A-2 Calibrations of Standards and Measuring Apparatus Owned and Used by Authorized Service Providers to Conduct Inspections

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Category: Programs for authorized service providers

Document(s): Criteria for the Accreditation of Organizations to Perform Inspections Pursuant to the *Electricity and Gas Inspection Act* and the *Weights and Measures Act* (S-A-01); Registration Program Terms and Conditions; Conditions and Administrative Requirements for the Recognition Program of Calibration Results from CLAS Laboratories Program (RC-01); *Weights and Measures Act* and *Regulations; Electricity and Gas Inspection Act* and *Regulations*

Supersedes A-2-E, rev. 9

1.0 Purpose

The purpose of this bulletin is to outline how Measurement Canada (MC) determines the number of standards and measuring apparatus owned by authorized service providers (ASPs) that are calibrated by MC for use by ASPs to conduct inspections (examinations). It also sets out ASPs’ responsibilities in this regard and the conditions under which weights and measures calibrations are provided by MC free of charge.

2.0 Scope

This bulletin applies to standards and measuring apparatus owned and used by ASPs to conduct inspections (examinations) pursuant to the *Electricity and Gas Inspection Act* and the *Weights and Measures Act*. Information on the calibration of other standards can be found in bulletin GEN-08. Bulletin GEN-08 cannot be used to circumvent the requirements of the present bulletin.

3.0 Definitions

Note: For the purposes of this bulletin, the term “inspection” is used in a generic manner and is intended to include verifications and reverifications under the *Electricity and Gas Inspection Act* and examinations under the *Weights and Measures Act*.

"Calibration" means a comparison between a standard under test and a reference standard for the purpose of determining if the value of the standard under test is within the specified tolerances.

Note: The term "calibration" does not necessarily include the adjustment of a standard required to ensure it meets specified tolerances.

“Standard” means any standard designated as a local standard by the Minister under section 13 of the *Weights and Measures Act*.

“Measuring apparatus” means an apparatus required for the measurement or examination of electricity,
4.0 Responsibilities of Authorized Service Providers

Authorized service providers are responsible for the following:

4.1 Ensuring their standards and measuring apparatus are calibrated and certified at least at intervals prescribed by the *Weights and Measures Regulations* or the *Electricity and Gas Inspection Regulations*.

4.2 Ensuring standards and measuring apparatus submitted for certification by MC are in good condition and properly cleaned and marked.

4.3 Ensuring mass standards are adjusted as outlined in this bulletin before submitting them for certification by MC.

4.4 Ensuring, for companies seeking accreditation or registration, standards and measuring apparatus are sent for calibration only when instructed by the Regional Manager, Alternative Service Delivery (ASD) or the Regional Coordinator, ASD, or his or her delegate.

   4.4.1 Under the Accreditation Program, standards and measuring apparatus must be sent for calibration when the quality management system documentation review is completed (or very close to completed) by MC.

   4.4.2 Under the Registration Program, standards must be sent for calibration when at least one technician has successfully passed the theoretical training and the associated practical evaluation is very close to being completed.

4.5 Contacting MC’s Approval and Calibration Services Laboratory (ACSL) or district office, as appropriate, to make prior arrangements before sending standards and measuring apparatus for calibration and certification.

4.6 Ensuring that the number of standards and measuring apparatus submitted for certification by MC is:

   4.6.1 commensurate with the number of recognized technicians and the expected inspection workload to be performed, and

   4.6.2 necessary to fulfill mandatory inspection requirements.

4.7 Ensuring all standards and measuring apparatus sent to MC’s ACSL are accompanied by a correctly completed *Calibration Services Request form*.

   4.7.1 A written explanation as to why a standard or measuring apparatus has been sent for recalibration with an expired certification, a broken seal or in a condition affecting the certificate’s validity, must accompany the form.

4.8 Ensuring all standards and measuring apparatus sent to MC’s ACSL are properly packaged to ensure adequate protection during shipping.
4.9 Providing standards and measuring apparatus to MC upon request prior to the end of the prescribed certification interval for the purpose of verifying the condition of the standards and measuring apparatus, establishing their “as found” value, and determining whether an ASP is maintaining its standards and measuring apparatus in satisfactory condition.

