8.0	25	80	250	800	2,500
2 kg	1.0	3.0	10	30	100	300	1,000
1 kg	0.5	1.6	5.0	16	50	160	500
500 g	0.25	0.8	2.5	8.0	25	80	250
200 g	0.1	0.3	1.0	3.0	10	30	100
100 g	0.05	0.16	0.5	1.6	5.0	16	50
50 g	0.03	0.10	0.3	1.0	3.0	10	30
20 g	0.025	0.08	0.25	0.8	2.5	8.0	25
10 g	0.020	0.06	0.20	0.6	2.0	6.0	20
5 g	0.016	0.05	0.16	0.5	1.6	5.0	16
2 g	0.012	0.04	0.12	0.4	1.2	4.0	12
1 g	0.010	0.03	0.10	0.3	1.0	3.0	10
500 mg	0.008	0.025	0.08	0.25	0.8	2.5	
200 mg	0.006	0.020	0.06	0.20	0.6	2.0	
100 mg	0.005	0.016	0.05	0.16	0.5	1.6	
50 mg	0.004	0.012	0.04	0.12	0.4		
20 mg	0.003	0.010	0.03	0.10	0.3		
10 mg	0.003	0.008	0.025	0.08	0.25		
5 mg	0.003	0.006	0.020	0.06	0.20		
2 mg	0.003	0.006	0.020	0.06	0.20		
1 mg	0.003	0.006	0.020	0.06	0.20		

Reprinted OIML R111-1:2004(E)

Weight Classification, U.S. Field Standard

Specification and Tolerances for Field Standard Weights (NIST Handbook 105-1, Class F, Revised 2019)

These specifications and tolerances are minimum requirements for standards used primarily to test weighing devices.

Introduction

A Class F field standard weight (after this, called "weight") is intended to be used primarily to test commercial weighing devices for compliance with the requirements of NIST Handbook 44. Class F weights may be used to test most accuracy Class 2 III scales, all scales of Class IIIL or IV, and scales not marked with a class designation.

A weight shall be verified to be within tolerance prior to use. The within-tolerance status of a weight shall be rechecked as often as regulations or circumstances require, especially when damage to it is known or suspected.

General

These specifications apply to new weights placed in service after the publication of this standard; the tolerances apply to all weights in service.

A weight in service prior to the publication of this standard that has maintained Class F tolerances between verification tests shall continue to be acceptable.

The specifications permit the use of a weight at its nominal value in normal testing operations, where the tolerance on the item under test is at least three times as great as the tolerance of the weight.

NIST Handbook 44, Specifications Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. (See current edition.)
See Handbook 44, Section 2, Scales Code.
See Handbook 44, Appendix A, par. 3.2.

A partial list of specifications from Handbook 105-1

1. Material

1.1 A weight made of brass or a fabricated weight (such as a laminated weight or a weight of nonuniform density) shall not be placed in service after the publication date of this standard (1990).

1.2 A weight smaller than 5 grams (0.01 pounds) shall be constructed of stainless steel, tantalum, nickel-chromium alloy aluminum alloy, or other material sufficiently resistant to corrosion and oxidation that the surface need not be protected or coated.

1.3 A weight of 5 grams (0.01 pounds) up to and including 5 kilogram (10 pounds) shall be constructed of material having a hardness of Rockwell B 80 or greater (such as 300-series stainless steel), and be resistant to abrasion, corrosion, denting and chipping.

1.4 A weight larger than 5 kilograms (10 pounds) shall be constructed of materials such as iron, steel or stainless steel, have a hardness of Rockwell B 80 or greater, and be resistant to abrasion, corrosion, denting and chipping. Cast iron may be used for weights 10 kilograms (20 pounds) and larger. Body filler (e.g., fiberglass, putty or plaster) shall not be used to correct a poor casting or finish.

2. Finish

2.1 The surface finish of a new weight machined from round bar stock shall have a roughness average of 0.80 micrometers (32 microinches) or better, determined by use of a handheld surface roughness indicator (available from several manufacturers) or more accurate method, and be free of scratches, dents, and chipped corners or edges, determined by visual examination. A beaded or blasted finish (with roughness average 1.25 micrometers (50 microinches) or better) is acceptable on a cube weight to facilitate gripping.

2.2 A weight 5 kilograms (10 pounds) or less shall not have a surface coating.

2.3 A weight larger than 5 kilograms (10 pounds) constructed of materials susceptible to corrosion or tarnishing shall have a protective surface coating. A light coat of sprayed-on flat aluminum paint is recommended. Lacquer is also acceptable. Epoxy paint or plated surfaces are not acceptable. A coating is recommended for the bottom of a weight, particularly if the bottom is recessed. If paint or lacquer is used, it shall be hard and resistant to chipping. Cast metric and avoirdupois field standards shall be color coded (i.e. gold for metric and silver for avoirdupois) to differentiate the weights.

2.4 The surface finish of a cast weight shall have a roughness average of between 12.5 and 25 micrometers (50 and 1,000 microinches), determined by use of a handheld surface roughness indicator or more accurate method, and be free of sharp surface irregularities such as scabbing (as defined in ASTM A 025), visible cracks or holes which affect the surface finish average. Surface imperfections corrected by machining or welding are acceptable.

2.5 For a cast weight with a pipe handle, the casting near the handle must not be heavily cracked; the visible space between the handle and casting shall be as small as possible, consistent with good manufacturing practices. For cast weight with a handle welded in place, the welded seam shall be continuous and show not obvious air holes or cracks as determined by a visual examination.

2.6 Plating or coating shall not be used on a sheet metal type weight.

Weight Tolerance, Metric

ASTM E617-23

Nominal Size	Class 000	Class 00	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
	mg	mg	mg	mg	g and mg	g and mg	g and mg	g and mg	g and mg	g and mg
5 000 kg					25 g	50 g	100 g	250 g	500 g	750 g
3 000 kg					15 g	30 g	60 g	150 g	300 g	450 g
2 000 kg					10 g	20 g	40 g	100 g	200 g	300 g
1 000 kg					5.0 g	10 g	20 g	50 g	100 g	150 g
500 kg					2.5 g	5.0 g	10 g	25 g	50 g	75 g
300 kg					1.5 g	3.0 g	6.0 g	15 g	30 g	45 g
200 kg					1.0 g	2.0 g	4.0 g	10 g	20 g	30 g
100 kg					500 mg	1.0 g	2.0 g	5.0 g	10 g	15 g
50 kg	13 mg	25 mg	63 mg	120 mg	250	500 mg	1.0 g	2.5 g	5.0 g	7.5 g
30 kg	7.5	15	38	75	150	300	600 mg	1.5 g	3.0 g	5.1 g
25 kg	6.25	12.5	31	62	125	250	500	1.3 g	2.5 g	4.5 g
20 kg	5.0	10	25	50	100	200	400	1.0 g	2.0 g	3.8 g
10 kg	2.5	5.0	13	25	50	100	200	500 mg	1.0 g	2.2 g
5 kg	1.3	2.5	6.0	12	25	50	100	250	500 mg	1.4 g
3 kg	0.75	1.5	3.8	7.5	15	30	60	150	300	1.0 g
2 kg	0.5	1.0	2.5	5.0	10	20	40	100	200	750 mg
1 kg	0.25	0.5	1.3	2.5	5.0	10	20	50	100	470
500 g	0.13	0.25	0.60	1.2	2.5	5.0	10	35	70	300
300 g	0.075	0.15	0.38	0.75	1.5	3.0	6.0	30	60	210
200 g	0.05	0.10	0.25	0.50	1.0	2.0	4.0	20	40	160
100 g	0.025	0.05	0.13	0.25	0.50	1.0	2.0	10	20	100
50 g	0.015	0.030	0.060	0.12	0.25	0.60	1.2	5.0	10	62
30 g	0.014	0.026	0.037	0.074	0.15	0.45	0.90	3.0	6.0	44
20 g	0.013	0.025	0.037	0.074	0.10	0.35	0.70	2.0	4.0	33
10 g	0.010	0.020	0.025	0.050	0.074	0.25	0.50	1.0	2.0	21
5 g	0.005	0.010	0.017	0.034	0.054	0.18	0.36	0.75	1.5	13
3 g	0.005	0.010	0.017	0.034	0.054	0.15	0.30	0.64	1.3	9.4
2 g	0.005	0.010	0.017	0.034	0.054	0.13	0.26	0.56	1.1	7.0
1 g	0.005	0.010	0.017	0.034	0.054	0.10	0.20	0.45	0.90	4.5
500 mg	0.002	0.003	0.005	0.010	0.025	0.080	0.16	0.36	0.72	3.0
300 mg	0.002	0.003	0.005	0.010	0.025	0.070	0.14	0.31	0.61	2.2
200 mg	0.002	0.003	0.005	0.010	0.025	0.060	0.12	0.27	0.54	1.8
100 mg	0.002	0.003	0.005	0.010	0.025	0.050	0.10	0.22	0.43	1.2
50 mg	0.002	0.003	0.005	0.010	0.014	0.042	0.085	0.17	0.35	0.88
30 mg	0.002	0.003	0.005	0.010	0.014	0.038	0.075	0.15	0.30	0.68
20 mg	0.002	0.003	0.005	0.010	0.014	0.035	0.070	0.13	0.26	0.56
10 mg	0.002	0.003	0.005	0.010	0.014	0.030	0.060	0.10	0.21	0.40
5 mg	0.002	0.003	0.005	0.010	0.014	0.028	0.055	0.083	0.17	
3 mg	0.002	0.003	0.005	0.010	0.014	0.026	0.052	0.071	0.14	
2 mg	0.002	0.003	0.005	0.010	0.014	0.025	0.050	0.062	0.12	
1 mg	0.002	0.003	0.005	0.010	0.014	0.025	0.050	0.050	0.10	
0.5 mg	0.002	0.003	0.005	0.010	0.014	0.025	0.050	0.050	0.080	
0.3 mg	0.002	0.003	0.005	0.010	0.014	0.025				
0.2 mg	0.002	0.003	0.005	0.010	0.014					
0.1 mg	0.002	0.003	0.005	0.010						
0.05 mg	0.002	0.003	0.005	0.010						

**Reprinted, with permission from the Annual Book of ASTM Standards, Copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. *Reprinted ASTM E617.*

Weight Tolerance, Avoirdupois

ASTM E617-23

Nominal Size	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
	mg	mg	mg	g and mg	g and mg	g and mg	g and mg	g and mg
10 000 lb				45 g	91 g	230 g	450 g	680 g
5 000 lb				23 g	45 g	110 g	230 g	340 g
3 000 lb				14 g	27 g	68 g	140 g	200 g
2 500 lb				11 g	23 g	57 g	110 g	170 g
2 000 lb				9.1 g	18 g	45 g	91 g	140 g
1 000 lb				4.5 g	9.1 g	23 g	45 g	68 g
500 lb				2.3 g	4.5 g	11 g	23 g	34 g
300 lb				1.4 g	2.7 g	6.8 g	14 g	20 g
200 lb				910 mg	1.8 g	4.5 g	9.1 g	14 g
100 lb	57	110	230	450	910 mg	2.3 g	4.5 g	6.8 g
50 lb	29	57	110	230	450	1.1 g	2.3 g	4.1 g
30 lb	17	32	68	140	270	680 mg	1.4 g	2.7 g
25 lb	14	28	57	110	230	570	1.1 g	2.4 g
20 lb	12	23	45	91	180	450	910 mg	2.0 g
10 lb	5.5	11	23	45	91	230	450	1.3 g
5 lb	2.7	5.4	11	23	45	110	230	780 mg
3 lb	1.7	3.4	6.8	14	27	68	140	580
2 lb	1.2	2.3	4.5	9.1	18	45	91	440
1 lb	0.55	1.1	2.3	4.5	9.1	35	70	270
0.5 lb	0.27	0.54	1.1	2.3	4.5	23	45	170
0.3 lb	0.17	0.34	0.68	1.4	2.7	14	27	120
0.2 lb	0.12	0.23	0.45	0.91	1.8	9.0	18	97
0.1 lb	0.055	0.11	0.23	0.57	1.1	4.5	9.1	59
0.05 lb	0.037	0.074	0.11	0.36	0.77	2.3	4.5	37
0.03 lb	0.029	0.059	0.083	0.32	0.59	1.4	2.7	26
0.02 lb	0.024	0.047	0.070	0.23	0.45	0.91	1.8	20
0.01 lb	0.017	0.034	0.054	0.16	0.34	0.73	1.5	12
0.005 lb	0.017	0.034	0.054	0.14	0.27	0.58	1.2	7.8
0.003 lb	0.017	0.034	0.054	0.11	0.22	0.50	0.99	5.4
0.002 lb	0.015	0.030	0.049	0.091	0.19	0.44	0.87	4.2
0.001 lb	0.0050	0.010	0.024	0.078	0.15	0.35	0.70	2.9
0.0005 lb	0.0045	0.0091	0.023	0.064	0.13	0.28	0.56	2.0
0.0003 lb	0.0045	0.0091	0.023	0.054	0.11	0.23		1.5
0.0002 lb	0.0045	0.0091	0.023	0.045	0.095	0.20		1.2
0.0001 lb	0.0045	0.0091	0.023	0.041	0.086	0.16		0.84

**Reprinted, with permission from the Annual Book of ASTM Standards, Copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. *Reprinted ASTM E617.*

Weight Tolerance, Avoirdupois Ounces

ASTM E617-23

Nominal Size	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
	mg	mg	mg	mg	mg	mg	mg	mg
10 oz	0.35	0.70	1.4	2.8	5.4	28	57	200
8 oz	0.27	0.54	1.1	2.3	4.5	23	45	170
5 oz	0.18	0.35	0.71	1.4	2.8	14	28	130
4 oz	0.14	0.28	0.57	1.1	2.3	11	23	110
3 oz	0.10	0.21	0.43	0.91	1.8	8.5	17	90
2 oz	0.070	0.14	0.28	0.64	1.3	5.7	11	70
1 oz	0.037	0.074	0.14	0.43	0.86	2.8	5.4	42
1/2 oz	0.030	0.060	0.085	0.30	0.59	1.4	2.8	27
1/4 oz	0.020	0.041	0.062	0.20	0.43	0.84	1.7	17
1/8 oz	0.017	0.034	0.054	0.16	0.31	0.67	1.3	10
1/16 oz	0.017	0.034	0.054	0.12	0.24	0.50	1.1	6.5
1/32 oz	0.014	0.029	0.047	0.095	0.19	0.43	0.87	4.2
1/64 oz	0.0050	0.010	0.023	0.077	0.15	0.35	0.69	2.8

**Reprinted, with permission from the Annual Book of ASTM Standards, Copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. *Reprinted ASTM E617.*

Weight Tolerance, Troy Ounces

ASTM E617-23

Nominal Size	Class 000	Class 00	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
						mg	mg	g and mg		
1000 oz t						310	620	1.6 g	3.1 g	
500 oz t						160	310	780 mg	1.6 g	
300 oz t						91	190	470	930 mg	
200 oz t						62	120	310	620	
100 oz t						31	62	160	310	
50 oz t						16	31	78	160	
30 oz t						9.1	19	47	93	
20 oz t						6.2	12	39	77	
10 oz t						3.1	6.2	30	61	
5 oz t						1.6	3.1	16	31	
3 oz t						0.91	1.9	9.3	19	
2 oz t						0.71	1.4	6.2	12	
1 oz t						0.45	0.91	3.1	6.2	
0.5 oz t						0.31	0.62	1.6	3.1	
0.3 oz t						0.24	0.49	0.92	1.8	
0.2 oz t						0.20	0.40	0.80	1.6	
0.1 oz t						0.15	0.30	0.65	1.3	
0.05 oz t						0.12	0.23	0.52	1.0	
0.03 oz t						0.097	0.19	0.44	0.88	
0.02 oz t						0.084	0.17	0.39	0.77	
0.01 oz t						0.071	0.14	0.31	0.62	
0.005 oz t						0.056	0.11	0.25	0.50	

**Reprinted, with permission from the Annual Book of ASTM Standards, Copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. *Reprinted ASTM E617.*

