S-E-02—Specifications for the verification and the reverification of electricity meters

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1.0 General

1.1 Scope

These specifications apply to any electricity meter submitted for verification or reverification under the *Electricity and Gas Inspection Act*.

2.0 Authority

These specifications are issued under the authority of section 18 of the *Electricity and Gas Inspection Regulations.*

3.0 Normative references

3.1 *Electricity and Gas Inspection Act*

3.2 *Electricity and Gas Inspection Regulations*

3.3 Measurement Canada, LMB-EG-07: Specification for the Approval of Type of Electricity Meters, Instrument Transformers and Auxiliary Devices

3.4 National Standard of Canada, CAN/CSA-Z234.4-89: All-Numeric Dates and Times (Reaffirmed 2000-05-25)

3.5 International Organization for Standardization, ISO 3534-2:1993: Statistics - Vocabulary and Symbols - Part 2: Statistical Quality Control

3.6 S-S-01 — Specifications for Random Sampling and Randomization

3.7 S-S-02 — Measurement Uncertainty and Meter Conformity Evaluation Specifications

3.8 S-S-03 — Prerequisites to the Use of Sampling Inspection

Canada

3.9 S-S-04 — Sampling Plans for the Inspection of Isolated Lots and Short Series Lots

3.10 E-26 — Reverification Periods for Electricity Meters and Metering Installations

4.0 Definitions

Act
The *Electricity and Gas Inspection Act*

Advanced meter function
A function built into a meter which uses metered information to provide additional information directly related to the establishment of a charge for electricity. Examples include: pulse constants, meter multipliers and loss compensation. (*fonction de mesurage avancée*)

Auto service detect meter
Meters which are capable of determining service configurations. (*compteur à detection automatique du service*)

Case (of a meter)
The complete enclosure. (*boîtier* [*d'un compteur*])

Configurable meter
A meter that is designed such that its service configuration can be modified either by software or hardware to make it compatible with different circuit arrangements. This may be performed automatically or by operator intervention. For example, a meter may be reconfigured from a 2½ element meter for metering a 3 phase, 4 wire wye circuit to a 2 element meter for metering a 3 phase, 3 wire circuit. (*compteur configurable*)

Constants
(*constantes*)

> **Disk constant K_h (induction type meter)**
> The number of energy units being measured per disk revolution. For a watt-hour meter, the disk constant K_h, is watt-hours per revolution. (*constante du disque K_h* [*compteur à induction*])
>
> **Pulse initiator output constant K_p (pulse constant)**
> The number of energy units being measured per pulse output. The pulse may be from a KYZ output or any other pulse output device. (*constante de sortie du générateur d'impulsions K_p* [*constant d'impulsions*])
>
> **Single phase test constant**
> A multiplication factor required to determine correct registration when testing certain multi-element meters using series-parallel, single phase testing techniques. (*constante d'essai monophasé*)

Test constant K_s (electronic meter)
The number of energy units being measured per indication of the meter's test means (LED, LCD indicator or other). (*constante d'essai K_s* [*compteur électronique*])

Cover (of a meter)
The part of the case which is removable or can be opened to provide access to the interior of the meter. (*couvercle* [*d'un compteur*])

Cumulative register
A non-resettable energy register which accumulates the total energy measured by the meter (Wh, varh, VAh and joule). (*enregistreur cumulatif*)

Current range
The range of currents over which the meter or transformer is designed to function within specified error limits. (*gamme de courant*)

Current transformer
An instrument transformer designed for the measurement and control of current. (*transformateur de courant*)

Defect
A departure of a meter's quality characteristic from its intended level or state that occurs with a severity sufficient to cause the meter to not satisfy normal usage requirements. Depending on the nature and severity of the defect, it may cause a nonconformity to occur immediately or at some time in the future. (*défaut*)

Delivered energy
Energy measured when current flows through the meter from the electricity grid to the load. (*énergie livrée*)

Demand
(*puissance appelée*)
The average value of the power measured over a specified time interval. The following are the most commonly used types:

Demand interval
The specified duration of time on which a demand measurement is based. (*période d'intégration de la puissance appelée*)

Integrating demand (block-interval demand)
Demand determined by measuring energy consumed over a fixed interval of time, divided by the time interval. (*puissance appelée à période d'intégration* [*puissance appelée à tranches d'intégration*])

Lagged or exponentially responding demand meter
A demand meter in which the indication of the demand is determined by monitoring the exponential or thermal response to an applied load. (*compteur de puissance appelée à retardement ou à réponse exponentielle*)

Maximum (or peak) demand
The greatest of all demands which have occurred during a specific period of time, usually the billing period. (*puissance appelée maximale* [*ou de crête*])

Maximum (full-scale) demand rating

The largest demand that a meter is capable of metering within specified error limits. (*puissance appelée maximale nominale*)

Response period - exponential demand meter

The time required for the meter indication to reach 90 percent of the final response to a step change in the measured quantity. (*temps de réponse – compteur de puissance appelée à réponse exponentielle*)

Sliding window

A type of demand response whereby at the end of each new sub-interval, the value of the oldest sub-interval demand value is discarded, and a new demand value is calculated based on the sum of energy registered in the most recent contiguous sub-intervals which comprise the total demand interval. (*puissance appelée à fenêtre mobile*)

Director

The Director as referenced in the Act and Regulations refers to the President of Measurement Canada, Department of Industry. (*directeur*)

Display

A device or other means used to visually present the value of a measured quantity and other relevant information. It may take the form of an integral part of a meter or a separate display module. (*affichage ou dispositif afficheur*)

Electromechanical meter

An electricity meter that incorporates mechanical elements to measure and register metered quantities. (*compteur électromécanique*)

Electronic meter

A solid state electricity meter. (*compteur électronique*)

Element

The combination of the voltage sensing unit (i.e. sensor or coil) associated with a current sensing unit (i.e. sensor or coil). (*élément*)

Split coil element

The split coil element is comprises a current sensing circuit which is associated with more than one voltage sensing circuit. Sometimes also referred to as the Z-coil sensor. (*bobine à prises*)

Energy meter

A device which sums the elemental energy quantities of a measured input either continuously, or over a fixed interval of time for the case where the energy meter is used to determine demand. (*compteur d'énergie*)

Error

(*erreur*)

Absolute error

The value registered by the meter minus the true value. (*erreur absolue*)

Relative (true) error

The absolute error of measurement divided by the conventional true value of the measure, traditionally referred to as the "true error". Expressed as a percentage, relative error is calculated as:

$$E_r = \left(\frac{Qm - Qs}{Qs}\right) X\ 100\% \left(\frac{Qm}{Qs} - 1\right) X\ 100\%$$

where,

E_r is the relative error of the meter under test, expressed in percent

Q_m is the quantity indicated by the meter under test

Q_s is the quantity indicated by the reference standard, expressed in the same units as Q_m (*erreur relative* [*vraie*])

Full scale error

The ratio of the absolute error to the full scale value. (*erreur pleine échelle*)

Firmware

A program embedded in non-volatile memory of the meter. (*micrologiciel*)

Frame (of a meter)

That part to which are affixed the working parts and adjustments. (*bâti* [*d'un compteur*])

Full scale value

The largest value of the actuating electrical quantity that can be indicated on the scale or, in the case of an instrument having its zero between the ends of the scale, the full scale value is the arithmetic sum of the absolute values of the actuating electrical quantity corresponding to the two ends of the scale. (*valeur de pleine échelle*)

Function

An operation within a device which performs a specified action or results in a defined output. (*fonction*)

Induction type meter

An energy meter which operates by the rotation of the disk of an induction measuring element. (*compteur à induction*)

Instrument transformer

A transformer which is intended to reproduce in its secondary circuit, in a definite and known proportion, the current or voltage of its primary circuit with the phase relations substantially preserved. (*transformateur de mesure*)