4.10 Assuming all packaging, shipping and handling costs and any brokerage fees for international shipments associated with the certification of the standards and measuring apparatus.

All ASPs must submit, no later than December 15 of that year, a list of the standards and measuring apparatus they would like MC to certify and designate during the next calendar year to the Regional Coordinator, ASD for acceptance. Any addition to the list must also be approved by the Regional Coordinator, ASD. These lists assist MC to provide calibration services within service standards. Weights and measures standards used to perform inspections are calibrated and certified as local standards by MC free of charge, in accordance with section 59 of the Weights and Measures Regulations. See Appendix 1 for the maximum number of weights and measures standards that can be calibrated and designated as local standards by MC free of charge.

Measuring apparatus used to conduct inspections pursuant to the Electricity and Gas Inspection Act are calibrated and certified in accordance with section 47 of the Electricity and Gas Inspection Regulations. At this time, there is no maximum number of measuring apparatus that can be accepted by the Regional Coordinator, ASD. Fees apply to the calibration of electricity and gas measuring apparatus.

5.0 Accuracy requirements

Standards presented for calibration and certification must meet the accuracy requirements set out in Schedule IV of the Weights and Measures Regulations.

Measuring apparatus presented for calibration and certification must meet the accuracy requirements set out in the Electricity and Gas Inspection Act and Regulations.

6.0 Types of standards and measuring apparatus and their calibration location

6.1 Dimensional
   - Gauge block (6)
   - Tape measure (6)

6.2 Electrical
   - Digital multifunction standard (1)

6.3 Gas
   - Barometer (1)
   - Bell prover (5)
   - Dead weight tester, pneumatic (1)
   - Pressure gauge (1)
   - Pressure module (1)
   - Pressure transducer (1)
- Pressure controller (1)

6.4 Gravimetric

- Mass standards of 5 kg (10 lb) or larger (2 or 4), see section 7.1.1
- Mass standards of 5 kg (10 lb) and smaller (1 or 4), see section 7.1.2
- Mass standards of 20 kg and smaller used to inspect Class II devices (1), see section 7.1

6.5 Temperature

- Thermometer (1), see section 7.3

6.6 Volumetric

- Narrow neck 20 litre standard (1), see section 7.2
- Test measure and prover of 100 litres and less used to calibrate other provers or to certify ASPs’ pipe provers (1), see section 7.2
- Test measure and prover used to inspect volumetric meters (2), see section 7.2
- Pipe prover (2), see section 7.2
- Hydrometer/LPG (1) and (3)
- Pycnometer (1)

Calibration locations:

(1) MC
ACSL
Standards Building
151 Tunney's Pasture Driveway
Ottawa, Ontario, K1Y 1G9

(2) MC district offices (various locations)

(3) National Research Council of Canada (NRC), Ottawa

(4) CLAS Type I Laboratories recognized by MC

(5) On-site calibration by MC’s ACSL

(6) CLAS laboratory or laboratory recognized by the NRC providing traceability to the definition of the metre as per the Weights and Measures Act.

7.0 Information on standard types

7.1 Gravimetric standards

Mass standards that meet International Organization of Legal Metrology (OIML) Class M1 requirements are suitable for the inspection of Class III, III HD and IIII weighing devices.
Mass standards that meet OIML Class F2 requirements or better shall be used to perform inspections of
Class II weighing devices.

Initial inspections:

- When performing initial inspections of Class II devices, mass standards meeting OIML Class F2 requirements can only be used to verify Class II devices having no more than 31,250 scale intervals and where “e” is equal to or greater than 10 mg. Class II devices having more than 31,250 scale intervals or where “e” is smaller than 10 mg must be verified with mass standards of OIML Class F1 or better.

Subsequent inspections:

- When verifying in-service tolerances, Class II devices having up to 62,500 scale intervals and where “e” is equal to or greater than 2 mg may be verified with OIML Class F2 mass standards. Class II devices having more than 62,500 scale intervals or where “e” is smaller than 2 mg must be verified while in service with mass standards of OIML Class F1 or better.

Mass standards meeting OIML Class F1 can be used to inspect all Class II devices.

Please consult the MC Regional Gravimetric Specialist for advice on the selection of mass standards.