Weight Tolerance, Pennyweight and Grain

ASTM E617-23

Nominal Size	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
				mg	mg	mg	mg	
10,000 dwt				155	310	780	1600	
5,000 dwt				78	160	390	780	
3,000 dwt				47	91	230	470	
2,000 dwt				31	62	160	310	
1,000 dwt				16	31	78	160	
500 dwt				7.8	16	43	87	
300 dwt				4.7	9.1	34	68	
200 dwt				3.1	6.2	30	61	
100 dwt				1.6	3.1	16	31	
50 dwt				0.78	1.6	7.8	16	
30 dwt				0.58	1.2	4.7	9.3	
20 dwt				0.46	0.91	3.1	6.2	
10 dwt				0.31	0.62	1.6	3.1	
5 dwt				0.22	0.44	0.89	1.7	
3 dwt				0.17	0.34	0.73	1.5	
2 dwt				0.15	0.3	0.65	1.3	
1 dwt				0.12	0.23	0.52	1.0	

Nominal Size	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
				mg	mg	mg	mg	
10,000 gr				6.5	13	36	79	
5,000 gr				3.2	6.5	31	61	
3,000 gr				1.9	3.9	19	39	
2,000 gr				1.3	2.6	13	26	
1,000 gr				0.71	1.4	6.5	13	
500 gr				0.48	0.91	3.2	6.5	
300 gr				0.35	0.65	1.9	3.9	
200 gr				0.28	0.57	1.3	2.6	
100 gr				0.20	0.4	0.82	1.6	
50 gr				0.15	0.3	0.65	1.3	
30 gr				0.12	0.25	0.55	1.1	
20 gr				0.11	0.21	0.48	0.91	
10 gr				0.084	0.17	0.42	0.77	
5 gr				0.071	0.14	0.31	0.62	
3 gr				0.060	0.12	0.25	0.53	
2 gr				0.054	0.11	0.22	0.45	
1 gr				0.045	0.091	0.17	0.37	
0.5 gr				0.039	0.078	0.14	0.31	

**Reprinted, with permission from the Annual Book of ASTM Standards, Copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. *Reprinted ASTM E617.*

Weight Tolerance, Carats, Apothecary Scruples

ASTM E617-23

Nominal Size	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
				mg	mg		mg	
5 000 c				10	20			
3 000 c				6.0	12			
2 000 c				4.0	8.0			
1 000 c				2.0	4.0			
500 c				1.0	2.0			
300 c				0.69	1.3			
200 c				0.52	1.0			
100 c				0.35	0.7			
50 c				0.25	0.50			
30 c				0.19	0.40			
20 c				0.16	0.33			
10 c				0.13	0.26			
5 c				0.10	0.20			
3 c				0.086	0.17			
2 c				0.075	0.15			
1 c				0.060	0.12			
0.5 c				0.050	0.10			
Apothecary Ounce								
12 oz ap							64	
10 oz ap							61	
6 oz ap							37	
5 oz ap							31	
4 oz ap							25	
3 oz ap							19	
2 oz ap							12	
1 oz ap							6.2	
Apothecary Dram								
6 dr ap							4.7	
5 dr ap							3.9	
4 dr ap							3.1	
3 dr ap							2.3	
2 dr ap							1.8	
1 dr ap							1.4	
Apothecary Scruple								
2 s ap							1.2	
1 s ap							0.91	

**Reprinted, with permission from the Annual Book of ASTM Standards, Copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. *Reprinted ASTM E617.*

Weight Tolerances for Historical NIST Handbook 105-1 (1990)

NIST Handbook

NIST Class F

Tolerances are based on NIST Handbook 105-1 (1990)

Metric

Nominal Size	105-1 Class F g and mg
500 kg	50 g
300 kg	30 g
200 kg	20 g
100 kg	10 g
50 kg	5.0 g
30 kg	3.0 g
20 kg	2.0 g
10 kg	1.0 g
5 kg	0.50 g
3 kg	0.30 g
2 kg	0.20 g
1 kg	0.10 g
500 g	70 mg
300 g	60 mg
200 g	40 mg
100 g	20 mg
50 g	10 mg
30 g	6.0 mg
20 g	4.0 mg
10 g	2.0 mg
5 g	1.5 mg
3 g	1.3 mg
2 g	1.1 mg
1 g	0.90 mg
500 mg	0.72 mg
300 mg	0.61 mg
200 mg	0.54 mg
100 mg	0.43 mg
50 mg	0.35 mg
30 mg	0.30 mg
20 mg	0.26 mg
10 mg	0.21 mg
5 mg	0.17 mg
3 mg	0.14 mg
2 mg	0.12 mg
1 mg	0.10 mg

Avoirdupois Pounds

Nominal Size	105-1 Class F g and mg
10,000 lb	450 g
5,000 lb	230 g
3,000 lb	140 g
2,500 lb	110 g
2,000 lb	91 g
1,000 lb	45 g
500 lb	23 g
100 lb	4.5 g
50 lb	2.3 g
30 lb	1.4 g
25 lb	1.1 g
20 lb	0.91 g
10 lb	0.45 g
5 lb	230 mg
3 lb	140 mg
2 lb	91 mg
1 lb	70 mg
0.5 lb	45 mg
0.3 lb	27 mg
0.2 lb	18 mg
0.1 lb	9.1 mg
0.05 lb	4.5 mg
0.03 lb	2.7 mg
0.02 lb	1.8 mg
0.01 lb	1.5 mg
0.005 lb	1.2 mg
0.003 lb	0.99 mg
0.002 lb	0.87 mg
0.001 lb	0.70 mg

Avoirdupois Ounces

Nominal Size	105-1 Class F mg
8 oz	45 mg
4 oz	23 mg
2 oz	11 mg
1 oz	5.4 mg
0.5 (1/2) oz	2.8 mg
0.3 oz	1.8 mg
0.25 (1/4) oz	1.7 mg
0.2 oz	1.6 mg
0.125 (1/8) oz	1.3 mg
0.1 oz	1.3 mg
0.0625 (1/16) oz	1.1 mg
0.05 oz	1.0 mg
0.03125 (1/32) oz	0.87 mg
0.03 oz	0.85 mg
0.02 oz	0.75 mg
0.012325 (1/64) oz	0.69 mg
0.01 oz	0.60 mg

Conversion Factors for Units of Measure

To convert one unit of measure to another, use our online weight conversion tool located with our resources found at **www.ricelake.com/scaletools.**

Units of Mass Not Greater than Pounds and Kilograms

(All underlined figures are exact) multiply by the conversion factor below the ending

Units	Grains	Apothecaries Scruples	Pennyweights	Avoirdupois Drams	Apothecaries Drams	Avoirdupois Ounces
1 grain =	1	0.05	0.041 666 67	0.036 571 43	0.016 666 67	0.002 285 714
1 apoth. scruple =	20	1	0.833 333 3	0.731 428 6	0.333 333 3	0.045 714 29
1 pennyweight =	24	1.2	1	0.877 714 3	0.4	0.054 857 14
1 avdp. dram =	27.343 75	1.367 187 5	1.139 323	1	0.455 729 2	0.062 5
1 apoth. dram =	60	3	2.5	2.194 286	1	0.137 142 9
1 avdp. ounce =	437.5	21.875	18.229 17	16	7.291 667	1
1 apoth. or troy oz. =	480	24	20	17.554 29	8	1.097 143
1 apoth. or troy pound =	5 760	288	240	210.651 4	96	13.165 71
1 avdp. pound =	7 000	350	291.666 7	256	116.666 7	16
1 milligram =	0.015 432 36	0.000 771 617 9	0.000 643 014 9	0.000 564 383 4	0.000 257 206 0	0.000 035 273 96
1 gram =	15.432 36	0.771 617 9	0.643 014 9	0.564 383 4	0.257 206 0	0.035 273 96
1 kilogram =	15432.36	771.617 9	643.014 9	564.383 4	257.206 0	35.273 96

Units	Apothecaries or Troy Ounces	Apothecaries or Troy Pounds	Avoirdupois Pounds	Milligrams	Grams	Kilograms
1 grain =	0.002 083 333	0.000 173 611 1	0.000 142 857 1	64.798 91	0.064 798 91	0.000 064 798 91
1 apoth. scruple =	0.041 666 67	0.003 472 222	0.002 857 143	1 295.978 2	1.295 978 2	0.001 295 978 2
1 pennyweight =	0.05	0.004 166 667	0.003 428 571	1 555.173 84	1.555 173 84	0.001 555 173 84
1 avdp. dram =	0.56 966 15	0.004 747 179	0.003 906 25	1 771.845 195 312 5	1.771 845 195 312 5	0.001 771 845 195 312 5
1 apoth. dram =	0.125	0.010 416 67	0.008 571 429	3 887.934 6	3.887 934 6	0.003 887 934 6
1 avdp. ounce =	0.911 458 3	0.075 954 86	0.062 5	28 349.523 125	28.349 523 125	0.028 349 523 125
1 apoth. or troy ounce =	1	0.083 333 333	0.068 571 43	31 103.476 8	31.103 476 8	0.031 103 476 8
1 apoth. or troy pound =	12	1	0.822 857 1	373 241.721 6	373.241 721 6	0.373 241 721 6
1 avdp. pound =	14.583 33	1.215 278	1	453 592.37	453.592 37	0.453 592 37
1 milligram =	0.000 032 150 75	0.000 002 679 229	0.000 002 204 623	1	0.001	0.000 001
1 gram =	0.032 150 75	0.002 679 229	0.002 204 623	1 000	1	0.001
1 kilogram =	32.150 75	2.679 229	2.204 623	1 000 000	1 000	1

Units	Avoirdupois Ounces	Avoirdupois Pounds	Short Hundred-Weights	Short Tons	Long Tons	Kilograms	Metric Tons
1 avoirdupois ounce =	1	0.0625	0.000 625	0.000 031 25	0.000 027 901 79	0.028 349 523 125	0.000 028 349 523 125
1 avoirdupois pound =	16	1	0.01	0.000 5	0.000 446 428 6	0.453 592 37	0.000 453 592 37
1 short hundredweight =	1 600	100	1	0.05	0.044 642 86	45.359 237	0.045 359 237
1 short ton =	32 000	2 000	20	1	0.892 857 1	907.184 74	0.907 184 74
1 long ton =	35 840	2 240	22.4	1.12	1	1016.046 908 8	1.016 046 908 8
1 kilogram =	35.273 96	2.204 623	0.022 046 23	0.001 102 311	0.000 984 206 5	1	0.001
1 metric ton =	35 273.96	2204.623	22.046 23	1.102 311	0.984 206 5	1 000	1

Based on NIST Handbook 44, Appendix C - General Tables of Measurement

Weight Cleaning Procedures

The following guidance is based on information published in ASTM E617 and/or OIML R111 documentary standards. These instructions are provided for informational purposes only and can be found online in the publication Precision Calibration Weights Type I and II, Handling, Cleaning and Shipping Manual (PN 178619).

It is essential to clean weights before any measurements are made because the cleaning process may change the mass of the weight. Cleaning should not remove any significant amounts of weight material. Weights should be handled and stored in a such a way that they stay contamination-free. Before calibration, dust and any foreign particles shall be removed by brushing with a clean soft-bristle brush or gentle wiping with a non-abrasive lint-free wipe. Care must be taken to not change surface properties of the weight (i.e., by scratching the weight).

If the weight contains significant amounts of contamination that cannot be removed by brushing with a clean soft-bristle brush or gentle wiping with a non-abrasive lint-free wipe, the weight or some part of it can be washed with clean alcohol, distilled water or other solvents. Weights with internal cavities should normally not be immersed in the solvent to avoid the possibility that the fluid will penetrate the opening. If there is a need to monitor the stability of a weight in use, the mass of the weight should, if possible, be determined before cleaning.

After weights are cleaned with solvents, they shall be stabilized for the times per ASTM E617 for classes 000-7 and OIML R111 for classes E1, E2, E3 and F2-M3 shown in the table below.

Stabilization Timeline				
Weight Class	000 00 0 E1	1 E2	2 F1	3-7 F2-M3
After cleaning with alcohol	7-10 days	3-6 days	1-2 days	1 hour
After cleaning with distilled water	4-6 days	2-3 days	1 day	1 hour

Categories of Weights

Weights are divided into four categories for cleaning purposes.

- One-piece weights (except lacquered, sheet metal or small wire weights).
- Screw knob weights, which includes all weights with adjusting cavities (except lacquered weights).
- Lacquered weights.
- Sheet metal weights and wire weights.

NOTE: Do not touch the weight with bare hands.

One-piece Weights

Wipe one-piece weights clean with a soft, non-abrasive material, such as high-grade cheesecloth, which is free from oils or other substances that may leave a residue on the surface.

Occasionally, a weight may have foreign material adhered to it which requires the use of a solvent for removal. First, attempt to remove the foreign materials using ethyl alcohol. If this does not work, try another solvent. Once the foreign materials are removed, use ethyl alcohol to remove film or residue left by other solvents.

Screw-knob Weights

Wipe screw-knob weights clean with a soft, non-abrasive material, such as high-grade cheesecloth, which is free from oils or other substances that may leave a residue on the surface.

Occasionally, a weight may have foreign material adhered to it which requires the use of a solvent for removal. First, attempt to remove the foreign materials using ethyl alcohol. If this does not work, try another solvent. Once the foreign materials are removed, use ethyl alcohol to remove film or residue left by other solvents.

Lacquered Weights

The cleaning of lacquered weights requires special care because their protective lacquer coating is soluble in most solvents.

Wipe the weight clean using a soft, non abrasive material, such as high-grade cheesecloth, which is free from oils or other substances that may leave a residue on the surface. Brushing the weight with a soft brush, such as camel hair, can also be used to clean the weight.

A rubber bulb type syringe may be used to blow off lint or other small particles. Take care not to touch the weights with the nozzle or any other part of the rubber bulb.

An electrostatic charge may be placed on the surfaces of the weights during the cleaning process or while handling them. This can be especially troublesome in a very dry atmosphere. If reliable mass values are to be obtained, the charge must be bled off the weights before calibration.

Sheet Metal and Small Wire Weights

Wipe sheet metal and small wire weights clean with a soft, non-abrasive material, such as high-grade cheesecloth, which is free from oils or other substances that may leave a residue on the surface.

Occasionally, a weight may have foreign material adhered to it which requires the use of a solvent for removal. First, attempt to remove the foreign materials using ethyl alcohol. If this does not work, try another solvent. Once the foreign materials are removed, use ethyl alcohol to remove film or residue left by other solvents.

Weight Cleaning Procedures

Cleaning Interval

Weights should be maintained in a manner that the weight is kept free from dirt and contaminants which could affect the integrity of the weights.

Weights do not need to be cleaned every time they are used. The interval between cleanings may be several months if the weights are handled carefully, kept in a clean atmosphere and under a dust-tight cover when not in use. Under less favorable conditions, the interval between cleanings may be only a few weeks.

Temperature Equilibrium

Allow newly cleaned weights to come to room temperature prior to calibration. This may take several hours for large weights that have been cleaned. Generally, laboratory weights will come to temperature equilibrium overnight.

Storage

Weights are not typically placed on a balance immediately after cleaning, but rather are placed in storage. Store weights under a dust-tight cover to keep them clean. Weights weighing one gram or more may be stored on a tray lined with filter paper and covered with an inverted glass dish. Smaller weights may be stored in a small glass dish covered with a watch glass. In both cases, the container should be labeled with the weight identification. Carry the tray or dish in a level position so the weights do not slide around.

Prior to using a weight on a balance, be sure to brush off any particles that may be on it. A small bulb-type rubber syringe is useful for removing lint and other small particles. Use the bulb at a short distance from the weight to blow off particles. Ensure that neither the nozzle, nor any part of the syringe, comes in contact with the weight.

Brushes

All equipment used in cleaning and handling weights should, of course, be clean. Brushes, however, require special attention because they are easily contaminated and are often the last cleaning device used before the weights are calibrated. Use only soft brushes, such as camel hair, on the weights.

Clean the brushes using soap and water, rinse in ethyl alcohol and allow to air dry. Place the brushes in a manner that they do not touch anything else while air drying. Prior to using new brushes, they must be cleaned to remove oil or other substances that could contaminate the weights. Clean used brushes as often as necessary to ensure the brushes themselves do not contaminate the weights. Store cleaned brushes in containers that will keep them clean until needed. When handling the brushes, do not touch the bristles, as oil from the skin will contaminate them. If the brushes need to be set down, place them so the bristles do not touch anything.