Maximum current rating (I_{max})

The largest current value for which a meter has been approved such that it maintains its performance within specified error limits. Nominally rated meters have an I_{max} equal to four times the nominal current rating for the meter. (*courant maximal nominal* [I_{max}])

Measuring apparatus

A device or instrument that is used for the measurement of electricity for the purposes of calibrating electricity meters. (*appareil de mesure*)

Meter

An electricity meter that includes any apparatus used for the purpose of making measurements of, or obtaining the basis of a charge for, electricity supplied to a purchaser (reference: *Electricity and Gas Inspection Act*). (*compteur*)

Meter multiplier

The factor by which the meter reading must be multiplied to obtain the correct magnitude of the measured quantity. (*multiplicateur d'échelle*)

Metrological function, feature, characteristic or parameter

Any function, feature, characteristic or parameter of a meter that provides a metered quantity or contributes to the determination of a quantity which may be used for billing. (*fonction, propriété, caractéristique ou paramètre métrologique*)

Minimum current rating (I_{min})

The smallest current value for which a meter has been approved so that it maintains its performance within specified error limits. (*courant minimal nominal* [I_{min}])

Multifunction meter

A meter capable of performing two or more measurement functions. (*compteur multifonctions*)

Multi-register meter (e.g. Multi-rate Register Meter)

A metering application which records the measured values of electricity into different registers or "bins" (electronic or mechanical) based on various conditions such as time (i.e., time-of-use, real-time pricing), temperature, etc. (*compteur à registres multiples*)

Nonconformity

A departure of a meter's quality characteristic from its intended level or state that occurs with a severity sufficient to cause the meter to not satisfy one or more specification requirements. (*non-conformité*)

Normal operating mode

The operating mode assumed by the meter while in service without any operator intervention. (*mode de fonctionnement normal*)

Phase shifting transformer (phasing transformer)

An instrument transformer that is an assembly of two or more auto-transformers used as auxiliary instrument transformers, intended to be connected across the phases of a polyphase circuit so as to provide voltages in the proper phase relations for energizing var meters, var hour meters or other measurement equipment. (*transformateur déphaseur*)

President

The President of Measurement Canada having the authorities of "Director" as referred to in the Act. (*présidente*)

Power factor

The ratio of the active power to the apparent power. Under pure sine wave conditions, the power factor is given by cos φ where φ is the phase displacement between the voltage and the current. (*facteur de puissance*)

Pulse initiator

A data initiator used with a source meter to initiate pulses, the number of which is proportional to the quantity being measured. (*générateur d'impulsions*)

Pulse recorder

A device which accumulates pulses from an external source representing integral units of energy. (*enregistreur d'impulsions*)

Q hour meter

An electricity meter that measures energy by effectively lagging applied voltage by 60°. (*q-heuremètre*)

Range (of an indicating or recording meter)

The region covered by the span and expressed by stating the two end-scale values. If the span passes through zero, the range is stated by inserting "zero" or "0" between the end-scale values. (*gamme de mesure* [*d'un compteur indicateur ou enregistreur*])

Rated frequency

The frequency or frequencies at which the meter is designed to operate. (*fréquence nominale*)

Rated voltage

The voltage at which the meter or device is designed to operate, or for the case of meters designed for operation with a variety of voltage circuits, any preferred voltage (as identified in Specifications for Approval of Type of Electricity Meters, Instrument Transformers and Auxiliary Devices) at which the meter can operate. (*tension nominale*)

Received energy

The energy measured when the current flows through the meter from the load side of the service back to the electricity grid. (*énergie reçue*)

Reference meter

A measuring instrument having errors traceable to the National Research Council of Canada and used to establish the true value of a measurement. (*compteur de reference*)

Register (electronic)

A memory location in the meter where the value of a measured quantity is electronically recorded. (*registre* [*électronique*])

Register (mechanical)

A mechanical device integral to the meter where the value of a measured quantity is recorded and visually presented. (*registre* [*mécanique*])

Register ratio R_r - induction type integrating meter

The number of revolutions of the first gear of the register for one revolution of the first dial pointer. (*rapport de registre R_r – compteur intégrateur à induction*)

Regulations

The *Electricity and Gas Inspection Regulations*. (*Règlement*)

Reset time - mechanical demand register

The interval of time within each demand interval during which the driving element and demand indicator disengage from each other to allow the driving element to be restored to its initial position. (*temps de débrayage - registre de puissance appelée mécanique*)

Reverification

Any subsequent confirmation of a meter's conformance to legal requirements following its initial verification of conformance to those same requirements, performed upon expiration of the meter's reverification period (i.e. seal period). (*revérification*)

Seal

A means whereby unauthorized access to the interior, adjustments, or controls of a meter may be effectively detected. (*sceau*)

Self-contained meter

A meter designed to be connected directly to a power circuit, without the use of external devices such as instrument transformers or shunts. (*compteur autonome*)

Series test

A test performed on a meter whereby all voltage input circuits are energized with voltages of the same magnitude and phase relation, and all current input circuits are energized with currents of the same magnitude and phase relation. This may be accomplished by placing all meter voltage input circuits in a parallel circuit, and all meter current circuits in a series circuit. (*essai en série*)

Service type

The number of wires and phases and the interconnection between them used to supply a metering load. (*type de service*)

Single phase services

(*services monophasés*)

Single phase services may be provided as follows:

> **Network service**
>
> A three-wire service supplied from a three phase, four wire, wye distribution system, with one of the conductors being the neutral conductor, and the other two conductors being phase conductors. (*service réseau*)
>
> **Three-wire service**
>
> A single phase three wire service may be provided from a single phase or polyphase distribution system. One conductor, the neutral, is grounded, and the normal service voltages are 240 V between the ungrounded conductors and 120 V between either of the ungrounded conductors and the grounded conductor. (*service trois fils*)
>
> **Two-wire service**
>
> A single phase two-wire service may be provided from many distribution systems, and normally has one conductor grounded, with a nominal voltage of 120 V between conductors. (*service deux fils*)

Polyphase services

(*services polyphasés*)

Polyphase services may be provided as follows:

> **Three phase, four wire delta service**
>
> A three phase, four wire delta service is a delta service which has one transformer centre tapped and connected to a neutral conductor (and grounded). In this case, where the voltage between any two phases is 240 V, the voltage between the grounded wire and either of the two phases from which it is centre tapped will be 120 V, and the voltage from the third phase to the grounded phases will be 208 V. (*service triphasé quatre fils en triangle*)

Three phase, four wire, wye
A three phase, four wire wye service has three phases and a neutral conductor where the phase to neutral voltages are nominally equal to each other, and the phase to phase voltage is equal to $\sqrt{3}$ times the phase to neutral voltage. (*service triphasé quatre fils en étoile*)

Three phase, three wire
A three phase, three wire service has no neutral conductor and may be supplied by either an open-delta or closed-delta transformer bank. (*service triphasé trois fils*)

Single-register, bi-directional meter
A meter that is specified as capable of measuring both positive and negative mean energy flow, and where the net result will be placed in a single register. The process is equivalent to that defined as "netting". (*compteur bidirectionnel à un registre*)

Single-register, one direction only meter
A meter that is specified as capable of measuring and registering either positive or negative mean energy flow only. This has historically been referred to in Canada as a "unidirectional meter". (*compteur unidirectionnel seulement à un registre*)

Specification limit
The maximum permissible error for a meter's performance characteristic. (*limite de spécification*)

Test link
A means to totally or partially isolate the voltage circuit from the current circuit of a meter. (*lien d'essai*)

Test mode
A mode of operation or output which facilitates meter accuracy testing by introducing shorter test periods and/or greater resolution of readings. The output of a test mode feature or operation is not the output used in establishing the basis of a charge for electricity legal units of measurement during normal meter operation. (*mode d'essai*)