7.1.1 OIML Class M1 mass standards of 5 kg or larger

Mass standards (usually cast iron or fabricated weights) of 5 kg or larger (10 lb or larger) must meet all requirements, including those relating to construction, material and fabrication defined in OIML R111-1 and Appendix 2 of this document. It is recommended that organizations consult the local MC Regional Gravimetric Specialist prior to the purchase or fabrication of any new weight design.

Before being submitted for calibration and certification, mass standards must be cleaned and prepared in accordance with the procedure described in Appendix 2 of this document. Mass standards which deviate from the nominal value (error) by more than two-thirds of the prescribed tolerance will have to be adjusted as close as possible to the nominal value. ASPs must provide the necessary personnel to assist in making these adjustments. The purpose of adjusting mass standards as close as possible to the nominal value is to ensure that, during the certification period, the error of mass standards does not exceed the tolerances prescribed in the Weights and Measures Regulations.

1 This section is under review. Until further notice, OIML Class F2 mass standards are suitable for inspection of all Class II devices.
7.1.2 OIML Class M1 mass standards of 5 kg and smaller

Mass standards must meet all MC requirements. Weights of 5 kg (10 lb) and smaller that are part of an inspector's weight kit and individual weights shall be made of stainless steel or other material sufficiently resistant to corrosion and oxidation. Material and fabrication requirements for these weights are defined in OIML R111-1 and in Appendix 2 of this document. All weights belonging to an inspector's weight kit shall be submitted for calibration at the same time. Prior to the selection of materials other than stainless steel or for any other questions or concerns relating to mass standards of 5 kg and smaller, it is strongly recommended that organizations consult MC's ACSL.

The ACSL issues certificates for mass standards which do not deviate from the nominal value (error) by more than one-half the tolerance prescribed in Schedule IV to the Weights and Measures Regulations. Mass standards with an error exceeding one-half the prescribed tolerance will have to be adjusted as close as possible to the nominal value prior to certification. The purpose of this provision is to ensure that, during the certification period, the error of mass standards does not exceed the tolerance prescribed in the Weights and Measures Regulations. Adjustments of standards are the responsibility of the ASP (weight owner).

MC's ACSL does not provide weight cleaning, stamping or adjustment services. Inspectors’ weight kits and individual weights that are not properly cleaned as required or adjusted within the tolerance prescribed in Schedule IV to the Weights and Measures Regulations will be returned to their owner without being certified.

All weights shall be kept in a case that is comprised of appropriate compartments for each weight of a series. This is applicable to sets of weights (inspectors' weight kits) as well as individual weights. The interior of the case shall be such that the weight is protected against any wear, abrasion or shock that may be encountered during transportation. All weights from a weight set must be kept in the same primary case.

In order to link inspectors’ weight kits and individual weights to MC calibration certificates or verification documents, all inspectors’ weight kits and individual weights shall be identified by the applicant, if not already done so by the manufacturer, by a unique serial number that consists of numbers, letters and/or symbols. All cases belonging to the same weight set and individual weights must display the same serial number.
7.1.3  OIML Class F2 or better mass standards of 20 kg and smaller used to inspect Class II devices (high precision weight sets)

Mass standards of 20 kg and smaller used to inspect Class II devices shall only be used for the inspection of legal for trade Class II devices; otherwise, the integrity of the weights may be compromised and they may be outside the prescribed tolerance before the end of their calibration cycle.

All weights in a set shall be kept in a case that is comprised of appropriate compartments for each individual weight. The interior of the case shall be such that the weight is protected against any wear, abrasion or shock that may be encountered during transportation. All weights from a weight set must be kept in the same primary case. When stored, the carrying cases should be kept protected from dampness, which can affect the stability of the standards.

Mass standards must meet all MC requirements. High precision weights shall be made of stainless steel or other material sufficiently resistant to corrosion and oxidation. Material and fabrication requirements for these weights are defined in OIML R111-1 and in Appendix 2 of this document. Prior to the selection of materials other than stainless steel or for any other questions or concerns relating to mass standards for inspecting Class II devices, it is strongly recommended that organizations consult MC’s ACSL.