Environmental Impacts on Precise Measurements

To be able to conduct more precise measurements, it is necessary to minimize the factors that contribute to measurement errors. There are a great variety of such error-inducing factors, which can be linked to machine error and performance of the balance itself, as well as the properties and condition of sample being measured, and the measuring environment (e.g., vibration, temperature/humidity). These factors can readily affect the results of measurement on a balance.

This material includes some precautionary notes that the user should bear in mind to eliminate error factors and ensure accurate measurement results.

1. Measuring Room

1.1 Temperature/Humidity

- Try to maintain constant room temperature as much as possible to prevent condensation and unstable indications due to fluctuations in temperature.
- Low relative humidity tends to induce static electricity. (Relative humidity of about 60% is considered ideal.)

1.2 Vibration/Shaking

- The measuring room should preferably be located on the ground floor or in the basement. Higher floors are more susceptible to heavy vibration and shaking, which make such locations less suitable for measurement. A room facing a railway or road with heavy traffic should also be avoided as much as possible.

1.3 Drafts

- Avoid choosing a location subject to a direct draft of airflow from an air-conditioning unit or exposed to direct sunlight, which may cause abrupt fluctuation in temperature.
- Avoid a room subject to a heavy flow of people, since fluctuations in drafts and temperature are likely to occur in such a location.

1.4 Gravity

- The gravity acting on a sample varies depending on the latitude or height of the location where measurement is being conducted. For this reason, the same sample may show different weight indications from one place to another. Therefore, make it a rule to calibrate the balance every time it is relocated.

1.5 Electromagnetic Waves

- When the balance is located near an object that generates intense electromagnetic waves, it may be hindered from showing accurate weight due to the effects of such waves.

2. Measuring Bench

2.1 Vibration/Shaking

- If the balance is subjected to vibration during measurement, its indications will become unstable, thus preventing accurate measurement from being conducted. To avoid this situation, select a solid measuring bench that is less susceptible to vibration. (A bench in a vibration-proof structure or one made of concrete or stonework will be suitable.) Moreover, do not conduct measurement with a soft cloth or paper placed under the balance, since the balance may be rocked out of precise level positioning.
- Place the measuring bench in a location free from vibration as much as possible. It is a good idea to install the measuring bench in a corner of the measuring room, where less vibration is likely to occur than in the center of the room.

2.2 Magnetism/Static Electricity

- Avoid operating the balance on a bench that is susceptible to the effects of magnetism or static electricity.

3. Samples

3.1 Static Electricity

- Generally speaking, objects made of synthetic resin and glass have high electric insulating properties and, therefore, are apt to be electrically charged. Measuring a charged sample may cause unstable indications. With this in mind, be sure to discharge samples before measurement.

3.2 Magnetism

- A sample affected by magnetism indicates different weight values depending on where it is located on the measuring pan, along with poor reproducibility of the results.

  When a magnetized sample must be measured, first demagnetize it or place an appropriate pedestal on the measuring pan to adequately separate the mechanism part of the balance from the magnetized sample to avoid the effects of magnetism.

3.3 Absorption/Evaporation of Moisture

- Measuring a sample with moisture absorbed or evaporated (volatilized) continuously increases or decreases the values indicated. In such case, measure the sample in a container with a small opening and sealed airtight with a cap.

3.4 Sample Temperature

- A difference in temperature between a sample and the interior of a windshield may cause convection to occur inside the windshield, resulting in erroneous measurement.

  Therefore, measure a very hot or cold sample only after allowing time for its temperature to acclimatize to room temperature. Moreover, to prevent convection inside the windshield, allow time for the interior of the windshield to acclimatize to room temperature.
- The body heat of a person conducting measurement can also affect measurement results. Avoid holding the sample with bare hands, and use long tweezers or a similar tool instead. Also refrain from putting your hands inside the windshields while measurement is in progress.

Environmental Impacts on Precise Measurements

4. Main Unit of the Balance

4.1 Precautions on Use

- The balance is protected with a transparent dust cover. The dust cover may be statically charged immediately after removal from the packing box or under low humidity conditions. Unstable indications by the balance may be due to a statically charged dust cover. Wipe the dust cover with a damp cloth or use a commercial antistatic agent. Simply operate the balance with the dust cover removed to assist with this problem.
- To achieve more accurate weighing, wait at least 30 minutes after switching on the balance, then use the balance only after loading it several times with an object of weight equal to the weighing capacity.

4.2 Calibration

- Periodically calibrate the balance to ensure accurate measurement at all times.
- For more precise calibration, use an external calibration weight that approximates the weighing capacity. Moreover, calibrate the balance only after allowing time for proper acclimation to ambient temperature following power-up.
- Wait at least 30 minutes after switching on the balance, then perform calibration only after loading the balance several times with an object of weight equal to the weighing capacity.

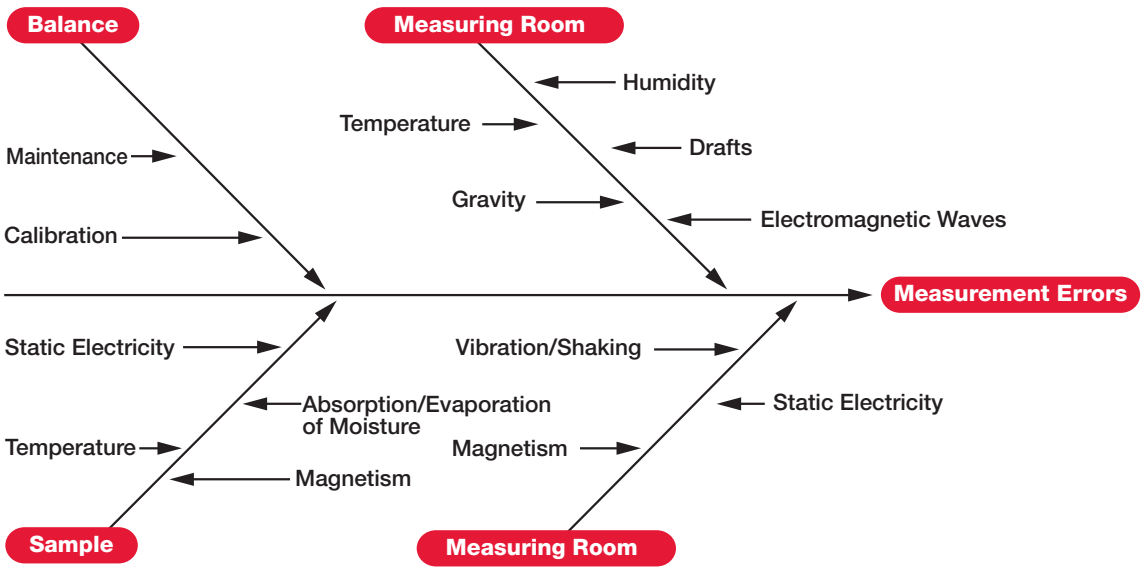
Calibration is also required in the following cases:

- When operating the balance for the first time
- When the balance has not been used regularly
- When relocating the balance
- When there is wide fluctuation in temperature, humidity or atmospheric pressure

4.3 Maintenance

- When the measuring pan or pan base is contaminated with powder or liquid, erroneous weight values may result or indications may remain unstable. Therefore, be sure to frequently clean the balance. When cleaning the balance, be very careful not to allow dirt or liquid to penetrate inside the mechanism.

Conditions that influence measurement results



Weights, Balances and Uncertainty

Factors that can influence which balance is appropriate for your application:

1. Capability (the need for multiple balances)
2. Readability
3. Capacity
4. "Accuracy" vs. "readability"
5. Repeatability and linearity
6. Units of measure
7. Platform dimensions
8. Environmental consideration
9. Communications interface
10. 21 CFR Part 11 compliance
11. Data reporting
12. Legal for Trade requirements

As with any other testing device or sensor in the laboratory, a complete understanding of the factors that can influence proper weighing/test results is very important.

For proper installation and maintenance of a balance, it is important to limit uncertainty. Uncertainty can be defined as a statistical estimated amount or percentage by which an observed or calculated value may differ from the true value.

Uncertainty of Weighing Results

For this exercise, presume the balance indication, sensitivity of the weighing device, application of the load and proper zero setting of the device are all operating without question and those elements under the original control of the device manufacturer (i.e., overall design, accuracy readability, sensitivity, drift and off-center loading characteristics) are within the device's design specifications. What needs to be determined is the impact of other influences on the uncertainty of test results.

Examining the design of the balance's installation is a critical step in the use of a precision weighing device and is often overlooked. The installation is the most imperative step in preparing for reliable results. If this area of use is understood and secure, reliable test results are more likely to be achieved.

Electromagnetic Force Restoration

In an electromagnetic force restoration balance, a current is regulated by a servo amplifier in a way that the electromagnetically generated force and the weight force applied to the platform by the object being weighed are in equilibrium (balanced). Maintenance of the equilibrium is controlled by a small sensor known as a position sensor. If weight is added to the weighing pan, this destabilizes the state of equilibrium and the overweight load causes the force-transmitting lever to move upward into the range of the position sensor. This in turn generates an input signal at the servo amplifier, causing a greater amount of current to flow through the coil and therefore increase the counter force until equilibrium is restored. The current simultaneously flows through a resistor where it causes a drop in voltage proportional to the change in weight on the platform. This voltage drop is digitized in an analog/digital converter so that the result is processed in a digital signal-processing unit (microprocessor), which can then in turn be indicated on a digital display with the appropriate mass indicator.

Leveling the Balance

Most balances available today include a bubble level or bull's-eye-level on the device. Along with this feature, two or more of the legs on the balance are adjustable, allowing for adjustment of the horizontal plane of the device to compensate for an out-of-level working surface. Use the bubble level and adjusting legs to ensure the balance is properly leveled. An out-of-level balance will add uncertainty to test results.

Room Conditions

Ideally, the laboratory should have the following characteristics at a minimum:

1. Only one door (to prevent air drafting).
2. Limited personnel access to prevent drafting and other changes to the environment in the areas of temperature, relative humidity and atmospheric pressure.
3. A limited number of windows, if any at all. If there are windows, choose a location so exposure to direct sunlight is limited.
4. A work surface that is dedicated to the balance should be located at a corner of the room, immediately opposite to the wall containing the door. Also, the door should swing inward into the laboratory with a balance table positioned so that the door can act as a shield against drafting from sources external to the laboratory.

Working Surface

Ensure the working surface is clean, firm and stable. Make sure it does not feature dual or tandem connection to the floor and a wall. If at all possible, the working surface should be used only for work involving test measurements with the balance.

Ergonomics

Ensure the balance does not need to be moved to meet the various requirements induced by testing and user parameters. Balances are not designed to be relocated between applications, technicians and laboratories. If a balance is moved after installation, the results of your installation and calibration work are no longer valid. Reinstallation should be performed before the balance is used again.

Types of Balances

Semi-micro and Micro: five or more decimal places

Analytical: 0.0001 g (0.1 mg)

Precision: 0.001 g (normally has a draft shield)

Toploader/Compact 0.01 g – 1.0 g

Weights, Balances and Uncertainty

Air Currents

Inherent with the sensitivity of most balances is the ability to be affected by even the slightest of air movements. There are two simple ways to evaluate the impact of air currents surrounding the balance.

Option 1: A simple device known as a smoke tube will generate a harmless trail of smoke that will follow an ambient air current. Although this is a good visual indication, this method is sufficient only during the time the test is being conducted.

Option 2: Use the balance as a "breeze sensor." To conduct this test, complete the balance installation and setup following the manufacturer's instructions. Connect the balance to a computer (according to manufacturer's instructions). Configure the balance to interval print every 10 seconds. Configure the computer so that the information from the balance is imported into a spreadsheet, such as Microsoft Excel. Begin the test by activating the print sequence on the balance. Interval printing will continue at 10-second intervals for a set period of time to secure an evaluation of the environment surrounding the balance. Once the test has been completed, turn off the interval testing. Chart the results of the data now resident in your spreadsheet. Evaluate the results to determine if there are factors in the environment that you wish to avoid. An optional breeze-break will modify the unwanted behavior. If you are using an analytical-style balance (those devices with an integral breeze-break), this observation should not be overlooked.

Vibration

This contaminant can result from something as subtle as a person walking by or a constant low-frequency hum of a large piece of manufacturing equipment located several work areas away from where the balance is located. Anti-vibration pads placed under the feet of the balance can be a low-cost solution.

Magnetism

Magnetic fields within close proximity to the balance may cause weighment errors. Sources of magnetic fields range from small motors and computer displays. To test weights and mass standards. Magnetism in mass standards and test weights cannot be completely eliminated once the device is in the field. The proper care and handling of test weights and mass standards is equally important to minimizing uncertainties as the proper installation and use of a balance.

Powerline Noise

If possible, ensure the balance is connected to a dedicated power circuit. At a minimum, use a conditioned power strip to ensure against errors in repeatability.

RFI/EMI

Common devices used in work environments can interfere with the proper operation of a weighing system. These include two-way radios, wireless telephones, cordless phones and wireless LAN communications. With the balance operating and presenting a stable zero reading, use a two-way radio, cell phone or any other electronic device within close and various proximity to the balance. Any sudden change in reading may indicate some level of interference and corrective action should be considered. Another option is to contract a professional experienced with detecting, measuring and compensating for RFI and EMI.

Fluctuations in Temperature

Ideally, lab temperature does not change over the course of a normal 24-hour period more than one to two degrees Celsius. Realistically, however, many factors prevent this ideal except in the most controlled environments. To compensate for this, many balances have an internal automatic temperature-sensitive calibration. It is important to purchase and use devices with this feature. When a change in temperature that could affect the outcome of a weighment is detected, the operator is notified that recalibration is required, or, on some units, the device's own internal calibration routine automatically compensates for the temperature change.

The laboratory should be as free from windows and direct sunlight as possible. If such a consideration is impossible, keep weighing areas away from windows, direct sunlight, heat and refrigeration sources. The ideal humidity range for most balances is between 45% and 60% non-condensing relative humidity.

To maintain the balance's optimal internal thermal equilibrium, the balance should not ever be turned off. When using a balance with an enclosed weighing chamber, always use a tweezers or other mechanical gripping device to place things in or remove things from the weighing chamber. When choosing a container to hold a weighing sample, select one with a small surface area.

NOTE: If using a device with an integral breeze-break, note the difference between the environment inside and outside the weighing chamber. If unsure about the weight vs. temperature properties of the commodities being tested, prepare two "identical" samples of the commodity. These "identical" samples should have the same weight value. Leave one sample outside the weighing chamber next to the balance. Place the other sample inside the weighing chamber, but not on the weighing platform. Add the second sample inside the chamber to equalize to the weighing chamber's temperature. Weigh the sample inside the weighing chamber once it has equalized to the chamber temperature. Immediately weigh the sample that was outside of the weighing chamber. If there is any difference in weight, you will need to achieve temperature equilibrium between the sample and the weighing chamber before making future weighing transactions.

Sample Conditions

The weight of a sample will increase or decrease depending on its exposure to volatile substances. Similarly, the sample will behave differently dependent on the evaporation of water or the absorption of moisture by the sample itself. Always use clean and dry weighing containers to hold the sample(s) under test. Keep the weighing platform and/or weighing chamber clean and free from foreign substances that may interfere with the testing results. Use weighing containers with as narrow an opening as possible and keep these containers covered unless direct and specific work is being done with the samples.

Weights, Balances and Uncertainty

Condition of Electrostatic Discharges

ESD usually demonstrates itself in one of two ways:

1. Repeated weighments of the same sample return dissimilar results.
2. The reading on the weight display is unusually unstable even though all other environmental concerns seem to be accounted for.

   The following procedures can help counteract ESD. In some instances, following more than one of these procedures may be necessary:

   a. Avoid weighing vessels made of plastic. Glass is preferable.
   b. Ground the device. This can be achieved by running a wire from the chassis of the device to a direct ground connection.
   c. Ground the technician. These solutions include ESD wrist straps, ESD-proof laboratory coats, anti-static hand soap, etc.
   d. Use anti-static brushes to discharge ESD within the weighing chamber.
   e. Discharge ESD in the balance's immediate environment.
   f. There are a number of solutions that provide a constant stream of neutralized ion air that eliminates antistatic build-up.
   g. If the above procedures fail to correct the ESD problem, consider using only metal sample containers.

