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# Section 3.41. Non-Utility Electricity-Measuring Systems – Tentative Code

This tentative code has only a trial or experimental status and is not intended to be enforced. The requirements are designed for study prior to the development and adoption of a final code. Officials wanting to conduct an official examination of a Non-Utility Electricity-Measuring System (NUEMS) are advised to see paragraph G A.3. Special and Unclassified Equipment.

(Tentative Code Added 2024)

NUEMS Acronym and Definition: As used throughout this code, a Non-Utility Electricity-Measuring System or "NUEMS" is defined as an electricity measuring system comprised of all the metrologically relevant components required to measure electrical energy, store the result, and report the result used in non-utility sales of electricity wherein the sale is based in whole or in part on one or more measured quantities.

**Safety Note:** This code does not specifically discuss Safety. It is essential that all personnel working with the devices covered by this code and associated electrical equipment be properly trained and adhere to all applicable safety standards, regulations, and codes. See also General Code Paragraph G-N.1. Conflict of Laws and Regulations.

## A. Application

**A.1. General.** – This code applies to measuring systems used in non-utility sales of electric energy wherein the sale is based in whole or in part on one or more measured quantities.

**A.2. Exceptions.** – This code does not apply to:

(a) The use of any measuring system owned, maintained, and/or used by a utility.

(b) Measuring systems used solely for delivering electric energy in connection with operations in which the amount delivered does not affect customer charges or compensation.

(c) Electric vehicle fueling systems. (See 3.40. Electric Vehicle Fueling Systems Code).

(d) Transactions not subject to weights and measures authority.

**A.3. Additional Code Requirements.** – In addition to the requirements of this code, Non-Utility Electricity-Measuring Systems shall meet the requirements of Section 1.10. General Code.

**A.4. Type Evaluation.** – The National Type Evaluation Program (NTEP) will accept for type evaluation only those measuring systems that have received safety certification by a nationally recognized testing laboratory (also referred to as "NRTL") and shall issue an NTEP Certificate of Conformance only to those measuring systems that comply with all requirements of this code.

**A.5. NUEMS Type Notation.** – Code sections and subsections with an [ES] notation apply to External Sensor NUEMS only. Code sections and subsections with a [IS] notation apply to Internal Sensor NUEMS only. Code sections and subsections without [ES] or [IS] notation apply to both NUEMS types.

# S. Specifications

## S.1. Indicating and Recording Elements.

### S.1.1. Units. – Units for any indicated or recorded measurements shall be as follows:

Active Energy: kilowatt-hours (kWh).

**S.1.1.1. Numerical Value of Quantity-Value Divisions.** – The value of an increment shall be equal to a decimal multiple or submultiple of 1.

Examples: quantity-value divisions may be 10; or 0.01; or 0.1; etc.

**S.1.1.2. Digital Indications.** – An indication shall include the display of a number for all places that are displayed to the right of the decimal point and at least one place to the left. Otherwise, leading zeros are not required.

**S.1.2. Nominal Capacity.** – *A device shall have a minimum capacity* indication *of five digits of resolution. [Nonretroactive as of January 1, 2025]*

### S.1.3. NUEMS Indications.

**S.1.3.1. Primary Indicating Element.** – Each NUEMS shall be equipped with a primary indicating element that includes a display visible and accessible after installation which at a minimum clearly indicates the number of kilowatt-hours measured by the NUEMS.

**S.1.3.2. Test Output.** – A NUEMS shall have either: (1) a rotating disk indicator; (2) a pulse output (visible or infrared), or (3) an electrical pulse (in the form of a closure relay or an electronic means), which provides a pulse with Kt or Kh Watt-Hours per pulse. The value of Kt or Kh shall be such that the NUEMS's accuracy can be tested in 5 minutes or less for any specific test.

**S.1.3.3. Segments.** – A segmented digital indicating element shall have an easily accessible provision for checking that all segments are operational.

**S.1.3.4. Real-time Indicating Element.** – If the indicating element is not on continuously, it shall be accumulated continuously so that real-time measurement is indicated during activation.