The ACSL issues certificates for mass standards which do not deviate from the nominal value (error) by more than one-half the tolerance prescribed in Schedule IV to the Weights and Measures Regulations. Mass standards with an error exceeding one-half the prescribed tolerance will have to be adjusted as close as possible to the nominal value prior to certification. The purpose of this provision is to ensure that, during the certification period, the error of mass standards does not exceed the tolerance prescribed in the Weights and Measures Regulations. Adjustments of standards are the responsibility of the ASP (weight owner).

MC’s ACSL does not provide weight cleaning, stamping or adjustment services. High precision weight sets should not be cleaned other than by lightly dusting them with a lint-free cloth. They must never be cleaned by rubbing, polishing or using compressed air. High precision weight sets that are not properly cleaned, stamped or adjusted within the tolerance prescribed in Schedule IV to the Weights and Measures Regulations will be returned to their owner without being certified.

In order to link high precision weight sets to MC calibration certificates or verification documents, all high precision weight sets shall be identified by the applicant, if not already done so by the manufacturer, by a unique serial number that consists of numbers, letters and/or symbols. All cases belonging to the same high precision weight set must display the same serial number.
7.1.4 Recognition Program of Calibration Results from CLAS Laboratories

Mass standards of 20 kg and smaller used to inspect Class II devices (high precision weight sets) are weights calibrated to within the tolerances used to inspect devices for weighing precious metals (Parts I and II of Schedule IV of the Weights and Measures Regulations), which are not presently open to the Recognition Program of Calibration Results from CLAS Laboratories. All high precision weight sets used for the inspection of legal for trade Class II devices shall be sent to MC for calibration and certification.

Mass standards that meet OIML Class M1 requirements and that are suitable for the inspection of Class III, III HD and IIII weighing devices must be submitted to MC for the initial evaluation unless they have been initially evaluated and accepted for use by MC. Only subsequent evaluations can be performed by a recognized CLAS Type I Laboratory under the Recognition Program of Calibration Results from CLAS Laboratories.

ASPs utilizing the services of a laboratory recognised under the Recognition Program of Calibration Results from CLAS Laboratories for the calibration of their weights and weight sets must meet the requirements of sections 4.1, 4.6 and 4.9. The requirements of section 4.6 are applicable to weights and weight sets certified and designated as standards and not to other weights and weight sets ASPs may need to have calibrated. The requirements of sections 7.1.1 and 7.1.2 must also be met. Mass standards can be cleaned, stamped and adjusted by a CLAS Type I Laboratory.

All weights and weight sets sent to a CLAS Type I Laboratory must be properly packaged to ensure adequate protection during shipping. They must also be accompanied by a correctly completed Calibration Services Request form and the last calibration certificate issued by MC.

7.2 Volumetric standards

Volumetric standards must meet all requirements, including those relating to construction set out in MC’s Guidelines for the Calibration and Certification of Volumetric Standards, available from your MC contact. It is recommended that organizations consult the MC Regional Volumetric Specialist prior to the purchase or fabrication of any new standards design and equipment not included in the Guidelines for the Calibration and Certification of Volumetric Standards.

Before being submitted for calibration and certification, volumetric standards must be cleaned. Walls must be free of greasy or oily residue, dirt and rust. The coating on the inside surface of standards must be in good condition with no obvious peeling. The standards must be free of flammable or noxious vapours.

The ACSL and MC district offices do not clean volumetric standards. Volumetric standards that do not meet construction requirements or are not properly cleaned will be returned to their owner without being certified.

7.3 Temperature standards

Temperature standards must meet the accuracy requirements set out in Schedule IV to the Weights and Measures Regulations. It is recommended that organizations consult the local MC Regional Volumetric or Gas Specialist prior to the purchase of temperature standards.