Installation

There are essentially three types of "installers" for precision weighing equipment: laboratory technicians, maintenance staff or a dealer technician. If you have purchased your balance directly from one of the major catalog suppliers, your options for installation and maintenance are limited to either a laboratory technician or the in-house maintenance staff. Find the individual with the most experience and ensure they thoroughly follow the instructions that come with the device. If you have purchased your balance from a local scale or balance dealer, you have the benefit of requesting installation by a dealer technician. This is the preferable option. A dealer technician is a trained professional sensitive to all of the factors that we have discussed in this section. Additionally, you have the benefit of being able to call them back and troubleshoot either the device or the environment if you have difficulty.

Operator Training and Certification

Operator training and certification on a weighing device is essential. Operator errors are not only a result of individuals being inadequately trained, they also add untold degrees of uncertainty to valuable test results. Every operator should have at least a background in weighing technology, even if it is limited only to the device in question. Additionally, they should have a thorough understanding of the test process and the necessity to correctly record data thus preventing an erroneous influence in the significant process evaluation.

In summary, careful planning and/or suitable corrective action will minimize and possibly even eliminate many sources of uncertainty within your weighing process. It is possible that you will determine the need to test the balance at its planned location, and perhaps other alternative working sites in order to arrive at the best performance parameters. This will exclude influences of the surroundings or the operating personnel. By controlling the optimum performance of the balance based on its location and proper installation, you can significantly reduce uncertainties in your weighing processes.

With all of these factors under control, you should be able to proceed now using good laboratory weighing practices to determine the standard deviation of your device, as well as the uncertainty of your process.

Weights, Balances and Uncertainty

USP Modifications in Chapters 41 and 1251

After its initial modification to Chapters 41 and 1251 in December 2013, The U.S. Pharmacopeial Convention (USP) is continually refining its requirements for balance calibrations. A balance calibration is a check to verify that the balance's weight display matches the nominal weight value. Many people interpret this to be calibration with adjustment; however, a calibration is a verification not an adjustment.

The USP requirements state that calibrations are applicable when substances must be "accurately weighed." Balance weighing should be performed using calibrated equipment that has been calibrated at capacity and tested for repeatability and accuracy. The balance should also be tested at a minimum weighing point and not used below that point.

Complete, up-to-date information can be found at www.usp.org.

The new minimum weight requirements establish guidelines for operators to use the balances within a certain range. This is calculated from the repeatability test and begins at a point where the balance's repeatability is less than or equal to 0.10%. The specification states that the minimum weighing range will be 0.41 divisions (or the larger repeatability test result).

The impact of these requirements establishes best practices for balance applications. Balances that may have been purchased for applications based on specification sheets may not perform to those specifications in real-life applications. With these requirements, balances will be calibrated (checked) and a routine system established to make sure that the balance meets the application requirements.

REPEATABILITY of the balance is tested by weighing one test weight 10 times. The weight used is within the balance's operating range. The weight does not need to meet any calibration requirements as the weight is used to check that the readings are repeatable. The results are acceptable if "two times the standard deviation of the weighed value, divided by the desired smallest net weight (i.e., smallest net weight that the users plan to use on that balance) does not exceed 0.10%."

ACCURACY is acceptable if the balance's weighing value is within 0.10% of the test weight value. The accuracy test weight is a calibrated weight with maximum permissible error (MPE), or its uncertainty, of one-third of the applied test limit of the accuracy test.

In order to help laboratories and businesses comply with these updated guidelines, Rice Lake offers Essential Weights™. Designed with convenience in mind without sacrificing precision, Essential Weights are sets of stainless steel test weights specifically tailored to your balance.

Chapter 41	Previous	Updated
Scope	Defines the requirement for balances used to weigh analytes for quantitative measures	Same scope with new language for added clarity
Calibrated balance	Not specified	All balances must always be calibrated
Number of balance tests	1 - repeatability	2 - repeatability and accuracy
Test 1 - Repeatability		
Limit of repeatability test	≤ 0.1%	≤ 0.10%
Expansion factor	3	2
Total replicate weighing procedures	10	10
Acceptance criterion	3*s/m ≤ 0.1%	2*s/m ≤ 0.10%
Other criterion	N/A	If the repeatability obtained is smaller than 0.4 d, where d is the scale interval, replace the standard deviation with 0.41 d
Test 2 - Accuracy		
Limit of accuracy test	N/A	≤ 0.10%
Test weights	N/A	Between 5% and 100% of the balance capacity
Chapter 1251	**Previous**	**Updated**
Scope	Applies to all analytical procedures	No change
Balance Test		
Performance test	Drift check to be performed daily	Risk analysis determines the frequency of any test
Built-in weights	N/A	Checks can be partially replaced using automatic or manually triggered adjustment by means of built-in weights
Minimum weight	N/A	The minimum weight applies to the sample weight, not the tare or gross weight
Calculation of minimum weight	N/A	Derived by using a test weight up to a few % of the balance capacity: m=2000*s
Repeatability test	N/A	As repeatability fluctuates, weighing should be performed at larger values than the minimum weight

Properties of Magnetism in Mass Standards

Editor's Note

Since this article was first published, the concern over magnetism in calibration weights has evolved to a new level. Unfortunately, a number of issues surrounding the measurement of magnetism in mass measurement has created frustration for mass calibration laboratories and for accreditation bodies. To proactively address this topic, NCSLI brought together interested parties to discuss issues with the intent of coming to some resolutions on how to handle the various issues. As a result of these discussions a number of resolutions were adopted.

1. Laboratories should not include an uncertainty component for magnetism measurements in mass calibrations.
2. NVLAP's position is that for Echelon I and II measurements (corresponding to OIML R 111 classes E1, E2, F1 and F2) laboratories should:
    1) State on their certificates whether or not they are screening for magnetism.
    2) State that no component is included in their uncertainty statement for magnetism effects.
    3) Include a discussion/written agreement as to the laboratory's practice regarding magnetism screening (or lack of screening) as a part of normal contract review with laboratory customers.

Rice lake screens calibration weights for magnetic influences because we are dedicated to provide you with the utmost value for your dollar. Should we fail to test for magnetism, we could inadvertently provide you with erroneous calibration data. This data would not be repeatable in your facility. Therefore the assurance and traceability of your own work could be jeopardized.

Our philosophy always has been and will always be to take care of the customer first.

By testing for magnetic influences prior to executing a weight calibration, we continue to provide you with a quality of work unparalleled within the industry, keeping your needs first.

What Problems Can Magnetic Balances Cause?

When working with balances, magnetic field strength can be increased in a standard that has high susceptibility, even if the standard previously had a low or insignificant magnetic field strength. Therefore do not expose the standard to a balance with magnetic properties. However, this is difficult because a balance with magnetic properties will reproduce its measurements as long as there are no other magnetic fields intersecting the balance's own field; thus, the magnetic field of the balance goes undetected. Introducing a standard into the balance's magnetic field, even one with very low field strength, has the potential to increase the magnetism of the standard. In this manner, a standard that formerly had no problems could potentially accumulate serious problems. To avoid this situation, the magnetic field of the balance and the magnetic susceptibility of the standard must be measured.

In 1994, a magnetic round robin was performed by several metrology laboratories to test the effect magnetism has on weight measurements. This round robin was designed to show how close the laboratories' results would be after performing a calibration on one kilogram standards with known magnetic properties.

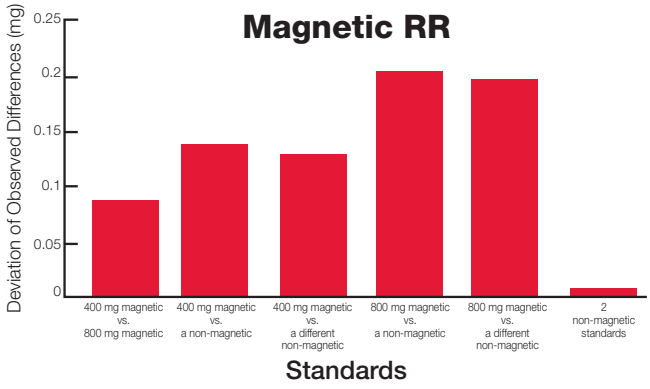
The balances compared and the approximate standard deviation of observed differences for these tests are shown below.

Balance Comparison	Standard Deviation
400 mG magnetic vs. 800 m non-magnetic	0.09 mg
400 mG magnetic vs. a non-magnetic	0.14 mg
400 mG magnetic vs. a different non-magnetic	0.14 mg
800 mG magnetic vs. a non-magnetic	0.2 mg
800 mG magnetic vs. a different non-magnetic	0.2 mg
Non-magnetic vs. another non-magnetic	0.3 mg

These tests show that a balance responds to magnetic properties of a mass regardless of the type of force the magnetic properties are exerting. However, the magnetic fields which are present in one balance are not necessarily reproduced in a different balance. Because of this phenomenon, it is difficult to reproduce the measurements from one facility to another. If this theory is true, the link of traceability for standards with magnetic properties is obviously broken because the magnetism causes an inability to reproduce consistent measurement results.

The graph below shows the results of the magnetic round robin, clearly showing the inconsistencies that can occur.

Results of magnetic round-robin.



How Does Magnetism Develop During the Manufacturing of Mass Standards?

The existence of magnetic properties during the manufacturing of mass standards warrants careful consideration. Due to the numerous possibilities of creating magnetic properties, it is difficult to produce a mass standard from austenitic (virtually non-magnetic, highly corrosion resistant) stainless steel completely free of magnetic properties.

Properties of Magnetism in Mass Standards

On April 11, 1946, F. A. Gould from the National Physical Laboratory wrote in the Journal of Scientific Instrumentation: "Analytical weights of stainless steel have been on the market for several years. The kind of stainless steel used for their construction is one which purports to be reasonably non-magnetic, being of the austenitic variety; and up to the present time the 18/8 type of austenitic steel, that containing 18% chromium and 8% nickel, has been employed for this purpose in this country. The quality of the finished weights, however, has not been very satisfactory in regard to their magnetic properties, and some have been found permanently magnetized to an appreciable extent."

Mass standards are manufactured through a variety of methods, including turning, milling and casting. Before the manufacturing process, it is imperative to choose the proper materials. When choosing materials, the most important factors to consider are machinability, corrosion resistance, porosity and magnetic properties. The magnetic properties generally develop when austenitic stainless steel is cold-worked. Although cold-working adds tensile strength, mass standards do not normally require added tensile strength.

Which Materials Are Best for Manufacturing Mass Standards?

Three hundred (300) series stainless steels are often used to manufacture mass standards because their chemical composition is highly resistant to corrosion. Certain materials found within 300 series stainless steels such as iron, cobalt and nickel may possess ferromagnetism. Ferromagnetism occurs when a small external magnetic field produces an alignment of atomic magnetic dipole moments, which in some cases can persist even when there is no external magnetic field. This occurs because the magnetism of these substances exerts such a strong force over a small region of space that the magnetism is found on surrounding materials, even when no external magnetic field exists. In addition, cold-working these materials often changes the austenite to ferrite in the material.

Several tests were conducted by the National Physical Laboratory, United Kingdom, to evaluate the materials used for manufacturing weights. In one of these tests, finished weights of 18/8 steel obtained from several sources of supply were tested. About half of the weights in these tests exhibited a magnetic permeability of 1.02 or less, but the remainder of the weights showed higher magnetism. Several weights showed a permeability value of 1.1, and one showed a high permeability value of 2.6. Some of this material was found to have become permanently magnetized to an elevated extent.

Because of the variety of austenitic steel which is available, additional tests were performed to help in the selection of a material with non-magnetic properties. These tests found that 18/8 materials were not satisfactory with respect to magnetic properties. The chart below depicts the magnetic permeability of different stainless steel compositions.

When comparing the processes required to manufacture mass standards or to manufacture the stainless steel to produce the standards, this chart provides a general idea of the magnetism problems which may occur. Most purchasing personnel are not aware of the problems of magnetism, so when the purchase of materials takes place, materials are requested by their manufacturing names, such as 310, 304 and 316.

These names are like recipes in that they give a process for heat treating the material and a range for the chemical composition. Most of these materials have a heat treating process that returns the materials to an austenite state after any cold working process. However, sometimes this heat treating process may leave the materials bent or twisted. In order to supply vendors with the proper materials, a secondary process to straighten the materials must be performed. This process is still within the requirements for the materials, but the cold-working during the straightening process leaves the materials with magnetic properties. This is most common in smaller size diameters.

Aside from the risk of the materials having magnetic properties from the start, weight manufacturers add to the possibility of elevating magnetism during the series of cold-working processes necessary to produce the mass standard. Manufacturers must use either a saw or lathe operation to start the process. The removal of any metal in this fashion is considered a cold-working process. Polishing and stamping are also cold-working processes. These operations can and do produce magnetic properties in the standards.

Chemical Composition									Magnetic Permeability	Magnetic Permeability After Cold Rolled to give a 33% Reduction in Area
C	Si	Mn	S	P	Cr	Ni	W	Cu		
0.03	0.57	0.55			17.45	11.9			1.003	1.10
0.14	0.6	0.58			19.8	12.96			1.003	1.005
0.07	0.24	0.44			10.33	20.7	1.73	2.14	1.015	1.04
0.09	0.23	0.44			10.3	20.26	1.79	2.20	1.013	1.021
0.13	0.19	0.36			9.72	20.28	1.55	2.39	1.021	1.045
0.10	0.26	0.42			10.85	20.71	1.83	2.13	1.016	1.043
0.10	0.26	0.48			10.42	20.77	1.57	2.32	1.012	1.021
0.09	0.22	0.39			10.41	20.17	1.67	2.19	1.014	1.024
0.10	1.71	0.78	0.017	0.011	24.27	20.40			1.002	1.003

Properties of Magnetism in Mass Standards

What Are the Requirements for Magnetic Properties in Mass Standards?

The United States uses the American Society for Testing Materials (ASTM) specification E617-23 for specifying the requirements of magnetic properties in laboratory weights and precision mass standards. This specification was replaced by the National Bureau of Standards (NBS) Circular 547, Section 1 in 1978 and recognizes the international recommendations of the Organization Internationale De Metrologie Legale (OIML) R111, edition 2004.

According to the ASTM E617-23 specification, magnetic properties must be measured in magnetic field gradients because unshielded devices in the vicinity of the measurement can affect the accuracy of measurements. Higher grades of weights have lower magnetic susceptibility. Grades S, S', O and P should not be more magnetic than 300 stainless steel.

The OIML international recommendations include requirements for magnitude of magnetic susceptibility. They state that the metal or alloy used for weights of Classes E1 and E2 shall be practically non-magnetic (magnetic susceptibility K not to exceed K=0.01 for Class E1, K=0.03 for Class E2, and K=0.05 for Classes F1 and F2).

How Can Magnetism Be Avoided?

Although magnetism cannot be completely avoided, steps can be taken to control the effects of magnetism on the accuracy of weight measurements. The area where the weighing occurs should be tested with a gaussmeter for magnetism created by electrical wiring, motors and any other components in the area. If the testing shows magnetism is present in the area, another location should be chosen for the measuring process.

A gaussmeter should also be used to test the balances for magnetism. Even if the standards have very low magnetic strength, the internal components of a balance may cause varying results. For example, if the components of the balance have a magnetic charge, the standard introduced to the balance will change the force exerted on the load device, causing inconsistent results from one device to another. Balances should be tested whenever there is any suspicion of magnetic problems, such as erratic weight measurements. The gaussmeter shows which part or parts of the balance are magnetized and need to be replaced.

The elimination of magnetism in mass standards is not likely to happen. However, if the proper steps are taken, the magnetism in mass standards can be significantly reduced. Starting with the manufacturing process, the proper methods and materials must be chosen. Then, the mass standards should be tested for magnetic properties. Finally, remember that the magnetism inherent in the environment, balances and standards will cause some degree of inconsistency in mass measurements, no matter what preventive steps are taken.

How Are the Magnetic Properties of Mass Standards Measured?