Test value (e_i)
The result of a measurement after correction for any known systematic errors, at test point "i". (*valeur d'essai* [e_i])

Thermal stability
A meter is considered to have reached thermal stability following a change in temperature when the metrological characteristics of the meter have not changed by more than ±0.2% over a 10-minute interval. (*stabilité thermique*)

Transformer
See instrument transformer. (*transformateur*)

Transformer (primary) rated meter
A transformer-type meter which indicates or records the primary quantity being measured by using specific instrument transformer ratios. (*compteur branché sur transformateur*)

Transformer-type meter
A meter designed to be used with instrument transformers. (*compteur à transformateur*)

Two-register, bi-directional meter
A meter that is specified as capable of measuring both positive and negative mean energy flow, as defined by the connection of the meter, and where the positive result and negative result are placed in different registers. This has historically been referred to in Canada as a "bi-directional meter". (*compteur bidirectionnel à deux registres*)

Type
The designation assigned to a meter or device by the manufacturer for the purpose of distinguishing its particular design and construction from other designs, models or patterns. Such type designation must embrace only those ranges and ratings that are essentially similar in appearance and performance. (*type*)

Var hour (delivered)
Is defined as var hours when the phase angle between voltage and current is between 0° and 90° (quadrant I), and between 90° and 180° (quadrant II). (*varheure* [*livré*])

Var hour (received)
Is as defined as var hours when the phase angle between voltage and current is between 180° and 270° (quadrant III), and between 270 to 360° (quadrant IV). (*varheure* [*reçu*])

Var hour meter
An integrating instrument which measures reactive energy in var hours or in suitable multiples thereof. (*varheuremètre*)

Verification
The process by which an approved meter is evaluated for compliance to the metrological, technical and administrative requirements specified in the Act, Regulations and these specifications. (*vérification*)

Volt-ampere hour
Volt-ampere hours irrespective of load direction or quadrant. (*voltampèreheure*)

Volt-ampere hour (delivered)
Volt-ampere hours associated with watt-hours delivered. (*voltampèreheure* [*livré*])

Volt-ampere hour (received)
Volt-ampere hours associated with watt-hours received. (*voltampèreheure* [*reçu*])

Volt-ampere hour meter
An integrating instrument which measures apparent energy in volt ampere hours or in suitable multiples thereof. (*Voltampèreheuremètre*)

Voltage transformer
An instrument transformer intended to have its primary winding connected across circuit with the voltage to be measured. (*transformateur de tension*)

Watt-hour (delivered)
Is defined as watt-hours when the phase angle between voltage and current is between 0° and 90° (quadrant I), and between 270° and 360° (quadrant IV).

Watt-hour (received)
Is defined as watt-hours when the phase angle between voltage and current is between 90° and 180° (quadrant II), and between 180° and 270° (quadrant III).

Watt-hour meter
An integrating instrument which measures active energy in watt-hours or in suitable multiples thereof. (*wattheuremètre*)

Zero load
A condition of null current or energy passing through the meter to the load being measured. (*à vide*)

5.0 Administrative requirements

5.1 General

5.1.1 Verification and reverification are intended to confirm that a meter conforms to all of the performance and non-performance requirements of an approved pattern (design, features, functions, marking, etc.). The extent of verification or reverification inspections must be as specified in these specifications and any additional requirements authorized by Measurement Canada (MC) in regards to these specifications. Although the application of these requirements allows for verification and reverification of electricity meters, the owner of the meter remains legally responsible for ensuring meters' compliance with the Act and related MC policies and programs. Meter owners must also subject meters to marketplace monitoring programs established by MC.

5.1.2 Any meter that fails to meet a performance or non-performance requirement, or that possesses a defect which could affect its ability to meet specified requirements, must be classified as nonconforming.

5.1.3 All meter conformity tests must be performed in accordance with documented procedures that have been evaluated for technical adequacy by the relevant MC technical experts.

5.2 Administrative requirements related to performance

5.2.1 Conditions for testing

All conditions specified herein for testing must be satisfied prior to the meter being evaluated for performance.

5.2.2 Range of tests used to assess measuring function accuracy

5.2.2.1 In principle, verification or reverification confirms the performance capabilities of each approved measurement function of a meter that may be used for the basis of establishing a charge for the consumption of electricity; however, the extent of testing required for this purpose must be based on meter design and the evaluations performed during the approval examinations.

5.2.2.2 Approved measurement functions that the meter owner has requested not to be verified must be disabled. Such functions must not be accessible by any means, including the meter display or meter communication ports, upon verification and sealing of the meter.

5.2.2.3 Where the meter design permits and as approved by MC, certain measurement function tests may be waived, if the function's performance characteristics can be determined through other related tests. These functions will be considered to have been verified upon completion of approved related tests.

5.2.2.4 The tests which may be waived during verification and/or reverification must have been determined through the approval process.

5.2.2.5 Approval tests may also indicate that additional tests over and above standardized verification and/or reverification tests specified herein may be required.

5.2.3 Implicit accuracy of each measurement function

Although the decision regarding the acceptability of a measurement function's accuracy is based upon results of tests at a few discrete points, all measurement functions must be accurate to within specified limits throughout their respective measuring ranges.

5.2.4 Correction for known errors

The results of meter tests performed for the purpose of verification and reverification must be corrected for all known systematic errors. These errors must include the known errors of the calibration console.

5.2.5 Documentation of errors

Each error determined for a meter at any test point must be reported as a minimum to the nearest 0.1% for electromechanical meters and 0.01% for electronic meters.

5.2.6 Limits of calibration

Although a test point error is considered acceptable if it does not fall outside the specification limit for that test point, this fact does not imply that a meter may be intentionally calibrated to register with errors near the specification limits. The calibration target is the midpoint of the specification range.

5.3 Sampling plan for the inspection of isolated lots of meters in service

Meters in service may be reverified as a lot by compliance sampling with use of a MC-authorized compliance sampling plan.

5.4 Verification and reverification methods

Meters may be verified or reverified by 100% inspection. Meters falling under the scope of Measurement Canada sampling plans may be sampled; however, the sample meters must meet the requirements for 100% inspection. In-service meters may be sampled in accordance with section 5.3; however, the sample meters must meet the requirements for 100% inspection. Meters that fall under the scope of Annex A must be verified or reverified by 100% inspection or by sampling in accordance with that annex.

5.5 Verification seal and marking requirements

All meters examined and determined to meet the verification or reverification requirements must have suitable verification markings affixed to physically indicate that they have been examined and found to meet the requirements of these specifications. Meters verified or reverified must be sealed in accordance with the requirements of the *Electricity and Gas Inspection Act* and Regulations and any specifications established thereunder.

5.6 Reverification periods for electricity meters

All meters examined and determined to meet the verification or reverification requirements are permitted to remain in service for the periods prescribed by Measurement Canada in bulletin E-26—Reverification Periods for Electricity Meters and Metering Installations (reference 3.10). For meters that are not new and cannot be calibrated (i.e. mean absolute deviation from target [MADT] assessment is not made), the period for reverification will be as prescribed in reference 3.10 for reserviced meters.

5.7 Disposition of a meter with questionable accuracy

Any meter which has been mishandled or is suspected of being in a state that does not conform with these specifications must not be put in service or continued in use until it has been reverified.

5.8 Requirements for documentation of the inspection certificate or record of inspection

5.8.1 A certificate must be issued for each meter that is inspected, verified or reverified by an inspector or accredited organization that does not own the meter. The certificate must contain all the information required pursuant to section 21 of the *Electricity and Gas Inspection Regulations*, as well as the applicable information listed in section 5.8.3 below.