For the specified application, thermometers shall have a minimum resolution and range as follows.
<table>
<thead>
<tr>
<th>Application</th>
<th>Minimum Range</th>
<th>Minimum Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>General field inspection</td>
<td>-30 °C to +50 °C</td>
<td>0.1 °C</td>
</tr>
<tr>
<td>Calibration of thermometer used in gas prover for</td>
<td>0 °C to +35 °C</td>
<td>0.01 °C</td>
</tr>
<tr>
<td>temperature correction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature correction in gas measuring apparatus</td>
<td>0 °C to +35 °C</td>
<td>0.1 °C</td>
</tr>
<tr>
<td>Bell prover air temperature</td>
<td>0 °C to +35 °C</td>
<td>0.1 °C</td>
</tr>
</tbody>
</table>

Thermometers intended for field use shall be stored in a hard protective carrying case with foam inserts cut to the shape of the thermometer and the probes or similar means to protect them. The carrying case must have sufficient padding to prevent breakage of the thermometer and the probes.

The following information shall be permanently marked, or be capable of being displayed on thermometers: manufacturer’s name, model number and serial number. In the case of thermometers with multiple probes, each probe must be marked by a unique identifier.

Where the instrument is capable of being calibrated or adjusted, access to the adjustments shall be easily detectable or sealable.

### 8.0 Revisions

The initial version of this bulletin became effective January 28, 2004.

**8.1** The purpose of revision 1 (May 3, 2004) was to:

- remove the note on page 1 regarding the availability of the Calibration Procedures for Standards of Mass manual, which is now available online;
- clarify section 3 regarding requirements for weights equal to or less than 5 kg (10 lb) contained in a weight kit;
- remove the reference to the Engineering Division as direct contact;
- specify the number of standards acceptable for calibration;
- correct grammatical errors.

**8.2** The purpose of revision 2 (February 3, 2006) was to clarify:

- the responsibilities of ASPs as it pertains to the certification of mass standards;
- the services provided by MC’s ACSL.

**8.3** The purpose of revision 3 (November 17, 2006) was to:

- provide the new address of the ACSL.
8.4 The purpose of revision 4 (January 7, 2008) was to:

- expand the scope to include all standards used by ASPs;
- indicate the calibration location;
- include the Recognition Program of Calibration Results from CLAS Laboratories.

8.5 The purpose of revision 5 (July 21, 2008) was to:

- require a justification when a standard is sent for recalibration to MC’s ACSL with an expired certification, a broken seal, or in any condition affecting the certificate validity;
- clarify which weights and weight sets can be calibrated by a recognized CLAS Type I Laboratory under the Recognition Program of Calibration Results from CLAS Laboratories.

8.6 The purpose of revision 6 (June 9, 2010) was to:

- update section 4.4 on when standards should be sent to MC for calibration based on the new MC structure;
- add a reference to OIML R111-1 documentation for construction of standards;
- add the requirements for mass standards of 20 kg and smaller used to inspect Class II devices following the addition of Class II devices to the Accreditation Program.

8.7 The purpose of revision 7 (March 11, 2013) was to:

- expand the scope of the bulletin to address electricity and gas measuring apparatus;
- clarify the number of standards calibrated and certified by MC free of charge for weights and measures ASPs;
- clarify that ASPs must provide the required information in order to have their standards and measuring apparatus processed by MC.

8.8 The purpose of revision 8 (October 31, 2013) was to clarify:

- the terms “large test weights” and “set of test weights” used on a weight truck;
- the terms “narrow neck 20 litre standard” and “20 litre test measure”.

8.9 The purpose of revision 9 (October 1, 2014) was to:

- clarify the meaning of the term “inspection”;
- modify the deadline by which ASPs must submit the list of standards and measuring apparatus to the Regional Coordinator, ASD to match the process in place;
- clarify in section 4.3 that this requirement must be met before submitting any standard to MC for certification;
• make minor editorial corrections.

8.10 The purpose of revision 10 (October 1, 2015) is to:

• emphasize the responsibilities of ASPs with respect to calibrations of standards and measuring apparatus by Measurement Canada;
• add a statement to the effect that bulletin GEN-08 cannot be used to circumvent the requirements of the present bulletin;
• make minor editorial corrections.

9.0 Additional information

For additional information regarding this bulletin, please consult the contact us section of the Measurement Canada website or your departmental contact. The copy of this document located on Measurement Canada’s website is considered to be the controlled copy.
Appendix 1 — Number of Standards Certified and Designated as Local Standards by Measurement Canada Free of Charge for Weights and Measures Authorized Service Providers

The maximum number of standards MC can certify and designate as local standards free of charge for weights and measures ASPs is set out below.