Although specific requirements for magnetic susceptibility are a good start, magnetic field strength is also a very important factor that needs to be measured. Susceptibility adds to the potential of an item becoming magnetized or further charged. Measuring the magnetic field strength of the standard shows whether the magnetism is significant enough to cause mass measurement errors.

Richard Davis of Bureau International des Poids et Mesures (BIPM) wrote an article entitled, "New Method to Measure Magnetic Susceptibility," in which he describes a process he developed for measuring magnetic susceptibility. The following pieces of equipment are used to perform the measurements:

Balance

The balance must have a 5-gram capacity (to leave enough range in the balance to place the column and magnet on it and perform the measurement) and a resolution of greater than or equal to one microgram. The weighing chamber is a glass tube with a removable glass top. The original top is replaced with one made of an aluminum alloy because aluminum contains very little magnetism.

Magnets

Two high quality cylindrical magnets (constructed of neodymium-iron-boron) are used in this measuring process. Each magnet has a height of 2.5 millimeters and a diameter of 5 millimeters. The axis of magnetization coincides with the geometric axis of the cylinder. Two such magnets are combined to produce a cylinder of height equal to diameter.

Pedestal

The magnet sits on a tubular pedestal that is centered on the balance pan. Holes drilled through the wall of the tube ensure that the total mass of the magnet and pedestal is well within the capacity of the balance.

Bridge

Samples are centered on an aluminum alloy bridge that straddles the weighing chamber of the balance. The bridge must be designed so the span can be made level with respect to the balance pan. The span should be as thin as possible, with adequate mechanical rigidity. If the span sags in the middle, samples with a large diameter will be farther from the magnet than samples with a small diameter.

Gauge Blocks

It is convenient to place the bridge on non-magnetic gauge blocks so it may be raised or lowered in precise 5-millimeter increments.

Magnetic Susceptibility Standard

The magnetic susceptibility standard can be the identical shape of the item being tested or a cylindrical shape that has been calibrated by known standards.

Once all of the equipment has been assembled, the distance from the center of the magnets to the top of the bridge must be calculated to determine the magnetic force. This can be done by using the known magnetic standard. After the distance is calculated, the samples that need to be tested may be introduced. The samples are calculated based on the distance from the magnets and the response of the balance. If the samples have different geometrical values, additional calculations must be performed to solve for the volume of magnetic susceptibility.

Balance Verification Using Calibrated Weights

The following is an example of how to use calibration weights with the appropriate pedigree to calibrate and verify an electronic weighing device such as an electromagnetic force restoration balance. Manufacturer's operating and maintenance instructions should always be referenced prior to performing a test or making adjustments. Pay exceptional attention to the manufacturer's discussion on the environment suitable for the device. At the end of these procedures, refer to "Environmental Impacts on Precise Measurements" on page 252 of this catalog for information regarding weighing influence factors. Failure to consider these specifications and conditions will invalidate this procedure. Please contact us if you cannot locate the operating instructions for your device. We may be able to provide a duplicate.

Equipment Required:

- Balance
- Accessory printer (to document calibration changes and results)
- Cotton gloves
- Tweezers
- Tongs (as appropriate to handle the calibration weights)
- Weight calibration certificate or traceable certificate

Balance Verification Processes:

1. Using the manufacturer's operating instructions, set up the balance in the environment in which it is intended for use. Allow the balance to acclimatize to in the environment for a minimum of 24 hours prior to any testing. This is a critical step. Many of the mechanical structures in a balance are affected by the changes in environment. To ensure a proper test with definable results, the device must be allowed to equalize within its environment.
2. If the balance is equipped with an internal calibration feature, activate that feature and allow the printer, if so equipped, to document the results.
3. If the balance is not equipped with an internal calibration feature, use an external electronic balance calibration weight and, following the manufacturer's recommendations, calibrate the balance. Many electronic balances deployed in the field allow you to select the size of calibration weight you wish to use. To minimize the impact of hysteresis on linearity, it is strongly recommended that you use a weight that represents 100% of the rated capacity of the device.
4. Weight selection criteria. Selecting the appropriate size and class of an electronic balance calibration weight is not a difficult process.

   Option 1: Refer to the instructions provided by the manufacturer of the balance or other weighing device. Generally, the size (capacity) and class of the recommended calibration weight will be included for your reference.

   Option 2: Determine the nominal mass value needed based on the balance's capacity and resolution.

   a. Record the capacity of the balance.
   b. Record the minimum increment (readability) of the balance.
   c. Divide the result from item by a factor of four. This number results in the appropriate tolerance for the calibration weight required. For example, if the balance in question has a capacity of 120 grams and a displayed resolution of 1 milligram (0.001 gram), the result of the calculation would be 0.25 milligram (0.00025 gram).
   d. Refer to the ASTM Weight Tolerance Table on page 242.
   e. In the column titled "Nominal Size" find the weight value closest to the capacity of the balance. If the exact number is not available, select the next smallest value. For example, a balance has a capacity of 120 grams. The closest value but smaller than the rated capacity of the balance is 100 grams.
   f. Read across the table to the right to locate the tolerance that is closest to, but smaller than the value of 0.25 milligram calculated in item C. The first value that meets this criteria is 0.13 milligram, Class 0.
   g. To assure the most error-free results, an ASTM Class 0 calibration weight should be used for this calibration exercise. However, because the value in the next column is 0.025 milligrams exactly, an ASTM Class 1 device could be selected with satisfactory results.
   h. Now we know that every calibration weight we purchase for this device must be a minimum of ASTM Class 1.

   Option 3: Manually calculate the calibration weight based on the tolerance of the procedure or methodology.

   a. Given: your balance has a capacity of 120 grams.
   b. Given: your balance has a readability of 0.0001 gram (0.1 milligram).
   c. Given: you wish to check your balance at weighing capacities of 5 grams, 10 grams and 15 grams.
   d. To get the proper results, a 5-gram and a 10-gram weight are required.

      You will be able to use the 5-gram calibration weight alone to test the device at 5 grams; the 10-gram weight alone to test the device at 10 grams; and the 5-gram and 10-gram calibration weights together to test the device at 15 grams.

   e. Given: the tolerance you are looking for in your procedure is 0.5 milligram.
   f. Divide your tolerance of 0.5 milligram by a factor of four. This results in a tolerance of 0.125 milligram.
   g. Refer to the ASTM Weight Tolerance table on page 242.
   h. Because more than one weight is being used to accomplish this test, cumulative tolerance will need to be applied considering the tolerances of both a 5-gram and 10-gram test weight together to ensure they do not exceed 0.125 milligram.
   i. Find the first 10-gram weight value in the column titled "Nominal Size." Read across the chart to find the value that is closest to but smaller than the calculated tolerance of 0.25 mg from step 3c above. This would be the value of 0.074 under ASTM Class 2. ASTM Class 3 cannot be used since that value 0.25 milligram is larger than the calculated tolerance of 0.125 milligram.
   j. Follow the ASTM Class 2 column until you are across from the 5 g test weight, which is the next test weight being used. As listed on the chart, the tolerance for a 5 gram ASTM Class 2 test weight is 0.054 milligram.

Balance Verification Using Calibrated Weights

k. Add this to the tolerance of the 10 grams ASTM Class 2 test weight from step 4. The result is 0.74 milligram + 0.054 milligram = 0.128 milligram. This value is larger than the stated tolerance of 0.125 milligram. Because of this, tolerances for ASTM Class 1 need to be used to improve performance.

l. The tolerance for an ASTM Class 1 10-gram test weight is 0.050 milligram. The tolerance for an ASTM Class 1 5-grams test weight is 0.034 milligram. When combined, the total accumulated tolerance of 0.084 milligram of is well within the stated tolerance of 0.125 milligram. Therefore, for this procedure, ASTM Class 1 test weights should be used.

5. When external (preferred) or internal calibration has been successfully accomplished, select a verification weight that is representative of a typical sample used on a daily basis. If the weighing device is used for samples of exceptionally different values, consider the number of transactions with each typical sample. Develop a representative sample size for this test. The calibration weights you use for this test should not only be representative of the sample size, but also have the appropriate laboratory documentation and traceability to ensure test validity.

6. Tare or zero the balance and verify the display reads a stable zero value.

7. With the device reading zero, apply the sample calibration weight to the balance.

8. Wait until the balance indicates that it is no longer “in motion.”

9. Write down the reading on the display.

10. Remove the calibration weight from the balance.

11. Wait until the balance is no longer “in motion” and the display has returned to a stable zero value.

12. Repeat steps 5 through 11, 7 to 10 times.

13. Using the results from step 11, calculate a standard deviation.

14. Multiply the answer in step 13 by three. This is the random error that is expected for the balance with a 99% confidence level. This number now becomes the upper and lower limits for the performance verification. In other words, the balance is performing satisfactorily when the results of a balance reading compared to the practical test weight (PTW) are no more than PTW + STDV and no less than PTW – STDV.

15. It is important to now verify the results of the standard deviation against the repeatability specification for the weighing device under test. If the standard deviation value is greater than the repeatability factor of the balance under test, consider the following: Recheck the installation parameter of the balance. Be acutely aware of environmental influences on the balance under test as these can have a significant impact on the device’s performance. If you are confident that all preventative measures have been taken to ensure optimal balance performance, contact the manufacturer of the device for additional recommendations.

16. Determine the correction value from the laboratory documentation that accompanies the calibration weight used to calibrate the balance at 100% from step 3. The correction value is the error that was introduced into the balance mechanism and algorithms when the balance was calibrated in step 3. The calibration function in most electronic balances of recent manufacture compensates and sets the linearity of the device from the point in the weighing range representing the calibration load down through and including zero. It is critical that the calibration be performed as close as possible to 100% of the balance’s rated capacity. Perform balance calibration with an external calibration test weight since the linear error cannot be deduced by using an internal calibration weight. If the balance was calibrated at 100% of its rated load, 100% of the error in the calibration weight was also introduced at that point. This error is reduced to half its original value at the 50% load point. It is further reduced to 75% at the 25% load point. It is possible to make an estimation of the linear error of the calibration by the equation in figure 1 below.

LE = Linear Error
ECW = Rated Error of the Calibration Weight
L = Load
CL = Calibration Load

$$LE = \frac{(-1)x(ECWxL)}{CL}$$

Figure 1

17. A study of the points presented so far explains the fallacy of attempting to calibrate a balance at less than 100% of its rated capacity. Failure to do so can make the device’s performance completely theoretical and destroy the intent of uncertainty budgets.

18. It is now possible to determine the anticipated result for the verification process.

19. Using the laboratory documentation for the calibration weight that represents the typical sample weight, determine the error or correction of the weight. Also, check the uncertainty of the weight that you will use for this process. The uncertainty must be no greater than 25% of the random error of the balance being examined from step 15. If the uncertainty of the weight is greater than 25% of the random error of the balance, select a calibration weight of equivalent value but with a higher accuracy class. In the event that the correction on your laboratory documentation is a negative number, the weight in question is below nominal value by that amount. A positive value means the weight is heavier than nominal by that amount.

$$\sqrt{\frac{n\sum x^2-(\sum x)^2}{n(n-1)}}$$

Figure 2

Balance Verification Using Calibrated Weights

20. Calculate the expected value for performance verification using the following formula where:

    • EV = Expected Value

    • AMV = Actual Mass Value

    • LE = Linear Error (from step 14)

$$AMV = (NV+AM)$$

Where AMV = Actual Mass Value; NV = Nominal Value and AM = Apparent Mass vs. 8.0 correction in the following formula:

$$EV = (AMV+LE)$$

21. Verification: Zero the balance and place the verification weight on the balance. If the actual reading is within the random error range established in the calculation of the anticipated value, the verification passes.

    Example:

    - Balance specification: 100 g x 0.1 mg
    - Calibration load: 100 g (100% of rated capacity)
    - Calibration weight specifications
        a. 100 g Class 1 electronic balance calibration weight with a correction of + 0.10 mg
        b. 10 g Class 1 electronic balance calibration weight with a correction of + 0.010 mg
    - Typical sample value: 10 g

    Following the instructions in step 14, 20 measurements are taken and the standard deviation is found to be 0.3 mg. Applying a factor of three (3 x 0.3 milligram), the value calculates to 0.9 milligram.

    To calculate the Linear error =

$$LE = \frac{(-1)x(ECWxL)}{CL} \quad \text{or} \quad 0.01mg = \frac{(-1)x(1mgx10g)}{100g}$$

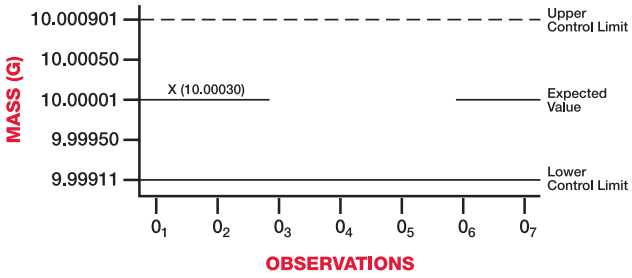
    Expected value =

$$EV = (AMV+LE) \quad \text{or} \quad 9.99999 = 10 + (-0.01\,mg)$$

    Verification range = ± 9.99999 g (-0.9 mg)

    The actual verification is performed and the reading on the balance results in a value of 10.0003 grams. Since this value is within the control limit, the results of the test is a “pass,” as relative to a “pass/fail” rating system.

    Refer to the chart below.



22. In the chart above, the methodology explained in this section has been followed. A weight of 10 grams is applied to the balance. The reading on the balance is 10.00010. This value has been plotted on the chart as X. It falls within the upper and lower limits and therefore, this verification observation passes.

Further Suggestions

- Perform verifications at different times of the day. If you notice the results are significantly different at these different times, it may suggest that the environmental conditions within the work space are changing and may have unforeseen impact on the work being conducted.
- Constantly monitor the condition and weight value of your test weights. Under the auspices of NIST H-150, laboratories providing recalibration services are prohibited from recommending or establishing scheduled recall dates without your explicit instructions. To learn more about how to determine when, and if, a weight is due for recalibration, please contact us. We will be happy to discuss the process with you.
- Keep a constant running record of your test results and chart these results using a program such as Microsoft® Excel™. This record can help you understand the data being recorded as well as help you gain additional insight into your laboratory conditions.
- From time to time, recalculate the random error to see if your balance is performing consistently.
- Have your balance serviced according to the manufacturer’s instructions or recommendations by your dealer to ensure it maintains optimum operational parameters.

Glossary of Terms

Standard Specification for Laboratory Weights and Precision Mass Standards

Reprinted from the Annual Book of ASTM Standards. © ASTM

Accuracy Class of Weights

A class of weights that meets certain metrological requirements intended to keep the errors within specified limits (definition from OIML D28 (E) 2004). Weight designated with "S" prime are higher-class weights.

Adjustment

The process of changing the mass either by polishing or adding and subtracting material, to bring the mass within the tolerance of a specified class.

As Found

The value of the mass recorded by Rice Lake Weighing Systems after cleaning and before any adjustment based on a density of 8.0 g/cm^3 at 20° C.

As Left

The value of the mass after any necessary adjustments are made based on a density of 8.0 g/cm^3 at 20° C.

Buoyancy Correction

The calculation needed to compensate for the varying air density in order to ascertain the true mass value.

Calibration

The acts of determining the mass difference between a standard of known mass value and an "unknown" test weight or set of weights, establishing the mass value and conventional mass value of the "unknown," and of determining a quantitative estimate of the uncertainty to be assigned to the stated mass or conventional mass value of the "unknown," or both. Set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards (definition from International Vocabulary of Basic and General Terms in Metrology).

Certificate of Tolerance Test

Document certifying subject weights are within specified tolerances. Referred to as an Rice Lake Statement of Accuracy or Rice Lake Traceable Mass Value Certificate.

Certificate of Calibration

Document presenting calibration results and other information relevant to a calibration (definition from NCSL Z-540-1-1994). Referred to as a Rice Lake Calibration Certificate or Rice Lake Traceable Certificate.

Conventional Mass

Conventional value of the result of weighing in air, in accordance to International Recommendation OIML D28 (E) 2004. For a weight taken at 20° C, the conventional mass is the mass of a reference weight of a density of 8000 kg/m^3 which it balances in air of density of 1.2 kg/m^3 (definition from OIML D28) (2004).