5.8.2 A record of inspection must be generated for each meter inspected, verified or reverified by an accredited organization that is also the owner of the meter. Such records must contain all the information required pursuant to section 21 of the *Electricity and Gas Inspection Regulations* as well as the applicable information listed in section 5.8.3 below.

5.8.3 Pursuant to 5.8.1 and 5.8.2 above, the following information must be included in the record of inspection or certificate of inspection as applicable:

(a) Whether the meter is verified or reverified.

(b) In the case of meters equipped with pulse initiators, the pulse value associated with the output pulse for each initiator as well as the pulse type or form (e.g. KYZ, 3-wire or 2-wire).

(c) The conformance status of the meter with respect to these specifications.

(d) The year in which the meter will be due for reverification.

(e) All operational parameters including the following:

(i) meter multiplier (or multipliers, if different multipliers are applied for different functions)

(ii) voltage rating or voltage range as marked on the meter's nameplate

(iii) current rating

(f) Where the verification or reverification was performed by sampling methods:

(i) the lot identification number

(ii) the number of meters in the lot

(iii) the values of all statistics determined from the errors of the sample meters

(iv) the conformance status

(v) for compliance sample groups, the level and the extension period in years determined for the sample and its parent lot

(g) Type of demand meter.

(h) Frequency rating, if other than 60 Hz.

(i) Element configuration.

(j) All electromechanical multifunction (combination) energy demand meters with the demand component deactivated must be noted on the inspection certificate.

(k) A listing or reference to a listing of any metrological parameters which were altered from the meter's normal operating state in order to facilitate efficient verification.

(l) A listing or reference to a listing of approved functions for which the meter has been programmed.

(m) Firmware revision.

5.8.4 The certificate or record of inspection serves as the formal record of the meter's verification status and must be maintained by the owner of the meter pursuant to the Act and Regulations.

5.9 Nameplate markings

5.9.1 General

Meters must be verified to ensure the location, legibility and markings meet the approval of type specification LMB-EG-07 referenced in section 3.3 and any additional markings which may be required in the Notice of Approval.

6.0 Technical requirements

6.1 General

6.1.1 Meter verification must include inspections to ensure that the technical requirements specified in this section are complied with.

6.1.2 Meters must be inspected for mechanical fitness and be free of any physical damage, defects in workmanship or material deficiencies which could affect the meter's ability to comply with the requirements of these specifications during the meter's usage.

6.2 Identification of measurement units

6.2.1 All meters must be verified to ensure the presence of the applicable measurement unit identifiers for each approved energy or demand quantity which is displayed or registered. These measurement unit identifiers may also use the standard abbreviation for the measurement units.

6.2.2 Meters equipped with electronic displays may use a coded identifier to identify the measurement unit of approved measurement quantities, provided the coded identifiers can be traced to a table of codes of associated measurement units resident in the meter memory and displayable by the meter. The table of codes may be located on the meter nameplate or any other readily visible location of the meter that is under the meter seal.

6.3 Meter multipliers

(1) All meters are required to identify the applicable meter multiplier, if this multiplier is other than unity.

(2) For electromechanical energy meters, the meter multiplier must be marked permanently and prominently, preferably in red, on the register or scale face.

(3) For electromechanical demand or combination demand/energy meters, the meter multiplier must be marked permanently and prominently, on either the register or nameplate, preferably in red.

(4) Where an electromechanical meter has different multipliers for different measurement quantities, the applicable multiplier for each register and/or scale must be marked in the proximity of the energy and demand unit markings, in a manner which readily identifies the associated function multiplier.

(5) For electronic meters, the meter multiplier must be distinctly marked on the meter's nameplate or electronic display.

6.4 Mechanical registers

6.4.1 Register markings

(1) Meters must be verified to ensure that there are no markings on the register face except for the manufacturer's name, trademark, the direction of rotation indicator, register ratio, rotation index mark, multiplier, or marks pertaining to the reading of the register. Where the register face and nameplate are integral, the above requirement does not apply but any markings must not interfere with the reading of the register.

(2) It is not permissible to indicate above or below any individual dial or drum, the magnitude of the complete indication or the divisions.

6.4.2 Register ratio - Induction type meters

(1) Induction type energy meters must be verified to ensure that the register ratio is marked on the register in such a manner that it is legible without removing the register. If sufficient space is available, the register ratio must be marked on the register faceplate.

(2) The register indication must be strictly in accord with the result computed from the number of disc revolutions, the disc constant as given on the nameplate and the multiplier.

6.4.3 Mechanical demand registers

The driving pointer must be examined to ensure that it is of a colour distinctly different from that of the driven pointer.

6.5 Electronic displays

Meters equipped with electronic displays and having programmable display parameters must be clearly readable under normal conditions of use.

6.6 Register resets

6.6.1 General

(1) The reset device must be checked to ensure that it is not possible to reset (i.e. reset to zero) or modify energy registers with the meter sealed, unless the readings are stored in another sealed memory or register location for recall at any time. Only demand quantities must be reset on a sealed meter.

(2) For the case of mechanical demand registers, the device for resetting demand must be such that, in its normal position, it does not affect either the maximum demand indicator or the driving element.

6.6.2 Resetting of demand registers

The peak demand reset event must be verified to ensure that it:

(a) resets the maximum demand indicator to zero (at no load conditions) or to the equivalent current demand position; and

(b) increments any associated cumulative demand register by a value equal to the peak demand reading.

6.7 Data retention requirements

6.7.1 General

The data retention capabilities of meters having metered data, chronological data or metrologically significant information which could be lost in the event of a power outage must be verified over a period of one minute, or any other period approved by MC, to ensure prevention of the loss of this information.

6.7.2 Carry-over battery

Any device fitted with a carry-over battery must be verified to confirm battery condition using one of the following means:

(a) Confirm that the battery condition indicator indicates a good battery.

(b) Measure battery voltage.

(c) For meters equipped with batteries which cannot be accessed without breaking the meter seal, use manufacturers' data on expected battery life and ensure that remaining battery life will be sufficient for the reverification period of the meter.

6.8 Circuit association check

All polyphase meters must be subject to a circuit association test to ensure that each current circuit is associated with the correct voltage circuit. This test is not required upon reverification if the meter seal has not been broken or damaged.

6.9 Pulse initiator requirements

(1) Meters having pulse initiators which represent functions that are not verified by other means must be subject to verification at all applicable energy meter test points using the same specification limit.

(2) Pulse initiators which are used as the fundamental means for establishing time-related demand must be verified for accuracy to specification limits of ±1.0% with a resolution of 0.1%.

6.10 Pulse recorder requirements

(1) Pulse recorders or meters equipped with one or more internal pulse recorders must be assessed to ensure that pulses are recorded accurately. Pulse recorders must record total pulses accurately to a specification limit of ± 2 pulses when at least 100 pulses have been applied. Devices with multi-channel input and recording capabilities must be assessed according to the above criteria at each input channel.

(2) Devices intended for use in determining demand must be subject to demand interval verification as per 6.13.5.

(3) Pulse recorders which convert pulses to energy values are subject to the requirements of multi-register metering (section 6.13.2), as well as pulse constants (section 6.13.7).

6.11 Reverse operation

(1) Meters intended to be used for reverse flow energy must be verified to ensure correct operation of the flow direction indicator.

(2) Meters equipped with pulse outputs must be verified to ensure that detents prevent pulse output for the case of reverse operation.

(3) Each detented register on a meter must be verified to confirm that there is no change in registration if the meter is connected to a load in the reverse direction.

6.12 Induction type var hour and Q hour metering

Where an induction type watt-hour meter is used with approved phase shifting transformers to meter var hours or Q hours, the meter must be verified for the presence of markings indicating the units being measured. The meter must also be verified for the presence of a marking to indicate that external phase shifting transformers are required. For the case of a watt-hour meter that has been cross connected in order to meter Q hours, the meter must be verified for the presence of marking indicating that it has been cross connected and for the units being measured.