When the number of standards to be submitted by an ASP exceeds the limits listed above, the ASP must provide a written justification to the local Regional Coordinator, ASD explaining the reason why the additional standards require MC certification and designation.

MC can also designate any supplementary standards calibrated by a recognized laboratory under the Recognition Program of Calibration Results from CLAS Laboratories as long as they are used to inspect devices.

1.0 Gravimetric standards

Mass standards of 5 kg or larger:

One metric ton or one avoirdupois ton of weights for every recognized technician. Two additional metric tons or two avoirdupois tons per point of service.

Large test weights (gravimetric standards in excess of 100 kg):

A "set" of large test weights (10 000 kg) per weight truck.

Mass standards of 5 kg and smaller (inspector’s weight kit):

One metric and one avoirdupois weight kit for every recognized technician. One additional weight kit of any type for every three recognized technicians per ASP.

Mass standards of 20 kg and smaller used to inspect Class II devices (weight set):

One metric high precision weight set for every recognized technician. One additional metric high precision weight set per ASP.

2.0 Temperature standards

Thermometer

Two thermometers per recognized technician. One additional thermometer for every two recognized technicians per ASP.

3.0 Volumetric standards

Definition

“Narrow neck standard” means a local standard of volume or capacity that has, on or adjacent to the narrow neck of the standard, a mark indicating the volume or capacity of the standard, or that has a machined rim that indicates the volume or capacity of the standard; typically used for the purpose of checking specialized test equipment.
(1) Twenty litre test measure used to inspect volumetric meters:

Two test measures of a given nominal volume for every recognized technician. One additional test measure for every two recognized technicians per ASP.

(2) Prover used to inspect volumetric meters:

As per historical data. Addition of new provers requires agreement from MC.

(3) Hydrometer / liquefied petroleum gas (LPG) dispenser:

Two hydrometers / LPG dispensers for every recognized technician. One additional hydrometer per ASP.

(4) Narrow neck 20 litre standard:

One narrow neck 20 litre standard for every recognized technician. One additional narrow neck 20 litre standard per ASP point of service.

(5) Test measure and prover of 100 litres and less used to calibrate other provers or used to certify ASPs’ pipe provers:

As per historical data. Addition of new test measure requires agreement from MC.
1.0 Material and fabrication requirements for mass standards

For specifications regarding material, construction, shape, density, surface conditions, etc. of mass standards, the international recommendation OIML R111-1: Weights of classes E1, E2, F1, F2, M1, M 1-2, M2, M2-3 and M3 should be consulted. Questions regarding design or acceptability of standards and industry weights should be addressed to the Gravimetric Specialist and when necessary, the Gravimetric Engineer.

To ensure consistency with past practice, the following should be observed in addition to the requirements of OIML R111-1 for standards equal to or larger than 10 kg.

1.1 Design

Standards of a nominal value equal to or greater than 10 kg shall be either “solid”, “layered” or “filled” as defined below:

- **“solid”** means constructed from a material such as grey cast iron or any other metal that meets the material requirements outlined further, and comprised of no more than one piece, excluding the handle, hook, seal or plug;

- **“layered”** means a construction consisting of stacked plates of steel or other metal of a minimum thickness of 6 mm that meets the material requirements outlined below:
  - where the thickness of plates exceeds 24 mm, they shall each be as long and wide as the dimensions of one of the sides or the top or bottom of the standard.
  - where the thickness of one or more of the plates is less than 24 mm, they shall each be as long and wide as the internal dimensions of one of the sides or the top or bottom of a container fabricated from plates of steel or other metal meeting these specifications, each with a minimum thickness of 9 mm.
  - the plates shall be suitably fastened to prevent movement.
  - the plates shall be stacked so that the total space between them is minimized.

- **“filled”** means a construction consisting of a container manufactured from steel plates or other metal meeting these specifications, each with a minimum thickness of 9 mm and filled with lead that was molten or poured into it.

Note: The use of industry weight baskets or weight racks is prohibited.
1.2 Seams

All exposed seams shall be joined with a continuous weld to form a closed system (with the exception of the seal and plug). Where seams may come in contact with other objects during normal use, the weld on these seams shall be ground smooth and flush with the surrounding metal.