Correction

Mass values are traditionally expressed by two numbers, one being the nominal mass of the weight, and the second being a correction. The mass of the weight is the assigned nominal value plus the assigned correction. Positive corrections indicate that the weight embodies more mass than is indicated by the assigned nominal value.

Density

The unit of mass divided by its volume. For a precision calibration, density testing is required to calculate buoyancy correction.

Kilogram

The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be 6.626 070 15 × 10^{-34} when expressed in the unit J s, which is equal to kg m^2 s^{-1}, where the metre and the second are defined in terms of c and Δv_{Cs}.

Metrological Traceability

Property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

Metrological Traceability Chain

Traceability chain sequence of measurement standards and calibrations that is used to relate a measurement result to a reference.

Metrological Traceability to a Measurement Unit

Unit metrological traceability where the reference is the definition of a measurement unit through its practical realization.

Set of Weights

A series of weights, usually presented in a case so arranged to make possible any weighing of all loads between the mass of the weight with the smallest nominal value and the sum of the masses of all weights of the series with a progression in which the mass of the smallest nominal value weight constitutes the smallest step of the series (definition from OIML D28 (E) 2004).

Glossary of Terms

Tolerance

(adjustment tolerance or maximum permissible errors)

The maximum amount by which the conventional mass of the weight is allowed to deviate from the assigned nominal value. Tolerance test verifications ensure that the conventional mass of the weights and their corresponding uncertainties as tested are correct within the maximum permissible errors of the respective weight class.

Traceability

Property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties (definition from International Vocabulary of Basic and General Terms in Metrology).

Uncertainty

Parameter associated with the result of a measurement that characterizing the dispersion of the values that could reasonably be attributed to the measured (definition from NCSL Z-540-1-1994). The range of values within which the true value is estimated to lie. U.S. National prototype standard Platinum iridium kilogram identified as K20, maintained at the National Institute of Standards and Technology, with value assigned relative to the SI (International System of Units) provides the United States access to the mass unit. Weight (mass standard): A material measure of mass, regulated in regard to its physical and metrological characteristics: shape, dimension, material, surface quality, nominal value and maximum permissible error (definition from OIML D28 (E) 2004).

A New Era of Measurement with the Redefined Kilogram

In November 2018, the State Parties to the Metre Convention, or simply "Member States," voted to change the International System of Units (SI). The change ruled that the system would no longer rely on physical objects and instead be determined by constants of physical science, such as the speed of light.

Currently, there is just one "true" kilogram used for every measure of mass on Earth. The International Prototype Kilogram (IPK), a cylinder of platinum-iridium, is locked securely in a vault within the International Bureau of Weights and Measures in France. Used to calibrate mass standards only once every 40 years, the IPK is treated with extreme care.

Yet even the "true" kilogram can undergo a change in mass. Because the IPK is a physical object, it is prone to wear, meaning it can lose—or gain—mass at any time. Yet since the IPK serves as the only true kilogram, there can be zero scientific uncertainty when the measurement is recorded.

Constants of nature, however, are allowed to have uncertainty in their value to compensate for errors that can occur in an experimental measurement. Following the vote by the Member States, scientists will use fixed values for constants such as Planck and Boltzmann to define the seven SI base units. The new SI redefines the kilogram by using an exact value for the Planck constant and the definition of the meter and second (already based on constants).

Although marketplace consumers are unlikely to notice any immediate effects of the change, manufacturers of scientific instruments may need to update their products in the near future.

The redefinition of the kilogram makes it possible to perform more precise, accurate measurement science without requiring calibration with the IPK. The kilogram's new definition will promote more accurate measurements of milligram and microgram masses. Measurement scalability will improve, as measuring with physical objects can decrease accuracy at smaller or larger sizes than the standard.

Rice Lake's metrology labs are prepared to continue to serve our customers with NIST traceability and precise calibration services. Learn more about our metrology labs at **www.ricelake.com/metrology-services**

Up until the SI redefinition in 2019, the National Institute of Standards and Technology (NIST) housed and maintained America's official mass standards. Pictured above, the K20 kilogram mass standard served as the primary prototype national standard.

Historical Class F Calibration Weights

No Longer Sold for Legal Metrology Uses Since January 1, 2020

Since January 1, 2020, Class F calibration weights will no longer be sold for legal metrology use. According to the newly updated NIST Handbook 105-1 (2019), new weights for use as field standards placed into service for weights and measures use after this date must comply with all of the requirements of NIST Handbook 105-1 (2019).

However, existing NIST Class F calibration weights in the field will be considered grandfathered in and may continue to be used for legal metrology use as long as they meet NIST Handbook 105-1 (1990) requirements. Although the new revision does supersede the 1990 version, it makes clear that existing Class F weights may continue to be used.

This change is taking place to accommodate for the increasing accuracy of weighing devices used for legal metrology. Class F weights are no longer sufficient for the calibration, inspection or sealing of weighing devices used for the jewelry, marijuana and pharmaceutical industries.

Although existing NIST Class F calibration weights may be reclassified to one of the new specifications if all specifications and tolerances fully comply with the alternative standard, the NIST Office of Weights and Measures strongly recommends that you do not reclassify existing Class F weights due to the difficulty of performing compliance evaluation.

At Rice Lake, our metrology labs are here to help guide customers to select the best calibration weight for each application. We have two metrology laboratories that meet the new calibration requirements of NIST Handbook 105-1 (2019) to ensure a seamless transition for your calibration needs.

For more information about Rice Lake's metrology services, visit **www.ricelake.com/calibration**

Trademarks

The following product names, logos, brands and other trademarks featured or referred to within this publication are the property of their respective trademark holders.

Access™
Adventure Pro®
Allen-Bradley®
Amphenol®
AstraLabel™
AstraLink™
AutoCal™
Beldfoil®
Bitstream®
Bluetooth®
Cardinal®
Cent-O-Gram®
Centronics®
Citizen®
ConnexLink™
ControlNet®
Conxall®
CRS™
Cubis®
Datalogic QuickScan®
Datamax-O'Neil®
DeviceNet®
Dial-O-Gram™
DIGI®
Discovery™
Dymo®
EPL®
EPL2®
EPSON®
ESC/POS®
EtherCAT®
EtherNet/IP™
Excel™
Explorer®
Fairbanks™
Flintec™
Genius®
Hewlett-Packard™
Howe™
IBM®
InCal™
Intel®
Interchange®
Intercomp CS™
Intercomp PT300DW™
Intercomp PT300™
IONMASTER™
iPAQ™
ISOBAR®
ISOBLOK®
Java™ POS
LabelView™
LifeGuard™
Linux®
LoopTracker™
Lotus™
Maxi-Scoop™
MaxWax™
Microline®
Microsoft®
Midrics®
MIFARE®
Minebea Intec®
Mobile 5.0™
Motiontrap™
Motorola ColdFire®
MS-DOS™
NatraSorb®
Novell®
OHAUS®
OKI®
Pax®
pcANYWHERE®
Peachtree®
Pelican™
Pick N Pluck™
Pioneer™
PowerCell®
Powerware®
PreVent™
Prodigy Max™
Prodigy™
PROFIBUS®
ProPrinter®
Quencharc®
Quickbooks®
QuickScan®
QuikSharp™
R STAHL®
Ranger™
Rapid Exchange®
Rockwell Automation®
Roman and Swiss™
S4M™
Sartorius®
Scout Pro®
SI®
STAR®
The Crosby Group LLC®
SUREFOOT™
Symbol®
TekLynx®
Toledo®
Torque™
TRANSCORE®
Trooper®
Turck®
Valor®
Voyager®
Vulcan®
WinCT®
Windows®
WinWedge®
Xscale®
XTend-PKG™
Zebra®
ZigBee™
ZPL®

Terms and Conditions

The terms "buyer," "authorized reseller," and "customer" as used herein, shall mean the party placing the purchase order with Rice Lake Weighing Systems. No contractual relationship between Rice Lake Weighing Systems and said party shall arise until such time as a purchase order has been accepted by Rice Lake Weighing Systems and such acceptance has been indicated on a written acknowledgment. Orders shall be subject to Rice Lake Weighing Systems' standard terms and conditions as printed below, subject to correction for clerical errors.

Any conditions stipulated by the buyer which are in contradiction to these sales terms and conditions shall only be valid if expressively acknowledged by Rice Lake Weighing Systems in writing.

1. Prices

(a) Rice Lake Weighing Systems (Rice Lake) prices are net 30 days Ex Works Rice Lake plants. Orders are subject to approval of our credit department with rights reserved to change or withdraw credit terms without notice and to terminate any orders when invoices for work done thereon have gone unpaid for 60 days.

(b) Prices do not include taxes of any kind by federal, state, municipality or other governmental authority, which Rice Lake may be required to collect or pay with respect to the sale or shipment of goods sold hereunder. Regardless of when any such taxes are determined or become payable, all taxes would be the responsibility of the customer and would be in addition to the prices quoted hereon.

(c) This quotation is made upon the basis of the cost of materials and labor as of the date of this quotation. A change in such costs shall give Rice Lake the right to alter prices to reflect such changes in cost.

(d) Requests for additional documentation, drawings, audits of factories or inspection of equipment in-process, additional testing, additional inspections and record retention will be quoted as a separate item even if we have already issued quotations for products and services.

2. Shipment, Title, Risk of Loss

(a) All shipments are Ex Works point of shipment. Title and risk of loss or damage passes to the customer upon presentation of the goods to the customer's carrier at Rice Lake's facility.

3. Quantity, Materials and Tolerances

(a) Rice Lake assumes no responsibility for loss or damage occurring by reason of delay or inability to deliver caused by fires, strikes, accidents, embargoes, car shortages, delays of carriers, insurrection, riots, acts of the civil or military authorities, nor will we assume responsibility for any reason whatever for damages of any kind on account of failure to deliver at the time specified. The customer shall indemnify and hold Rice Lake harmless from all direct and consequential costs and damages resulting from such loss or delay.

4. Weight Calibration Services

The uncertainty of measurement is included in the decision rule in determining pass/fail criteria of the Maximum Permissible Error (MPE).

5. Patents

If this quotation covers parts made specifically for the customer, the customer agrees to indemnify and hold Rice Lake harmless against any loss resulting from infringement of patents or trademarks, or from claims of such infringements and shall pay all legal and defense costs incurred by Rice Lake in the defense of such actions.

6. Software

Unless specifically otherwise stated, any and all software associated or part of any product sold, loaned on trial or demonstration to the customer is to be considered proprietary to Rice Lake. The customer agrees not to duplicate for distribution or to sell or distribute in any way without the prior written consent of Rice Lake.

7. Changes and Cancellation: Rejection, Claims

(a) Orders placed with Rice Lake are not subject to cancellation, change or reduction in amount or suspension of deliveries except with Rice Lake's consent and upon terms that indemnify Rice Lake against loss. Unless confirmed in writing, all verbal agreements are void.

(b) Rice Lake will not be responsible for changes in design, deliveries or other instructions, unless they are furnished in writing. The customer agrees to pay for all tooling charges caused by changes in design or specifications.

(c) Samples submitted shall be deemed approved unless written rejection is received within two weeks of submission.

(d) Manufactured parts will be shipped and billed as they are produced.

(e) Claims for shortage or rejections for defects must be made within 10 days of receipt of goods. Credit will be rendered on such defective parts after we have had an opportunity to inspect them, provided they are returned to our factory, transportation charges prepaid, within 30 days, and provided they have not been altered or defaced in any way.

8. Tooling and Designing

(a) In consideration of the engineering service necessary in the designing of jigs, fixtures and tooling not being charged for, but being quoted on the basis of labor and material only, and not at their fair market value, such jigs, fixtures and tooling shall remain in our possession for at least one year. Thereafter, the customer desiring delivery of such jigs, fixtures and tooling shall pay an engineering charge of 50 percent of the original price of said jigs, fixtures and tooling and accept same as-is.

(b) When requested, we will submit suggestions concerning design and construction of parts, but we will not accept responsibility of liability for the practicability of these suggestions if adopted by the customer.

9. Delivery and Adjustment to Price

(a) If the customer requests that the goods be manufactured and shipped on a date (or dates) earlier than originally agreed to by Rice Lake and the customer, and Rice Lake agrees to the earlier date (or dates), any increase in the cost of performance incurred by Rice Lake resulting from earlier manufacture and shipment will be included in an adjustment of the purchase price to be made by Rice Lake and will be paid by the customer.

Terms and Conditions

(b) Should shipments be held beyond scheduled date for convenience of the customer, goods will be billed and charges will be made for warehousing, trucking and other expenses incident to such delay. Reasonable and sufficient care is taken by Rice Lake in crating its goods. Rice Lake cannot be held responsible for breakage after having received "in-good-order" receipts from the transportation carrier. All claim for loss and damage must be made by the customer to the carrier, but we will assist insofar as practical in securing satisfactory adjustment of such claims.

10. Payment and Liens

(a) All invoices shall be due and payable when submitted for payment in accordance with the revisions of Rice Lake terms.
No withholding of funds, back charges or credits against amounts otherwise due to Rice Lake will be permitted unless specifically agreed to in writing by Rice Lake. Settlement of any amounts due to the customer will be negotiated as separate items and not as offsets against amounts otherwise due to Rice Lake from the customer for products sold hereunder.

(b) Any unpaid account for work done shall constitute a lien on any jigs, fixtures, manufactured parts and raw materials in Rice Lake possession. In the event any account remains open and unpaid for 90 days, Rice Lake reserves the right to use the customer's jigs and fixtures to make parts therefrom, and to sell or dispose of manufactured parts and raw materials.

(c) The customer shall not assign or transfer any rights or obligations arising from this proposal, or monies payable thereunder, without the prior written consent of Rice Lake, and
any such assignment or transfer made without such written consent shall be deemed null and void.

11. Additional Provisions

(a) Errors—stenographic and clerical errors are subject to correction.

(b) These terms and conditions constitute the entire contract between the customer and Rice Lake, transcending any oral arrangements or representations which may be inconsistent therewith.

(c) This quotation is made under and shall be governed by the laws of the state of Wisconsin.

12. Resale of Rice Lake Weighing Systems Products

In order to ensure compliance with the U.S. Export Administration Regulations we ask you to comply with the following:

(a) The customer shall not export or re-export Rice Lake Weighing Systems products, either directly or indirectly, in contravention of any applicable law, statute or regulation and will first obtain any required licenses or authorizations from the relevant government authority when necessary as prescribed by law.

(b) The customer confirms that it is familiar with and complies with the relevant national and international export control regulations and embargo regulations. The customer furthermore confirms that it is in particular familiar with and complies with the U.S. Department of Commerce, Export Administration Regulations; U.S. Department of Treasury, OFAC Sanctions; the U.S. Department of Defense, ITAR requirements and the U.S. Department of State regulations.

(c) If deemed necessary, Rice Lake Weighing Systems, in individual cases may make further requests from the customer for information required for export compliance.

(d) Should it be necessary for the customer to obtain an export license from the appropriate authorities pursuant to the aforementioned regulations, the customer shall apply for such a license autonomously and at their own expense.

13. Sale of Hazardous Area Equipment

It is the responsibility of the reseller to either:

(a) Keep a permanent, traceable record of the equipment location (the end user); or,

(b) Return a completed Rice Lake Hazardous Area Classification Form #1033 signed by the reseller and the end user's hazardous or classified area defining authority. The form must be returned to Rice Lake Weighing Systems for acceptance and permanent record. In the event of an incident, a third party may require that the record be produced. It is the end user's responsibility to maintain compliance with national and local regulations for proper specification, installation, operation and service of this equipment.

The foregoing warranties are exclusive and in lieu of all other express and implied warranties whatsoever, including but not limited to implied warranties of merchantability and fitness for a particular purpose. Rice Lake shall not be subject to any other obligations or liabilities whatsoever with respect to parts manufactured or supplied by Rice Lake or services rendered by it.

Anything herein to the contrary notwithstanding, Rice Lake shall not be liable for incidental and consequential damages, and in substitution for all remedies which the customer may have under any applicable law. The customer's sole and exclusive remedy against Rice Lake for any breach of warranty or any other breach relating to goods delivered pursuant hereto shall be for repair or replacement (at Rice Lake's option) of the goods or parts effected by such breach.