6.13 Verification of advanced meter functions

6.13.1 Programmed parameters

(1) Programmable metrological parameters and functions must be verified to ensure that they are programmed correctly according to the meter owner provided specification and, if present, the information printed on the meter nameplate. This may be accomplished through a number of means, at the option of the meter verifier, depending on the function.

(2) These checks are not required upon reverification if the meter has not been reprogrammed and the meter seal has not been broken or damaged.

6.13.2 Multi-register meter functions

Meters equipped with multi-register functions must be verified for the correctness of programmed information used to exercise switching of rate registers. This may be verified by one of the following means:

(a) Comparing the programmed information stored in the meter against specified information provided by the owner of the meter.

(b) Performing one or more tests which assess each register.

(c) Other means that the meter verifier can demonstrate are valid and accepted by MC.

6.13.3 Prepayment meters

In addition to all applicable administrative, technical and metrological requirements contained herein, prepayment meters must also be assessed for the correctness of programmed parameters related to the prepayment function. The correctness of programmed parameters must be verified by one of the following means:

(a) Comparing the programmed information stored in the meter against specified information provided by the owner of the meter.

(b) Performing one or more tests which exercise the programmed parameters related to the prepayment function.

(c) Other means that the meter verifier can demonstrate are valid and accepted by MC.

6.13.4 Multiplier

The meter multiplier must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the multiplier on the meter display, if it is programmed into one of the meter's display sequences.

(c) Performing an accuracy test that makes use of a register to which the multiplier is applied (e.g. a demand or dial test). The resolution of this test must be sufficient to determine the value of the multiplier to a resolution of 0.1%.

(d) Other means that the meter verifier can demonstrate are valid and accepted by MC.

6.13.5 Demand interval

The normal mode demand interval must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the demand interval on the meter display, if it is programmed into one of the meter's display sequences.

(c) Performing a demand accuracy test.

(d) Other means that the meter verifier can demonstrate are valid and approved by MC.

Meters equipped with more than one demand interval, either for different demand quantities or multiple demand input channels (i.e. mass memory) must have each interval assessed as above.

6.13.6 Demand type

Demand type refers to whether a meter is programmed for block, sliding window or exponential demand in normal mode. This must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the demand type on the meter display, if it is programmed into one of the meter's display sequences.

(c) Performing a demand test.

(d) Other means that the meter verifier can demonstrate are valid and accepted by MC.

6.13.7 Pulse constants and multipliers

(1) The value of each pulse constant and multiplier must be verified to ensure correctness of the programmed value in relation to the pulse or data type and form.

(2) For devices equipped with more than one pulse output and that have separately programmable pulse constants or multipliers, each constant and multiplier must be verified. If a single programmed parameter determines the pulse constant or multiplier for all pulse outputs, then only a single check is required. Constants and multipliers must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the pulse rate or multiplier on the meter display, if it is programmed into one of the meter's display sequences.

(c) Performing an accuracy test on one of the pulse outputs. This test may also be used to verify the corresponding energy function.

(d) Other means that the meter verifier can demonstrate are valid and accepted by MC.

6.13.8 Pulse output detent

(1) The detent setting must be verified on meters having pulse outputs with programmable detent.

(2) The detent of each output must be verified for meters equipped with more than one pulse output and which have detents that are separately programmable. If a single programmed parameter determines the detent for all pulse outputs, then only a single check is required.

(3) The pulse detent must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the detent setting on the meter display, if it is programmed into one of the meter's display sequences.

(c) Applying energy to the meter in the reverse direction relative to the direction of the pulse output, and confirming that no pulses are generated.

(d) Other means that the meter verifier can demonstrate are valid and accepted by MC.

6.13.9 Programmable register detent

(1) The detent setting must be verified on meters having registers with programmable detent.

(2) The detent of each register must be verified for meters equipped with more than one register having detents that are separately programmable. If a single programmed parameter determines the detent for all registers, then only a single check is required.

(3) The programmable register detent must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the detent setting on the meter display, if it is programmed into one of the meter's display sequences.

(c) Applying energy to the meter in the reverse direction relative to the direction of the register, and confirming that there is no change in registration.

(d) Other means that the meter verifier can demonstrate are valid and recognized by MC.

6.13.10 Bi-directional meters, single register (net)

Bi-directional meters with only one register must be verified to ensure that the meter is programmed such that the net register contains the arithmetic difference between received energy and delivered energy for each net legal unit of measure (LUM) for which the meter is approved to be used. The meter must be verified to ensure that the register clearly distinguishes net received values from net delivered values.

6.13.11 Loss compensation

The loss compensation factor(s) in meters equipped with loss compensation must be verified through one of the following means:

(a) Examining the program in the meter (e.g. by using software or push-buttons).

(b) Reading the loss compensation factor on the meter display, if it is programmed into one of the meter's display sequences.

(c) Performing an accuracy test that makes use of a register to which the loss compensation factor is applied (e.g. a demand or dial test). The resolution of this test must be sufficient to determine the value of the multiplier to a resolution of 0.1%.

(d) Other means that the meter verifier can demonstrate are valid and approved by MC.

6.14 Firmware verification

(1) Meter firmware must be identical to a version identified in the notice of approval or applicable modification acceptance letter (MAL).

(2) Meters approved with modifiable software or legally relevant parameters must be verified to ensure that the hash code generated by the meter is identical to that identified in the notice of approval or applicable MAL.

7.0 Metrological requirements

7.1 General

(1) The requirements including test points and specification limits provided in this document must be applied in conjunction with procedures either issued or accepted by MC.

(2) MC may establish additional test points and procedures as may be required for specific meter types.

(3) Unless otherwise noted, the specification limits specified in this document are provided in terms of relative error (percentage).

(4) Meters must be fully assembled and calibrated before undergoing verification or reverification tests. Removal of the meter cover or access to sealable components, adjustments or reprogramming during the verification process is permitted only when test procedures used have been issued or accepted by MC.

(5) All verification tests for accuracy of energy functions must be determined to a minimum resolution of 0.1% for electromechanical meters and 0.01% for electronic meters unless otherwise stated.

(6) The errors for exponentially responding demand meters must be determined after the test load has been applied for three full demand response periods.

7.2 Reference conditions for metrological requirements

Except as otherwise stated, the following reference conditions apply to all metrological requirements:

(a) The ambient temperature must be 23 ˚C ± 5 ˚C.

(b) All voltage circuits must be connected in parallel and all current circuits must be connected in series assisting (positive to negative).

(c) Before conducting any tests for the purpose of ascertaining meter performance, meters may be warmed up as specified by the manufacturer up to a maximum of two hours.

(d) The meter or device must be in its normal working condition or in a mode approved for verification or reverification. Except where the nature of the test requires otherwise, all registers, transmitting contacts, detents, etc., must be operating in the normal state. For cyclometer-type registers, only the fastest moving counter must be turning.

(e) The meter must be installed during testing such that the working position of the meter is within ±3˚ of the front-to-back and side-to-side vertical planes. This requirement is applicable to electromechanical integrating meters or other meter types whose accuracy may be affected by tilt.

(f) For the purpose of setting the test loads, all test points must be within ±2.0% of the established test current, nominal voltage and test load.

(g) Power factor set points must be within ±2.0° of that specified for the test, and unless otherwise specified, must be in the lag condition.

(h) Unless otherwise specified, meters must be evaluated at a nominally rated nameplate voltages.

(i) Unless otherwise specified, meter test loads are established as a percentage of the maximum current rating (I_{max}) for the meter. Transformer type meters having a meter I_{max} of 10 A or greater and intended to be installed with transformers having a secondary current rating of 5 A must be evaluated using a value for I_{max} of 10 A.