All welds shall be sufficiently strong to withstand, without breaking or cracking, all forces encountered during normal use.

1.3 Shape

The shape of the standard shall be simple without undue sharp angles and any exterior corners shall be rounded to a radius no smaller than 6 mm.

1.4 Surface roughness

The entire surface shall be smooth and reasonably free from grooves and/or indentations in which foreign matter may accumulate.

1.5 Density

The density of any material used to construct standards shall be such that when the actual air density at calibration is ± 10% away from the conventional value of 1.2 kg/m³, the total density of the standard does not cause a change in the calculated value of the conventional mass exceeding 1/3 of the tolerance for the standard being calibrated or certified.

Although Table 5 of OIML recommendation R111 (2004) states the minimum and maximum densities of various classes, all standards equal to or larger than 10 kg used by MC should have the following maximum and minimum densities:

- F2: 6 400 kg/m³ to 8 400 kg/m³
- M1: 6 000 kg/m³ to 8 400 kg/m³
- M1-2: 6 000 kg/m³ to 8 400 kg/m³
- M2: 6 000 kg/m³ to 8 400 kg/m³
- M2-3: 4 400 kg/m³ to 8 400 kg/m³
- M3: 4 400 kg/m³ to 8 400 kg/m³

MC imposes more stringent requirements for density because otherwise the effect of the variations in air density and of the uncertainty due to the material density of the standard would make its combined uncertainty too large.

Note that grey cast iron has an approximate density of 7 000 kg/m³ and the lowest density for cast iron is 6 000 kg/m³.
1.6 Material hardness

The material used shall not be softer than brass and shall be of suitable hardness and ductility to resist stress, wear and chipping to which standards may be subjected under normal use.

1.7 Adjustment cavities

Standards shall have one but no more than two adjustment cavities. The total volume of the cavity shall be as close to, but shall not exceed, 5% of the total volume of a standard.

Cavity enclosure shall result in a closed system with provisions made for the imprint of an inspection mark. To ensure that no liquids can enter and accumulate in cavities, adequate means for sealing must be provided with an undercut opening or other to ensure that lead is securely held in place to seal the opening. No lead shall project beyond the surface of the standard.

1.8 Flaws

A cast iron standard must be examined to ensure there are no cracks or flaws and the adjustment cavities are free of foreign matter.

The Rz (maximum height of roughness profile) of the surface finish of any new cast iron standard must not exceed 12.5 μm (500 μin). The Ra (mean height of roughness profile) of the surface finish must not exceed 2.5 μm. A further examination shall be made to ensure that the standard does not contain casting defects. Any depression deeper than 2 mm from the surrounding surface and at any point wider than 4 mm must be filled by welding to prevent accumulation of added weight after calibration. The use of foundry putty or body filler is not acceptable.

OIML recommendation R111-1 states that the value of Rz (maximum height of roughness profile) of stainless steel weights (classes E and F) shall be no greater than 0.5 micrometers (class E1), 1 micrometer (class E2), 2 micrometers (class F1) and 5 micrometers (class F2), for weights up to 50 kg. In the case of weights over 50 kg, the values are doubled. The value of Ra (mean height of roughness profile) is 1/5 of the above values.

<table>
<thead>
<tr>
<th>Class</th>
<th>E1</th>
<th>E2</th>
<th>F1</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rz (μm)</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Ra (μm)</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
<td>1</td>
</tr>
</tbody>
</table>

1.9 Nominal values

Standards should be constructed to represent nominal values of mass of denominations of 1, 2 and 5 x 10^n, where “n” is a positive or negative whole number or zero. Nominal values of standards not represented by nominal values of mass of denominations of 1, 2 and 5 x 10^n can be certified as standards but the appropriate tolerance must be determined.
2.0 Care and maintenance of mass standards

When not in use, standards should be covered or stored in their carrying cases. These cases shall have appropriate compartments for each weight of a series. The interior of the case shall be such that the standards are protected against any wear, abrasion or shock that may be encountered during transportation.

When stored, carrying cases should be kept off the floor to protect them from dampness, which can affect the stability of the standards.