Warranty and Limitation of Liability

Warranties

Standard Product Limited Warranty

Rice Lake Weighing Systems (Rice Lake) warrants that all Rice Lake branded equipment and systems properly installed by an authorized reseller or original equipment manufacturer (OEM) will operate per written specifications as confirmed by the authorized reseller/OEM and accepted by Rice Lake. All systems and components are warranted against defects in materials and workmanship for one (1) year from the date of shipment from Rice Lake, unless otherwise stated in the product catalog or manual. Rice Lake warrants that the equipment sold here under will conform to the current written specifications authorized by Rice Lake. Rice Lake warrants the equipment against faulty workmanship and defective materials. If any equipment fails to conform to these warranties, **Rice Lake will, at its option, repair or replace such goods returned within the warranty period subject to the following conditions:**

Upon discovery by the Customer of such nonconformity, Rice Lake will be given prompt written notice with a detailed explanation of the alleged deficiencies.

Individual electronic components returned to Rice Lake for warranty purposes must be packaged to prevent electrostatic discharge (ESD) damage in shipment. Packaging requirements are listed in the publication, "Protecting Your Components From Static Damage in Shipment," available from the Rice Lake Equipment Return Department.

Examination of such equipment by Rice Lake confirms that the non-conformity actually exists, and was not caused by accident, misuse, neglect, alteration, improper installation, improper repair, or improper testing. Rice Lake shall be the sole judge of all alleged non-conformities.

Such equipment has not been modified, altered, or changed by any person other than Rice Lake or its duly authorized repair agents.

Cutting the load cell cable will void the warranty.

Rice Lake will have a reasonable time to repair or replace the defective equipment. The Customer is responsible for shipping the product to Rice Lake. Rice Lake is responsible for shipping the product back to the Customer.

In no event will Rice Lake be responsible for travel time or on-location repairs, including assembly or disassembly of equipment. Nor will Rice Lake be liable for the cost of any repairs made by others.

On all intrinsically safe equipment, any field repair or modifications voids any and all warranties expressed or implied and void F.M. approval.

Any loose hardware, screws, washers or non-ESD bags of hardware stored inside indicator will void warranty. This could cause harm to repair technician or damage CPU board.

If just the board is sent in for repair, the serial number of the product the board is from should accompany the board.

These warranties exclude all other warranties, expressed or implied, including without limitation warranties of merchantability or fitness for a particular purpose. Neither Rice Lake nor the authorized reseller will, in any event, be liable for incidental or consequential damages at the point of use. Rice Lake and the Customer agree that Rice Lake's sole and exclusive liability here under is limited to repair or replacement of such goods. In accepting this warranty, the Customer waives any and all other claims to warranty.

Should the seller be other than Rice Lake, the Customer agrees to look only to the seller for warranty claims. No terms, conditions, understanding, or agreements purporting to modify the terms of this warranty shall have any legal effect unless made in writing and signed by a corporate officer of Rice Lake and the Customer.

Carrier Product Damage

As part of our commitment to customer satisfaction and in accordance with ISO 9001 standards, we make every attempt to pack our products so they will arrive in new condition. Occasionally due to rough handling or carelessness of carrier, product may arrive in a damaged condition. When this happens, don't assume that the shipment left Rice Lake in that condition or that the original packing was not sufficient.

The receiver, whether it is the authorized reseller or their Customer, is responsible for making a notation of damaged or missing items when signing the carrier's delivery receipt. If you or your Customer are not sure whether there is damage, we suggest adding a statement "CONDITION UNKNOWN" to the delivery receipt. In the event that damage or missing items are not properly documented at time of receipt, the carrier is relieved of responsibility and the receiver is then responsible for the cost to get the product back to new condition.

After the damage or shortage has been properly noted with the carrier, contact Rice Lake immediately and keep all the original packaging material for inspection by the carrier's representative. It is also helpful in the claim process to take pictures of the condition of the packaging and damage.

When drop-shipping items to your Customers, it is imperative that you advise them of their responsibility in accepting shipments from common carriers. Even if the equipment is not expected to be installed or used for a period of time, the shipment must be inspected at time of receipt in order to preserve their rights for making a claim.

Custom Software Limited Warranty

Rice Lake Weighing Systems (Rice Lake) warrants that (a) the software will perform in accordance with the specification and accompanying written endorsement by the Customer for a period of 90 days from the date of receipt; (b) any hardware accompanying the software will be free from defects in materials and workmanship under normal use and service for a period of one (1) year from the date of shipment from Rice Lake; and (c) the Customer should perform inspection and testing of software products prior to installation.

This limited warranty is void if failure of the software or hardware has resulted from accident, abuse, misapplication, or incorrect Customer specification. Any replacement software will be warranted for the remainder of the original warranty period or 30 days, whichever is longer.

If the software fails to conform to these warranties, Rice Lake will, at its option, repair or replace such goods returned within the warranty period subject to the following conditions:

Upon discovery by the Customer of such nonconformity, Rice Lake will be given prompt written notice with a detailed explanation of the alleged deficiencies.

Examination of software by Rice Lake confirms that the nonconformity exists, and was not caused by accident, misuse, neglect, alteration, improper installation, improper repair, improper testing, or incorrect Customer specification. Rice Lake shall be the sole judge of all alleged non-conformities.

Rice Lake will have a reasonable time to repair or replace the software. The Customer is responsible for shipping charges both ways.

Warranty and Limitation of Liability

In no event will Rice Lake be responsible for travel time or on-location repairs, including assembly or disassembly of equipment. Nor will Rice Lake be liable for the cost of any repairs made by others.

These warranties exclude all other warranties, expressed or implied, including without limitation warranties of merchantability or fitness for a particular purpose. Neither Rice Lake nor the authorized reseller will, in any event, be liable for incidental or consequential damages at the point of use.

Rice Lake and Customer agree that Rice Lake' sole and exclusive liability here under is limited to repair or replacement of such goods. In accepting this warranty, the Customer waives any and all other claims to warranty.

Should the seller be other than Rice Lake, the Customer agrees to look only to the seller for warranty claims.

No terms, conditions, understanding or agreements purporting to modify the terms of this warranty shall have any legal effect unless made in writing and signed by a corporate officer of Rice Lake and the Customer.

Return Policies

Our commitment to our Customers states that if any standard product purchased from Rice Lake does not work, or if the incorrect product is shipped, **return it in its original shipping carton with all accessories in "like new" condition** for full credit or replacement within 30 days of purchase. **Electronic components returned to Rice Lake must be properly packaged to prevent electrostatic discharge (ESD) damage in shipment.** Packaging requirements are listed in the publication, "Protecting Your Components from Static Damage in Shipment," available online or from our Returns Department. This policy and the 30-day limit also apply to any products drop-shipped directly from the manufacturer.

Please note that if an incorrect quantity of product was shipped, Rice Lake must be contacted within 10 days of the purchase. Upon notification, we will immediately correct the situation.

A restocking charge will apply if equipment is not in like-new condition. The restocking charge is directly proportional to the amount of time and material required to return the item to resalable condition—we will make every effort to do this quickly and economically. Equipment that has been abused and/or shows signs of excessive wear and cannot be reconditioned and resold will not be accepted for return or credit after excessive wear or has been modified.

As Applied to Drop Shipments

All Rice Lake return guidelines apply to products drop-shipped directly from the manufacturer. If a perceived error occurs, Rice Lake will investigate to the best of our ability to determine if the error occurred prior to shipping, during shipping, or at the end user site. If our records and subsequent investigation indicate that the shipment was correct when it left our factory, our responsibility extends only to the authorized reseller, not their end user. Our standard product warranty notes that our coverage extends only to equipment and systems **properly installed by an authorized reseller.**

Obtaining an RMA

A return merchandise authorization (RMA) number. is required for all materials being returned to Rice Lake for credit. Flat rate repairs require purchase orders at time of RMA issuance. When returning equipment for repair or warranty reimbursement consideration, these simple steps will help to expedite your request:

1. Contact our Returns Department.
2. Please have your customer number and both the item description and detailed findings of product problem for repair.
3. Please have the original sales order or invoice number for items to be returned for credit or warranty.
   NOTE: See return policy
4. An RMA number will be given for eligible returns. This RMA number may also be faxed or emailed per your request.

Return Shipments Outside the United States for Repair, Warranty, Calibration or Other Services and Re-export.

For shipment to the USA:

1. The commercial invoice must include the following statement:
   i. "These goods are being returned for maintenance under"
   ii. The RMA department will instruct you with the HTS code that you can use to achieve a duty free return. Typically the HTS code to use for articles returned temporarily for repair, alteration, process, and are expected to be reexported get classified as 9801.00.1012
2. The commercial invoice must list items individually and include the fair market value of the item based on its present condition for customs purposes only.
3. Please reference original Rice Lake commercial invoice number and date item was purchased if applicable.
4. Please note that failure to follow these procedures may cause delay and will certainly incur extra charges that will NOT be absorbed by Rice Lake.

Return Shipments Outside the United States Other Than for Repair, or Service Work Not Being Returned.

For shipment to the USA:

1. The commercial invoice must include the following statement:
   a. "These goods have not been improved in value.
   b. The RMA department will instruct you with the HTS code and country of origin that you can use to achieve a duty free return.
2. The commercial invoice must list items individually and include the fair market value of the item based on its present condition for customs purposes only.
3. Please reference original Rice Lake commercial invoice number and date item was purchased if applicable.

Warranty and Limitation of Liability

4. Please note that failure to follow these procedures may cause delay and possible reduction in your refund.
5. Please be advised that you may qualify for a refund of your duties and should contact your local customs authority for instructions and forms.

Special Order, Modified, Non-catalog or Non-stock Items

Due to the added resources and difficulty in reselling special or non-standard products, returns or credit are not allowed for special order equipment, special software programs, equipment physically modified or altered in the field, discrete electronic components, relays, manuals, or opened software packages.

Calibration Test Weights

All weights returned for credit will be assessed a restocking charge because of the required inspection and verification. Credit is not allowed for serialized weights, calibration or traceable services performed on weights.

Calibration Test Weights

No returns will be accepted for items that are specifically modified for the Customer's requirements. Examples of such modifications may include but not limited to:

1. Weights that have been specifically built to the customer's specifications.
2. Standard product specifically modified to the customer's specifications.
3. Standard product engraved with serial numbers at the customer's request.
4. Laboratory procedure charges.
5. Laboratory documentation fees.

Balances

Balances returned for credit within 30 days of purchase may be subject to a restocking fee if assessed by balance manufacturer.

Balance Repair Policy and Rates

We offer repair support on the following balance models:

- All Rice Lake brand models. Once we receive the equipment and the RMA form, an estimate will be prepared.

A minimum charge of one hour will apply. All balance repairs are covered by a 90-day limited warranty on parts and workmanship performed and noted under the scope of the specific repair. Balances must be packaged to adequately protect them from damage in transit. Please refer to "How to Prepare a Balance for Shipment" available on our website or call our Returns Department.

How to Prepare a Balance for Shipment

The best and most effective method for shipping a balance at any time and for any reason is to use the original manufacturer's packaging materials and subsequently double box it as described below. Due to the nature of the equipment, new packaging materials can be expensive. It is best to retain the original packing.

In the event that the original manufacturer's packaging materials are not available, follow these instructions for top loading balances:

1. Remove the weighing platform cover, support buttons, weighing platform, floor plate and other devices installed in the weighing chamber. Pack these pieces individually in bubble wrap and tape the wrapping closed. Follow this same procedure for AC adapters and power cords. Please note that AC adapters and power cords are necessary to adequately evaluate any issues with the balance.
2. Examine the device (refer to the operating instructions) and if necessary, re-install or tighten any shipping screws/retaining devices to prevent damage to the weighing mechanism during shipment.
3. If the floor plate is not removable, ensure it is securely in place and cannot come loose during shipment, even if the balance is inverted. Do NOT invert the balance to test the security of the floor plate.
4. Clean the device of any loose debris or potential contaminants to our testing facility.
5. Prepare and sign a Statement of Decontamination (form #0679). This form MUST be included in a separate packing list envelope on the outside of the box with "Statement of Decontamination Form" clearly visible.
6. Using Scotch or aluminum tape, carefully secure all the glass doors on the device CLOSED. Be sure the tape is securely affixed and will not come off during shipment. Please note that on some devices, the glass breeze-break around the weighing chamber can actually be disassembled and packed separate prior to shipment. Refer to the manufacturer's operating instructions. If this is a feature of the device being return, disassemble the breeze break and pack it in its own packing material and box.
7. Use a large box that will provide a minimum of 3 inch of space around the device for loose-fill packing material.
8. Place a padding of foam or Styrofoam (at least 1 in thick) at the bottom of the box.
9. Place the balance in a large plastic bag and seal the bag closed.
10. Please put the device on top of the foam padding or Styrofoam from step 8 above.
11. Ensure that there is at least three inches of clearance between the top of the balance and the top of the box.
12. Using generous amounts of anti-static loose-fill packing material, fill all the spaces around the balance. Shake the box to cause the material to settle and add additional loose fill as necessary.
13. Place the small box containing all the items from step 1 above on top of the loose fill covering the balance. Add additional loose fill to completely cover all items within the box.
14. Double pack this box in another box that will again provide an additional two inches of space around the inner box. Fill all existing space between the inner and outer box with copious amounts of anti-static loose fill packing material.
15. Seal the box and include all the necessary documentation on the outside of the box. Be sure to include the Statement of Decontamination (form #0679) from step 5 above.

Warranty and Limitation of Liability

Repair Service Policies

Our Service Department is staffed Monday through Friday from 6:30 a.m. to 6:30 p.m., and Saturday from 8:00 a.m. to noon, Central Time. Please call or email Rice Lake at service@ricelake.com for answers to your technical questions and the status of repair products during normal business hours.

We provide quality and timely repairs for the products we sell. Flat rate repair is offered for selected models of indicators, printers and remote displays. Prior to returning a product for repair, our returns department will work with you to determine some key factors that will help Rice Lake better serve you. Please provide the following via phone to extension 5348 or an RMA form.

- Customer Number: Without a customer number we cannot issue an RMA number.
- Ship-to Address: Your customer number will bring up the bill-to address. You must inform Rice Lake of the ship-to address if it's different than the bill-to address.
- **Original sales and invoice orders: Required on warranty claims.**
- Freight Type: Unless stated otherwise, we ship the device back to you utilizing the same freight type in which we received it. If Rice Lake is responsible for freight charges, the carrier will be selected at the sole discretion of Rice Lake.
- **Definition of Product and Problem: Please provide as much detail as possible regarding the type of product, application and problem.**
- Purchase Order Number for Flat Rate Repair: Once we receive the equipment and the RMA, equipment for flat rate repair will be processed immediately. Other equipment will be evaluated and a minimum evaluation charge will apply (contact Rice Lake for exact pricing).

You may be asked about the possibility of a new replacement product. It may be in your best interest to explore the option of purchasing a new product if the repair will exceed 50 percent of authorized reseller net price, since new products carry full-warranty benefits.

Please note our hourly service rate on all current Rice Lake products. Contact Rice Lake for exact pricing. There is a 120-day limited warranty on parts and workmanship performed and noted under the scope of the specific repair.

California Proposition 65

Rice Lake Weighing Systems Statement

Proposition 65 requires businesses to inform Californians about exposures to chemicals that are listed by the State of California as known to cause cancer, birth defects or other reproductive harm. There are over 900 different chemicals listed under Proposition 65 and more chemicals are listed by the State of California each year. These chemicals may be in the products you purchase, or you may be exposed to them at home, at the workplace or within the environment. Proposition 65 enables Californians to make informed purchasing decisions about products that can expose you to these chemicals even in minute or trace amounts. California's Proposition 65 is a California only law.