**S.1.3.5. Multiple Loads, Single Indicating Element.** – A primary indicating, or combination indicating-recording element coupled to two or more loads shall be provided with a means to easily, clearly, and definitely display information from a selected load and shall automatically indicate which load is associated with the currently displayed information.

**S.1.3.6. NUEMS With a Register Ratio.** – For NUEMS with a register ratio, the register ratio shall be indicated on the front of the registers that are not an integral part of the NUEMS nameplate. Means shall be provided for the tenant to read the register.

## S.2. Design of Measuring Elements and Measuring Systems.

**S.2.1. Metrological Components.** – A NUEMS shall be designed and constructed so that metrological components are adequately protected from environmental conditions likely to be detrimental to accuracy based on the specified installation locations for the NUEMS:

**S.2.2. Provision for Sealing.** – Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that undetected access to metrologically

significant mechanisms and parameters is prevented. Specifically, after sealing no adjustment or change may be made to:

(a) any measuring element;

(b) any metrological parameter that affects the metrological integrity of the device or system; and

(c) any wiring connection which affects the measurement.

When applicable, any adjusting mechanism shall be readily accessible for purposes of affixing a security seal. Audit trails shall use the format set forth in Table S.2.2. Categories of Device and Methods of Sealing.

**Table S.2.2.**
**Categories of Device and Methods of Sealing**

| Categories of Device | Method of Sealing |
|---|---|
| **Category 1:** No remote configuration capability. | Seal by physical seal or two event counters: one for calibration parameters and one for configuration parameters. |
| **Category 2:** Remote configuration capability, but access is controlled by physical hardware. | The device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode or shall not operate while in this mode. The hardware enabling access for remote communication must be on-site. The hardware must be sealed using a physical seal or an event counter for calibration parameters and an event counter for configuration parameters. The event counters may be located either at the individual measuring device or at the system controller; however, an adequate number of counters must be provided to monitor the calibration and configuration parameters of the individual devices at a location. If the counters are located in the system controller rather than at the individual device, means must be provided to generate a hard copy of the information. |
| **Category 3:** Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).<br><br>The device shall clearly indicate that it is in the remote configuration mode and record such message or shall not accumulate kWh while in this mode. | An event logger is required in the device; it must include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter. A printed copy of the information must be available through the device or through another on-site device. The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1000 records are required. (Note: Does not require 1000 changes to be stored for each parameter.) |

**S.2.3. NUEMS Watthour Registration Retention.** – The NUEMS shall retain the total accumulated watthour registration and shall not be affected by electrical, mechanical or temperature variations, radio-frequency interference, power failure, or any other environmental influences to the extent that accuracy is impaired. This also applies to other billable quantities.

**S.3. Markings.** – The following identification and marking requirements are in addition to the requirements of Section 1.10 General Code, paragraph G-S.1. Identification.

**S.3.1. Location of Marking Information.** – The marking information may be placed either internally or externally (as specified in paragraphs S.3.2. Device Identification and Marking Requirements and S.3.3. Device Identification and Marking Requirements – External Sensors and in the associated tables) provided.

(a) the information is permanent and easily read; and accessible for inspection;

(b) the information is on a portion of the device that cannot be readily removed or interchanged (e.g., not on a service access panel). A readily removable cover is an acceptable location for the required information provided: (1) the information is permanently marked elsewhere on the device or is readily accessible through other means such as through an electronic marking display; or (2) a unique marking on the removable cover can be matched with what is programmed into or permanently marked on the ES NUEMS body, thus linking that marking (and any other markings) included on the cover with that specific device; and

(c) accessing the information does not require accessing an area with live exposed voltages greater than 40 V.

The use of a key or tool to access internal marking information is permitted for retail electricity-measuring devices. Where possible, clear covers should be used to enable viewing of internally marked information.

**S.3.2. Device Identification and Marking Requirements.** – In addition to all the marking requirements of Section 1.10 General Code, paragraph G-S.1. Identification, each device shall have the following information conspicuously, legibly, and indelibly marked on the nameplate or register.

**S.3.2.1. Device Identification and Marking Requirements, Internal Sensor (IS) NUEMS.** – Device Identification and Marking Requirements, Internal Sensor (IS) NUEMS. – The following markings shall be physically marked on an Internal Sensor (IS) NUEMS.