Standards must be protected from drafts and dust and they should be touched only with protective gloves, chamois skin or special handling tools provided for this purpose. When these standards are handled with bare hands, perspiration (salty oils and dirt) can affect the standard's mass and can potentially contaminate the standard’s surface.

Stainless steel reacts with the chrome salts used in the manufacturing process of chamois, especially if the chamois is left in contact with the standards over a long period of time. Usually, a chamois is kept with the standards in a closed box, where it may remain for months at a time. Any new chamois must therefore be washed with soap and water, rinsed thoroughly and dried before use.

Small standards (50 g and less) of cylindrical, leaf or wire type shape should be handled with appropriate tweezers that will not scratch or damage the surface finish of the standard.

2.1 Adjustment of mass standards

A general rule for high accuracy standards is to handle them as seldom as possible. District standards should not require adjustments except under special circumstances. Adjustments are only to be made by the ACSL.

When field standards being calibrated or verified are not within 2/3 of their applicable tolerance, they are adjusted. The adjustment is made so that the standard’s value is now within 1/3 of the applicable tolerance.

Two-piece standards can be adjusted at will by removing the knob and adding or removing the required material from the adjusting cavity.

Inspector weights are adjusted using lead because it is malleable and its density is very high (11 340 kg/m³). The adjustment cavity is then closed and a MC inspection mark is applied. Whenever large quantities of adjusting material are added or when the ACSL adjusts district standards and precious metal standards, the adjusting material should be of the same material as that from which the standards were fabricated.

Leaf and wire type standards are not adjustable and in most cases, the ACSL replaces them when they are found to be out of tolerance.

2.2 Cleaning and refurbishing standards

District standards should not be cleaned other than by lightly dusting them with a lint-free cloth. District standards must never be cleaned by rubbing, polishing or using compressed air.
Inspector weights are cleaned by scrubbing off excess rust, flaking paint, etc. Oil and dirt may be removed by using a cloth moistened with mineral spirits; in this case, the cleaning solution must be allowed to evaporate over a 24-hour period prior to calibration taking place.

When a weight is made of a material that oxidizes such as cast iron, it is important that the surface finish be disturbed as little as possible to maintain weight stability. Once the surface acquires its initial oxidation coat, any further corrosion significantly slows. Therefore, the less the new surface is exposed to fresh oxidation, the more stable the standard. It is also important to use a surface finish with good flow and self-adhesive properties to fill minor gaps, seal the surface, and securely bond with previous coats of paint.

### 2.2.1 New cast iron standards

New standards shall be kept unfinished for two weeks prior to any finishing material being applied.

Before painting, new standards should be lightly cleaned with a wire brush to loosen surface rust, wiped with a cloth moistened with mineral spirits to remove dust, loosened rust, surface oils, etc., and then painted with a primer/sealer and allowed to dry thoroughly.

Two coats of metallic rust-preventative paint (aluminum based) should be applied with a brush or sprayed in very thin layers and then the required markings should be applied for identification.

A coating of paint is only recommended once for the bottom of standards greater than 5 kg and having recessed bottoms.

When two different colours are used to differentiate between avoirdupois and metric weights, it is recommended that metric standards be painted with gold aluminum paint and avoirdupois standards with silver aluminum paint.

The standard should be allowed to dry overnight, as a minimum, prior to calibration to ensure that the solvents have completely evaporated from the paint.

It is good lab practice to test the paint on one standard first and then test for adhesion first before applying to the full set.

### 2.2.2 Refurbishment of cast iron standards

Under no circumstance shall a cast iron standard be sandblasted. Regular maintenance as described below will ensure that the surface coatings do not become excessively thick.

As a minimum, the standard must be:

- free of loose, flaking paint or rust;
- free of cracks or other defects where foreign material can accumulate; and
- freshly painted and clearly marked so that it can be readily identified during its use.
A coating of paint is recommended for the bottom of standards greater than 5 kg and having recessed bottoms. When two different colours are used to differentiate between avoirdupois and metric weights, it is recommended that metric standards be painted with gold aluminum paint and avoirdupois standards with silver aluminum paint.

The standard should be allowed to dry overnight, as a minimum, prior to calibration to ensure that the solvents have completely evaporated from the paint.