Rice Lake Weighing Systems provides Proposition 65 warnings on the packaging of the products it sells that may require a warning in an abundance of caution. All of Rice Lake's products are safe for their intended use. We are providing this warning based on the knowledge that one or more chemicals included in the California Proposition 65 list is present in Rice Lake Weighing Systems products even if only in trace or minute amounts. To the extent that customers repackage any Rice Lake products they have sole responsibility for ensuring that the Rice Lake Proposition 65 warning is provided if the repackaged product is sold in California. Any Rice Lake customer who repackages a Rice Lake product but does not include the Rice Lake Proposition 65 warning that is included on the Rice Lake packaging agrees to defend and indemnify Rice Lake by counsel of its choice if a claim is asserted against Rice Lake based on the failure to provide a Proposition 65 warning on the repackaged product. The Rice Lake terms and conditions prevail over any conflicting terms in customer's purchase documentation and customer's order and receipt of Rice Lake Products is deemed acceptance of Rice Lake's terms and conditions. More information about California's Proposition 65 can be found at www.P65Warnings.ca.gov.

Ingress Protection (IP) Ratings

Rice Lake Weighing Systems uses universal ingress protection (IP) ratings to identify protection levels against the ingress of solid objects, dust and water for load cell seals and other products. The first number following IP identifies the level of protection against solid objects, including dust. The second number indicates the level of protection against various forms of moisture.

All load cell cables should be run through conduit to increase protection against moisture ingress.

Example: Protection level offered by an IP67 rated product

IP 67

Protection against solid objects
First number (in this case 6)

0 No protection
1 Protected from solid objects up to 50 mm (e.g., accidental touch by hands)
2 Protected from solid objects up to 12 mm (e.g., fingers)
3 Protected from solid objects more than 2.5 mm (e.g., tools and small wires)
4 Protected from solid objects more than 1 mm (e.g., small wires)
5 Protected from dust; limited entrance (no harmful deposit)
6 Totally protected from dust

Protection against liquids
Second number (in this case 7)

0 No protection
1 Protected from vertically-falling drops of water (e.g., condensation)
2 Protected from direct sprays of water up to 15° from vertical
3 Protected from direct sprays of water up to 60° from vertical
4 Protected from water sprayed from all directions; limited entrance allowed
5 Protected from low pressure jets of water from all directions; limited entrance allowed
6 Protected from strong jets of water (e.g., for use on ship decks); limited entrance allowed
7 Protected from the effects of immersion between 15 cm and 1 m for 30 minutes
8 Protected from extended periods of immersion under pressure

IP Numbers with Hermetically Sealed (HS) or Environmentally Protected (EP) Ratings

Rating	Protection
EP	Dust proof, not protected from moisture or water
IP65	Dust proof, protected from splashes and low-pressure jets
IP66	Dust proof, protected from strong water jets
IP67	Dust proof, protected from temporary immersion in water 1 meter deep for 30 minutes
IP68	Dust proof, protected from continuous immersion in water under more severe conditions than IP67
IP66/68	Dust proof, protected from strong water jets and/or constant immersion
IP69K	Dust proof, protected from high pressure washing and steam cleaning

Conversions

Abbreviation	Description	Conversion
kg	1 kilogram kilo 10^3	1000 grams
mg	1 milligram milli 10^{-3}	0.001 g
µg	1 microgram micro 10^{-6}	0.000 001 g
µlb	1 micro pound micro 10^{-6}	0.000 001 lb

Multiplication Factor	Prefix	Symbol
1,000,000,000 = 10^9	giga	G
1,000,000 = 10^6	mega	M
1,000 = 10^3	kilo	k
100 = 10^2	hecto	h
1 = 1		
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	µ
0.00000001 = 10^{-9}	nano	n

Abbreviation	Description	Conversion
T	Tera	1,000,000,000,000
G	Giga	1,000,000,000
M	Mega	1,000,000
k	kilo	1,000
h	hecto	100
dK -or- da	deca	10
	metre, gram, liter, second, celcius	
d	deci	.1
c	centi	.01
m	milli	.001
µ	micro	.000,001
n	nano	.000,000,001
p	pico	.000,000,000,001

Unit	"kg" RELATIONSHIP	"g" RELATIONSHIP
Nanogram (ng)	10^{-12} 0.000000000001 kg	10^{-9} 0.000000001 g
Microgram (µg)	10^{-9} 0.000000001 kg	10^{-6} 0.000001 g
Milligram (mg)	10^{-6} 0.000001 kg	10^{-3} 0.001 g
Gram (g)	10^{-3} 0.001 kg	1 g
Kilogram (kg)	1 kg	10^3 g 1000 g
Ton (t)	10^3 kg 1000 kg	10^6 g 100,000 g

Shipping Information

Signed. Sealed. Delivered. It's Yours!

**On average, regardless of carrier, 2% of all freight is damaged in transit.
Don't let the delivery person slip away. And don't get left holding the bag.**

Rice Lake merchandise is packaged carefully to arrive at your location on time, intact and in perfect working order. We don't ship damaged goods, and we work with many of the most reputable national carriers. But know this—anytime a package is sent, an average of 2 out of 100 will be mishandled. To be sure your business doesn't take the hit for someone else's mistake—INSPECT before you sign.

Whether or not the product itself has been damaged, remember—your signature accepts the delivery as is, releasing the carrier and supplier of all liability, unless you take action:

- Make note of any damage to the packaging, no matter how slight, including re-packaging, water damage, scratches to paint, etc. Take photos if possible to back up any necessary claims.
- Do not accept or sign for as "unchecked"—this is not an acceptable disclaimer.
- Where damage to contents is obvious, take photos and refuse the shipment.

Notify your supplier immediately with the claim number provided by the driver. Noting the condition of your delivery upon receipt is the only recourse when making a damage claim. Follow these steps and you'll get replacement merchandise faster, keep costs down and ensure the carrier is held responsible for their mistakes; not you, and not your supplier.

Same-day Services

These services do not carry the same service guarantees that standard delivery schedules do and are subject to availability.

Small Parcel Services

We ship with internationally recognized parcel carriers based on delivery time and services offered.

Determining Dimensional Weight for Small Parcel Shipments for Air and Ground

When shipping via air services, couriers require the shipping weight be determined by the greater of the boxed product's actual weight or its dimensional shipping weight. The formula for calculating dimensional shipping weight is as follows:

Domestic shipments via ground or air: L x W x H/139.

International air shipments: L x W x H/139.

Please note: Rice Lake Weighing Systems takes the added precaution of double-boxing some of our electronic products and balances. This may result in higher dimensional weight charges by the carrier. Even with this added precaution, we suggest you always ship high precision and fragile products via air services to reduce excessive handling.

Less than Truckload (LTL)

Full service LTL coverage for the continental United States, Puerto Rico, Canada and Mexico.
Note: A standard LTL delivery is considered to be one that ships from either a company or partner dock to arrival at a standard commercial address with disposition of the goods at the rear of the truck. This enables offloading by material handling equipment provided by the consignee at either ground level or via loading dock. The freight in question should be palletized and secured in a way to facilitate the safe handling of the freight with no one dimension over six feet.

Any LTL delivery falling outside of this criteria may accrue accessorial charges levied by the carrier in line with their tariff rules.It is recommended that any potential accessorial costs are discussed at the time of order placement so these costs can be billed appropriately at the time of shipment. If this is not the case, Rice Lake reserves the right to charge the customer retrospectively for any accessorial costs incurred during the delivery process.

Accessorial charges include, but are not limited to the following:
Lift gate, call for appointment and guaranteed delivery: Day and by 10:30 a.m. (where available). Excessive length, inside delivery.
Note: Cross the first threshold only for high-cost delivery areas such as government sites and mines, re-delivery, re-consignment, residential and restricted access shipments. All prices are available on request.

Full Truckload

Various truckload providers give us the ability to ship to the contiguous United States, Alaska, Canada and Mexico.

Forwarders (International Freight)

We can provide service through a forwarder of our choice, or select one of your preferred forwarders.
Air freight: All of our forwarders are internationally recognized brands.
Ocean freight: All of our forwarders are internationally recognized brands.

Shipping Information

FREIGHT SERVICES OFFERED	"SMALL PACK"	LTL	TRUCKLOAD
Nationwide Same-day Service	Y* and ***	Y*	N
Next Day (a.m.)	Y**	Y**	Y**
Next Day (END OF DAY)	Y	Y**	Y**
2-day	Y	Y	Y
3-day	Y	Y	Y
Ground	Y	Y	Y
Canada	Y	Y	Y
Mexico	Y	Y	Y
Express Freight (Air-over 150 lb)***	Y	Y	N
International (Sea)	Y	Y	Y
International (Air)	Y	Y	N

** Subject to cost/distance ** Subject to distance *** Subject to flight availability and proximity of nearest airport*

Rice Lake Weighing Systems Freight Claims Procedure

Incidents can happen anytime between a package's departure from Rice Lake's loading dock and the time you receive it. For that reason, we are asking you to follow the procedures below when receiving a shipment.

The Bill of Lading (BOL) or Delivery Receipt (D/R) is the only record of the product's condition when it arrives at your site. If you do not inspect a shipment before signing, you are essentially waiving the right to collect on a damage claim regardless of whether the damage is visible or concealed. Your signature on a delivering carrier's BOL or D/R constitutes acceptance of the merchandise "as is." This proof is essential in filing a claim and holding the responsible parties accountable for items damaged or missing while in transit. Remember, once you sign, the goods and responsibility are yours.

Receiving a Shipment

- Check immediately for possible damage during shipment. Inspect, examine and inventory your delivery as it is unloaded.
- Open cartons and containers. Any suspicion of damage or shortage must be noted on the BOL or D/R. This information must include the item, discrepancy and condition of the item in question. If this is NOT noted, the liability to prove the damage was done by the delivering carrier is your responsibility.
- The driver cannot leave your receiving dock until the BOL or D/R is signed, regardless if they are behind schedule or not. Do not be intimidated by the driver.

Damaged Shipment

- Discovered damage: If the box, crate or merchandise is visibly damaged beyond what you would consider to be normal shipping wear and tear, refuse the delivery and request a Return Authorization Number from the driver in order for the shipment to be sent back to its origin at no charge.
- Concealed damage: Immediately document and photograph the damage and packaging. Keep all crating and packaging material with the damaged item(s) for inspection by the company's claim inspector until told to either return or dispose of the item(s). The item(s) should be moved minimally—only to an area where it can be inspected by the carrier or their agent.
- Keep a second copy of the BOL or D/R noting the damage and the driver's signature.
- Call your Rice Lake customer service representative to report the shortage and/or damage. Ideally, the call should be made before the driver leaves the site.

At this point, a claim for concealed damage will be started and an inspection will be requested. The inspector will determine if the damage was possibly caused by the carrier. A report and claim must be filed with the carrier within seven days after delivery. The sooner concealed damage is discovered and reported, the better.

Small Parcel Shipments

In general, it is the policy of small parcel carriers to not deliver damaged packages but rather take them back to the distribution center for evaluation. However, that does not always happen. Occasionally if the package is deemed to be ok, it will be re-taped and delivered to the consignee. If damage is noticed while still at the distribution center, a notation should have been entered into the system.

If you do receive a package that appears to be damaged, you can either refuse as damaged or accept the damaged package and report the damage immediately to your Rice Lake customer service representative with the tracking number. They will, in turn, contact the relevant team member from their support group, so the claims process can be started. **Note: Drivers do not normally note the package was damaged until it is brought back to the distribution center. A clerk will note damage at that point.**

Questions

If you have any questions about shipping or potential damages to your shipment, contact us at 800-472-6703 and a member of our sales and logistics team will assist you.

Weight Recalibration Request

To receive a quote for recalibration, return this form via mail, fax, or email to orderdesk@ricelake.com
For questions, please contact our weights specialists at 800-472-6703 ext. 6655.

**To help us serve you better, please complete the required fields denoted with an asterisk.*

***RLWS Account #:** ______________________

***Bill to:** ______________________

Address: ______________________

____

City: ______________________

State: ____________ Zip: ____________

Contact: ______________________

Phone: ____________ Fax: ____________

Email: ______________________

***Shipping Method:** ______________________

Shipping Account #: ______________________

☐ (Shipping address is different from billing address.)

Ship to: ______________________

Address: ______________________

____

City: ______________________

State: ____________ Zip: ____________

Country: ______________________

***Payment Information**

Purchase Order #: ______________________ **Contact Number:** ______________________

***Certification/Report Information**

Contractor: ______________________

Client: ______________________

***Recalibration Date:** ☐ No ☐ Yes, number of years:_________

Select type of documentation (only one per quote request):

☐ Certificate of Weight Calibration—ISO/IEC 17025 accredited. Traceable to NIST. Classes ASTM 00-7, OIML E1, E2, F1, F2, M1, M2, M3, NIST Class F

☐ Certificate of Weight Calibration—Non-accredited. Traceable to NIST. Classes ASTM 1-3, OIML F1, F2

Range	Density	Serial #	Number of Weights	Number of Reports	Class	Recalibration Date	Documentation Type
				☐ Individual report each weight			☐ Accredited
				☐ All weights on one report			☐ Non-Accredited
				☐ Individual report each weight			☐ Accredited
				☐ All weights on one report			☐ Non-Accredited
				☐ Individual report each weight			☐ Accredited
				☐ All weights on one report			☐ Non-Accredited
				☐ Individual report each weight			☐ Accredited
				☐ All weights on one report			☐ Non-Accredited
				☐ Individual report each weight			☐ Accredited
				☐ All weights on one report			☐ Non-Accredited

For shipment originating outside the USA, weights are being returned for maintenance under:

☐ Made in USA (HTS 9801.00.1012) ☐ Not made in the USA (HTS 9801.00.2500)

Have these weights been exposed to hazardous materials? ☐ **Yes ☐ No

Signature: ______________________ **Title:** ______________________

Print Name: ______________________ **Date:** ______________________

***If yes, please complete Statement of Decontamination form and include a copy of this form and your order along with your weights. If weights have been exposed to hazardous materials, service will not be performed without a completed Decontamination Form.*

The uncertainty of measurement is included in the decision rule in determining pass/fail criteria of the Maximum Permissible Error (MPE).

Metrology Lab Locations:

TEL: 800-472-6703 • FAX: 715-234-6967

RICE LAKE: 230 W. Coleman St. • Rice Lake, WI 54868 • USA
CONCORD: 1400 Willow Pass Court, • Concord, CA 94520 • USA

RICE LAKE WEIGHING SYSTEMS

www.ricelake.com/recalibration

#0048 Rev 20, 03/21

Statement of Decontamination

All weights exposed to hazardous materials that are returned to Rice Lake Weighing Systems are required to have a completed decontamination form. By accepting authorization to return this product, the customer assumes all responsibility and liability for biological, chemical and radioactive decontamination and cleaning. Rice Lake Weighing Systems will not accept any delivery which does not include a completed decontamination form.

Customer Information

Company: _____ Address: _____

Cust No: _____ _____

Name: _____ City: _____

Phone: _____ State/Zip: _____

Email: _____ Country: _____

Product

Manufacturer: _____ Type: _____ Serial #: _____ Qty: _____

Manufacturer: _____ Type: _____ Serial #: _____ Qty: _____

Manufacturer: _____ Type: _____ Serial #: _____ Qty: _____

Manufacturer: _____ Type: _____ Serial #: _____ Qty: _____

List any exposure to hazardous fluids, gases or substances and attach copies of appropriate MSDS sheets

_____

_____

_____

_____

_____

Please describe decontamination procedure or process used:

☐ ETO ☐ Biocides ☐ Irradiation ☐ Manual Disassembly and Cleaning

☐ None Required ☐ Other_____

I certify that the aforementioned items are free of any radioactive, biohazardous, or otherwise dangerous substances/gases and are safe for human handling. By signing this form, I indicate that I have read and understand Rice Lake Weighing Systems' decontamination policy above and have taken any and all necessary steps to assure this product will not pose a chemical, biological or radioactive threat.

Signature: _____ **Title:** _____

Print Name: _____ **Date:** _____

To minimize delays, please include a copy of this form and your order along with your weights to be calibrated. Service will not be performed without a completed Decontamination Form.

Metrology Lab Locations:

RICE LAKE: 230 W. Coleman St. • Rice Lake, WI 54868 • USA
TEL: 800-472-6703 • FAX: 715-234-6967

CONCORD: 1400 Willow Pass Court, • Concord, CA 94520 • USA
TEL: 800-672-1440 • FAX: 925-798-8905

RICE LAKE WEIGHING SYSTEMS

www.ricelake.com/precision

#0047 Rev 4 1/19