7.3 Performance requirements

7.3.1 General

Unless otherwise stated, the requirements set out in section 7.3 are applicable to each LUM for which the meter is approved to be used.

7.3.2 Electromechanical meters

7.3.2.1 Zero load performance

(1) Energy meters must be subjected to a zero load test, with a load of zero current and nominally rated voltage.

(2) The disk of an energy meter must be stopped or it must not exhibit one complete revolution of its disk in a ten-minute period.

7.3.2.2 Comparative registration test

Electromechanical energy meters must be subjected to a comparative registration test (also known as a dial test). The specification limit is zero error relative to the disc, tested to a resolution of 3.0%.

7.3.2.3 Single phase 1 and 1½ element energy meters

All single phase, single element, and 1 and 1½ element energy meters must be evaluated at the test points and specification limits identified in table 7.1.

Table 7.1

Energy tests – Single phase, 1 element and 1½ element meters

Test configuration	Current	Power factor Pf	Specification limit
Series test	25% I_{max}	1.0	±1.0%
Series test	25% I_{max}	0.5	
Series test	2.5% I_{max}	1.0	

Notes:

(1) Reverification tests at 0.5 Pf are not required for magnetic suspension, single phase 1 and 1½ element energy meters.

(2) Reverification tests at 0.5 Pf are required for magnetic suspension, single phase 1 and 1½ element combination energy demand meters.

7.3.2.4 Polyphase 2½ element wye energy meters

Polyphase 2½ element wye meters must be evaluated at the test points and specification limits identified in table 7.2.

Table 7.2

Energy tests – Polyphase 2½ element wye meters

Test configuration	Current	Power factor Pf			Specification limit
		Wh, VAh	varh [1]	Qh [1]	
Series test	25% I_{max}	1.0	0.5	0.5	±1.0%
Series test	2.5% I_{max}	1.0	0.5	0.5	
Each element	50% I_{max}	1.0	0.5	0.5	
Each element	50% I_{max}	0.5	0.866	1.0	
Split coil element [2]	50% I_{max}	1.0	0.5	0.5	

Notes:

(1) Var hour and Q hour meters that operate on the crossed phase principle must be tested as watt-hour meters.

(2) The split coil element test is not required on reverification.

7.3.2.5 Polyphase 2 element, 2½ element delta and 3 element energy meters

Polyphase 2 element, 2½ element delta, and 3 element energy meters must be evaluated at the test points and specification limits identified in table 7.3.

Table 7.3

Energy tests – Polyphase 2 element, 2½ element delta and 3 element meters

Test configuration	Current	Power factor Pf			Specification limit
		Wh, VAh	varh [1]	Qh [1]	
Series test [3]	25% I_{max}	1.0	0.5	0.5	±1.0%
Series test [3]	2.5% I_{max}	1.0	0.5	0.5	
Each element [2]	25% I_{max}	1.0	0.5	0.5	
Each element [2]	25% I_{max}	0.5	0.866	1.0	
Each element [2] (2½ element 4-wire delta only)	2.5% I_{max}	1.0	0.5	0.5	

Notes:

(1) Var hour and Q hour meters that operate on the crossed phase principle must be tested as watt-hour meters.

(2) The tests for each element of 2½ element 4-wire delta meters must be applied to:

(a) the 2-wire element;

(b) the 3-wire element in series.

(3) The series test for 3 element 4-wire delta meters must be conducted at the rated voltage of the lower rated potential coil. The individual element tests must be conducted at the rated voltage of the respective potential coil.

7.3.2.6 Electromechanical bi-directional energy meters

Electromechanical bi-directional energy meters must be verified for each direction of energy flow. The test points and specification limits must be as specified in tables 7.1 to 7.3 as applicable.

7.3.2.7 Electromechanical demand meters – general

(1) Thermal demand meters must be tested for hysteresis (grease memory) by manually resetting the driven demand pointer a minimum of two major scale divisions and holding for a maximum of three seconds. After removing the demand reset mechanism, the driven demand pointer must not move up scale more than 1.0% FS (full scale).

(2) Thermal demand meters must be tested for pull-back after the demand test load is removed. The driven pointer must not move down scale by more than 1.0% FS.

(3) A thermally stable electromechanical thermal demand meter must be evaluated to ensure that zero load is registered to within 1/32 inch of true zero.

(4) For the purpose of evaluating thermal demand errors determined at the test points indicated in tables 7.4 and 7.5, readings of the driven pointer must be taken only after the driving pointer has disengaged.

7.3.2.8 Electromechanical 1 and 1½ element thermal demand meters

Single phase 1 and 1½ element electromechanical thermal demand meters must be evaluated at the test points and specification limits identified in table 7.4.

Table 7.4

Demand tests – Electromechanical 1 and 1½ element thermal demand meters

Test configuration	Test point	Power factor Pf	Specification limit
Series test	66.6% FS	1.0	±1.5% FS
VA only: Series test	66.6% FS	0.5	±1.5% FS
Any one element	20% FS	1.0	±1.5% FS

7.3.2.9 Electromechanical 2, 2½ and 3 element thermal demand meters

Polyphase 2, 2½ and 3 element electromechanical thermal demand meters must be evaluated at the test points and specification limits identified in table 7.5.

Table 7.5

Demand tests – Electromechanical 2, 2½ and 3 element thermal demand meters

Test configuration	Test point	Power factor Pf	Specification limit
Series test	66.6% FS	1.0	±1.5% FS
VA only: Series test	66.6% FS	0.5	±1.5% FS
2 el: Any one element	20% FS	1.0	±1.5% FS
3 el: Any two elements	20% FS	1.0	±1.5% FS
2½ el: Each single element (delta meters)	20% FS	1.0	±1.5% FS
2½ el: Each single element (wye meters)	16.6% FS	1.0	±1.5% FS

7.3.2.10 Electromechanical integrating demand meters

Where the demand pointer is driven by the meter disc, one series test must be performed at 66.6% FS, 1.0 Pf. The specification limit for this test is ±1.5% FS.

7.3.2.11 Accuracy of demand interval

The demand interval for electromechanical block interval demand meters must be within ±1.0% of the set interval.

7.3.3 Electronic meters

7.3.3.1 Zero load performance

(1) Electronic meters must be subject to a zero load verification test performed with zero current in all circuits, and at any rated voltage.

(2) Meters may be evaluated for zero load performance using one of the methods outlined in items (a) to (d) below. The duration of the evaluation test must be determined based on a hypothetical load of 0.05% I_{max} at the test voltage and the test condition described in (a) to (d) as applicable. No registration is permitted for the duration of the tests performed in (a) to (d) below.

(a) Demand test: The duration of the test must be at least one complete demand interval, or in the case of exponential demand three time constants. However, a demand test may be used only if the demand register has sufficient resolution to indicate a non-zero value at the load described in 7.3.3.1.2.

(b) Pulse output or disk revolution simulator: The minimum duration of the test must be the amount of time that would be required to obtain one pulse or disk revolution at the load described in 7.3.3.1.2.

(c) Energy register test: The minimum duration of the test must be the amount of time that would be required to register a non-zero value at the load described in 7.3.3.1.2., based on the resolution of the energy register.

(d) Other means such as instantaneous demand that the meter verifier can demonstrate are valid and are recognized by MC.

7.3.3.2 Accuracy requirements for energy meters

Electronic energy meters must be programmed to register active energy (watt-hours) and be verified for each applicable energy LUM at the test points found in table 7.6 below.

Table 7.6

Energy tests – Electronic energy meters – Delivered direction

Test configuration	Current	Power factor Pf				Specification limit
		Wh	VAh	varh	Qh	
Series test [1]	25% I_{max}	1.0		0.5	0.5	±1.00%
Series test [1]	25% I_{max}	0.5	0.5	0.866		
Individual elements [1, 2]	25% I_{max}	0.5				
Series test [1]	2.5% I_{max}	1.0				

Notes:

(1) The series test for 2 ½ and 3 element 4-wire Delta meters must be conducted at the nameplate rated voltage. The individual element tests must be conducted at the rated voltage of the respective potential coil.

(2) Individual element testing is not required for 1 and 1 ½ element meters.

7.3.3.3 Accuracy requirements for demand meters

Electronic demand meters must be evaluated for each applicable demand LUM identified in table 7.7 except as noted in (1) below. The 50% I_{max} test load must be used except where a 25% I_{max} test load can be shown to provide a 0.1% resolution of reading, in which case either test point may be used.

Table 7.7

Demand tests – Electronic demand meters

Test configuration	Current	Power factor Pf			Specification limit
		W	VA [1]	Var [1]	
Series test	50% Imax	0.5	0.5	0.866	±1.00%
Series test	25% Imax	0.5	0.5	0.866	±1.00%

Note: Meters which have been assessed for VAh and/or varh and watt demand are not required to be assessed for their respective VA and/or Var demand accuracy.

7.3.3.4 Meters with multiple or auto-ranging voltages

(1) Subject to the requirements of items (2) and (3) below, electronic meters that are capable of operating at multiple voltages must be verified at one additional nominal service voltage within the approved range using a previously verified current and power factor test point (i.e. energy or demand).

(2) Electronic meters capable of operating at multiple voltages may have a range of operating voltages within the approved voltage range marked on their nameplate. The requirement of item (1) above must be applied at an additional nominal service voltage within the marked range.

(3) Electronic meters approved with multiple voltages or auto-ranging voltages but having a single nominal voltage rating marked on their nameplate are not subject to the requirement of item (1) above.

7.3.3.5 Voltage squared hour meters

Meters which are capable of metering voltage squared hours must be evaluated at 95% and 105% of the nominal nameplate voltage. The specification limit for these V^2h tests is ±1.00%.

7.3.3.6 Ampere squared hour meters

Meters which are capable of metering ampere squared hours and have not been evaluated for the watt-hour LUM must be evaluated at 2.5% I_{max} and 25% $I_{max.}$ All other ampere squared hour meters may be evaluated at only one convenient test point which is at or greater than 25% I_{max}. The specification limit for these I^2h tests is ±1.00%.

7.3.3.7 Electronic demand meter response type

Each demand response type (exponential, block, sliding window, etc.) which has been programmed and not otherwise verified must be verified in accordance with the requirements of section 7.3.3.3.

7.3.3.8 Meters equipped with gain switching circuits

Meters equipped with gain switching circuits must be tested at one test point in each gain switching range. This may require additional test points for the case of meters having gain ranges not exercised by the standard test points. The additional test points within the various gain ranges of the meter must be as established within procedures, notices of approvals or other official documentation as established by MC.

7.3.3.9 Received direction energy meters

Electronic energy meters which are approved to register energy flowing in the received direction must be verified at the test points specified in Table 7.8 as applicable.

Table 7.8

Energy tests – Electronic energy meters – Received direction

Test configuration	Current	Power factor Pf			Specification limit
		Wh	VAh	varh	
Series test	25% I_{max}	0.5	0.5	0.866	±1.00%

7.3.3.10 Single-register and two-register bi-directional energy meters

(1) Electronic bi-directional energy meters must be verified for all of the applicable series tests in the delivered direction (Table 7.6) and at all the test points specified in the received direction (Table 7.8) as applicable.

(2) Test results for all corresponding test points must not differ by more than 1.0% between delivered direction error and received direction error.

(3) If the meter has only a single register (net) and not two (bi-directional) registers, then the register or pulse output must be assessed for energy flow in each direction.

7.3.4 Combination electromechanical-electronic meters

(1) Combination electromechanical-electronic meters which have the disk of the electromechanical induction portion of the meter monitored electronically to provide approved metering LUMs must be verified as follows:

(a) For each approved energy LUM provided electronically, the requirements of section 7.3.2 must apply.

(b) For each approved demand LUM provided electronically, the requirements of section 7.3.3 must apply.

(2) Combination electromechanical-electronic meters which have electromechanical and electronic metering elements which are independent of each other must be verified as two independent meters. The electromechanical portion of such devices must be verified in accordance with the applicable requirements of section 7.3.2 and the electronic portion of such devices must be verified in accordance with the applicable requirements of section 7.3.3.

8.0 Revisions

The purpose of revision 6 was to clarify requirements for documentation, verification and homogeneity of meters with multiple or auto-ranging voltages.

The purpose of revision 5 was to:

- clarify requirements for bi-directional meters;
- clarify which LUMs require verification;
- incorporate certain definitions from OIML R46 as necessary;
- include requirements to verify the hash code of meters so approved; and
- make other editorial and structural modifications.

The purpose of revision 4 was to add requirements for the sampling of electromechanical energy meters.

The purpose of revision 3 was to add requirements for the sampling of electronic polyphase and demand meters.

The purpose for revision 2 was to remove the nameplate requirements that were identified under the reduction initiative as being adequately addressed in the approval specification and the notice of approval where additional markings may be required.

The purpose of revision 1 was to remove the testing facilities requirements that were identified under the reduction initiative as being adequately addressed in section 19 of the Act.

Annex A—Acceptance sampling and 100% inspection requirements

A.1 Scope

This annex specifies the requirements for acceptance sampling and 100% inspection of electronic and electromechanical meters.

A.2 Applicability

A.2.1 The requirements of this annex are applicable to all:

a) electronic meters of section 7.3.3, which include single phase, network and polyphase self-contained and transformer type energy meters (Wh, VAh, varh and Qh), demand meters (Watts, VA, var) and loss meters (V^2h, I^2h) with or without advanced functions; and

b) electromechanical meters of section 7.3.2, which include single phase, network and polyphase self-contained and transformer type energy only meters (Wh, VAh, varh and Qh).

A.2.2 This annex states the requirements for verification and reverification when the test or measurement result is subject to uncertainty, in accordance with the requirements of MC specification S-S-02 (reference 3.7).

A.3 General

A.3.1 Meters must be verified or reverified in accordance with all of the applicable requirements in this document and as amended by this annex.

A.3.2 In general, for the purpose of verification, test results for the following quality characteristics must be treated as non-performance observations for functionality verification (i.e. pass/fail) of electronic meters. The following list, as applicable, is not exhaustive and is not intended to include all the possible combinations of non-performance attributes to be inspected within a quality system:

(a) Data retention capabilities

(b) Carry-over battery condition

(c) Pulse recording operation

(d) Validation of programmed parameters

(e) Multiplier verification

(f) Pulse constant verification

(g) Pulse output detent operation

(h) Loss compensation factors and/or function

(i) Zero load performance/creep test verification

(j) Phase association verification

(k) Confirmation of approved firmware

(l) Mechanical integrity confirmation

(m) Multi-register metering function

(n) Demand reset operation

(o) Demand type verification

(p) Demand interval verification

A.3.3 The following quality characteristics must be treated as non-performance observations for functionality verification (i.e. pass/fail) of electromechanical meters. The following list, as applicable, is not exhaustive and is not intended to include all the possible combinations of non-performance attributes to be inspected within a quality system:

(a) Multiplier verification

(b) Pulse constant verification

(c) Pulse output detent operation

(d) Zero load performance/creep test verification

(e) Phase association verification

(f) Mechanical integrity confirmation

(g) Multi-register metering function

(h) Comparative registration verification / dial test

(i) Register markings (ratio)

A.4 Symbols and abbreviations

k multiplier calculated to provide specified coverage for the uncertainty of a measurement
e_i test value
u_{ci} combined standard uncertainty of e_i
L_{SL} lower specification limit
U_{SL} upper specification limit

MADT mean absolute deviation from target
U_{MADT} Upper MADT specification limit
CSL1 compressed specification limits for type 1 marginal conformities (LQ = 3.15%)
CSL2 compressed specification limits for type 1 marginal conformities (LQ = 8.0%)
L_{CSL1} lower compressed specification limit (LQ = 3.15%)

L_{CSL2} lower compressed specification limit (LQ = 8.0%)
U_{CSL1} Upper compressed specification limit (LQ = 3.15%)
U_{CSL2} Upper compressed specification limit (LQ = 8.0%)

A.5 Limits of error and conformity determination

A.5.1 The specification limit is ±1.00% and the minimum coverage criterion for the extended measurement result is at least 99% coverage. For the purpose of 100% inspection, conformity exists if all of the inequalities below are satisfied. For meters which are not new and cannot be calibrated, conformity exists if inequalities in items (i) and (ii) are satisfied.

(i) $e_i - k\, u_{ci} \geq L_{SL}$

(ii) $e_i + k\, u_{ci} \leq U_{SL}$ and

(iii) mean ($|e_i|$) $\leq 0.50\ (U_{SL})$

where, k = 3.0000 and u_{ci} is determined in accordance with the requirements of MC specification S-S-02 (reference 3.7)

Notes:

(1) The MADT per A.5.1 (iii) is calculated from all observations identified in A.5.2 below. The calculation method is to first determine the absolute value of each error, e_i, then determine the mean of those values.

(2) The definition of new meter identified in A.5.1 above is as defined in bulletin E-26 reference 3.10. Also see section 5.6 for applicable reverification periods.

A.5.2 For single phase, polyphase and network electronic meters, the MADT is determined using the unweighted mean of all Wh energy observations at unity and 0.5 power factor.

A.5.3 Conformity must be determined using a one-stage procedure in accordance with the requirements of MC specification S-S-02 (reference 3.7).

A.5.4 Measurement results must be reported in accordance with S-S-02 (reference 3.7).

A.6 Acceptance sampling inspection for electronic and electromechanical (energy only) meters

A.6.1 Devices may have their conformity evaluated by 100% inspection or, where the prerequisites of MC Specification S-S-03 (reference 3.8) have been and continue to be met, by sampling inspection in accordance with the requirements of MC Specification S-S-04 (reference 3.9).

A.6.2 A lot of meters submitted for acceptance sampling must not contain a mixture of self-contained and transformer type meters. As well, meters in the lot must be homogeneous with respect to the following:

(a) Manufacturer and model, unless otherwise authorized by MC in accordance with section A.6.3;

(b) Voltage or voltage range (meters of a given approved voltage that are marked with a subset of nominal voltages or voltage ranges are not considered homogeneous with respect to meters marked with a different nominal voltage or voltage range);

(c) Maximum current rating;

(d) Configuration with respect to number of elements, wye, delta or auto configuration;

(e) Units of measure;

(f) Firmware version that is identified as being homogeneous by the manufacturer (not applicable to electromechanical meters);

(g) Frequency rating;

(h) Same model or type of telemetering device (if so equipped), unless otherwise authorized by MC in accordance with section A.6.3;

(i) Demand type, unless otherwise authorized by MC in accordance with section A.6.3. (not applicable to electromechanical meters);

(j) Permissible batch types:

(1) new and/or renewed meters produced within a six-month period; or

(2) previously-verified meters which have all been reconditioned (and/or repaired) and re-calibrated within a six-month period.

A.6.3 If an accredited organization wishes to combine, in one lot, various models or vintages of meters, and/or meters equipped with and without a telemetering device, or more than one telemetering device, the accredited organization must submit a request to MC with accompanying documentation in support of its claim that these differing meters can be considered homogeneous for purposes of acceptance sampling.

A.6.4 For the purposes of sampling inspection, a conforming unit is as defined in these specifications for performance and non-performance characteristics. A lot must be sentenced based on the specification limit of ±1.00%. The criterion for the extended measurement result is at least 95% coverage. An accredited organization must have the option to determine conformity using either a one-stage or two-stage procedure in accordance with the requirements of MC specification S-S-02 (reference 3.7).

A.6.5 The compressed specification limit (CSL) values determined from the device's performance specification limits are defined as follows:

Compressed specification limit

Marginal conformity type	Lower CSL	Upper CSL
Type 1 (LQ of 3.15%)	L_{CSL1} = 0.8350 (-1.00) = -0.8350	U_{CSL1} = 0.8350 (1.00) = 0.8350
Type 1 (LQ of 8.0%)	L_{CSL2} = 0.6797 (-1.00) = -0.6797	U_{CSL2} = 0.6797 (1.00) = 0.6797
Type 2 (MADT)	-------	U_{MADT} = 0.5 (1.00) = 0.50

A.6.6 A device is classified as a marginally conforming unit if it has no nonconformity but exhibits performance falling outside the interval defined by the lower and upper CSL values (type 1 marginally conforming) or has an MADT value exceeding the MADT limit (type 2 marginally conforming).

A.6.7 The conformity, marginal conformity or nonconformity of the device's performance must be determined in accordance with the requirements of S-S-02 (reference 3.7) and the following classification criteria based on the device's relative error (e_i), applied in the order presented below. For meters which are not new and cannot be calibrated, the conformity, marginal conformity or nonconformity determination is applied to items (a), (b), (c) and (e) below:

(a) nonconforming if $e_i + k\ u_{ci} > U_{SL}$ or $e_i - k\ u_{ci} < L_{SL}$

(b) marginally conforming type 1 if $e_i + k\ u_{ci} > U_{CSL1}$ or $e_i - k\ u_{ci} < L_{CSL1}$

(c) marginally conforming type 1 if $e_i + k\ u_{ci} > U_{CSL2}$ or $e_i - k\ u_{ci} < L_{CSL2}$ (optional under sampling inspection)

(d) marginally conforming type 2 if the mean ($|e_i|$) > U_{MADT}

(e) conforming otherwise

where k = 1.6449, u_{ci} is determined in accordance with the requirements of MC specification S-S-02 (reference 3.7). MADT is determined in accordance with A.5.2.

A.6.8 Measurement results must be reported in accordance with S-S-02 (reference 3.2).

A.7 Outgoing quality requirements

The outgoing quality standards for meter quality under both 100% inspection and sampling inspection are the following:

(a) Inspected meters can't be placed in service with a result which is not contained within the 100% inspection specification limits specified in subsection A.5.1.

(b) Meters can't be placed in service with one or more nonconformities or defects. (The accredited organization must be responsible for deciding which types of quality characteristic deficiencies are to be identified as a defect.)

(c) Subject to (a) and (b) above, sample meters are considered acceptable regardless of the status of the lot.

(d) The outgoing quality requirements must be met for the product of the associated limiting quality (LQ) value and the lot size, as specified in S-S-03 (reference 3.8) or S-S-04 (reference 3.9) for type 1 and type 2 marginal conformities.

(e) For meters which only undergo 100% inspection, the outgoing quality requirements of section A.7(d) are considered as being met if the 100% inspection requirements specified in section A.5 are met.

A.8 Disposition of nonconforming meters

A.8.1 For small lots inspected by 100% inspection or larger lots inspected but not accepted by sampling, nonconforming meters and excessive marginally conforming meters must be removed or repaired to ensure the outgoing quality standards of section A.7 are met.

A.8.2 Individual nonconforming or defective meters may be resubmitted for inspection only after their deficient characteristics have been corrected.

A.8.3 Unacceptable lots may be resubmitted for inspection only after the meter owner or his agent has re-examined all meters and removed or corrected all nonconforming or defective meters. Re-inspection must include evaluation of all quality characteristics where the non-acceptance is due to performance characteristics, or, for all other types of nonconformities and defects, evaluation of the characteristic(s) causing lot non-acceptance.