(a) AC voltage range or rating in VAC;

(b) Watthour constant ($K_h$) or Watthour test constant ($K_t$);

(c) Register ratio ($R_r$) for NUEMS with a rotating disc and multiplier (if greater than one) preceded by "multiply by" or "mult by";

(d) Number of wires (W);

(e) Form designation (FM) (for A-base and socket NUEMS only); and

(f) Current Class (CL).

**S.3.2.2. Device Identification and Marking Requirements of External Sensor (ES) NUEMS.** – In addition to the identification requirements specified in Section 1.10 General Code, paragraph G-S.1. Identification, External Sensor (ES) NUEMS shall have the following legibly, and indelibly marked on the ES NUEMS body as shown in:

- Tables S.3.2.2.a. Device Identification and Marking Requirements for External Sensor (ES) NUEMS; and

- Table S.3.2.2.b. Descriptors for Table S.3.2.2.a. Device Identification and Marking Requirements - External Sensor (ES) NUEMS.

**Table S.3.2.2.a.**
**Device Identification and Marking Requirements for External Sensor (ES) NUEMS**

| | Physical Marking | Electronic Marking Display*, ** |
|---|---|---|
| Manufacturer or Distributor name, initials, or trademark (1) | R | D |
| Model Prefix (2) | O | D |
| Model (3) | R | D |
| Serial Number Prefix (4) | O | D |
| Serial Number (5) | R | D |
| NTEP CC Number with Prefix (6) | R | D |
| *NUEMS Voltage Input Rating (7)* *[Nonretroactive as of January 1, 2024]* | O | D |
| *Voltage Sensor Rating (8)* *[Nonretroactive as of January 1, 2024]* | O | D |
| *Voltage Sensor Ratio (9)* *[Nonretroactive as of January 1, 2024]* | O | D |
| *NUEMS Current Input Rating (10)* *[Nonretroactive as of January 1, 2024]* | O | D |
| *Sensor Primary Current Rating (11)* *[Nonretroactive as of January 1, 2024]* | O | D |
| *Sensor True Ratio* (12) *[Nonretroactive as of January 1, 2024]* | O | D |
| $K_h$ or $K_t$ (13) | O | D |
| Sensor Input Polarity (14) | R | -- |
| Bi-directional (15) | O | D |
| Temperature Range if narrower than −20 °C to + 50 °C (− 4 °F to + 122 °F) (16) | O | D |

R Required to be marked on the NUEMS
O Required to be marked on the NUEMS only if information is not available on a display
D Alternate when information is not marked physically on the NUEMS. If device identification and markings are provided on an electronic marking display, then all fields must be provided.

*"Electronic Marking Display" includes, but is not limited to, displays of the required marking information through a NUEMS display or other secondary display connected to the NUEMS. If the information is provided via a secondary display then the display shall be provided by the device owner/operator as specified in UR.2.4.7. Devices for Viewing Marking Information Provided Via an Electronic Marking Display, External Sensor (ES) NUEMS. Also see S.3.4. Electronic Marking Display Security Protocol.

**Instructions on how to view required markings shall be marked on the device or provided in the NTEP CC.

General:

- Numbers appearing in parentheses (e.g., (1)) following each marking requirement above correspond to numbered descriptors in Table S.3.2.2.b. Descriptors for Table S.3.2.2.a. Device Identification and Marking Requirements - External Sensor (ES) NUEMS.
- For requirements and details on application, see Table S.3.2.2.b. Descriptors for Table S.3.2.2.a Device Identification and Marking Requirements - External Sensor (ES) NUEMS.

**Table S.3.2.2.b.**
**Descriptors for Table S.3.2.2.a Device Identification and Marking Requirements - External Sensor (ES) NUEMS**

1. Manufacturer's Identification. Marked per General Code paragraph G-S.1. Identification.

2. Manufacturer's Model Prefix. For an External Sensor (ES) NUEMS having its NTEP number clearly identified, conspicuously and indelibly marked on the ES NUEMS body, where the NTEP certificate contains the complete marking details (including a description of the location and purpose of specific markings), the associated NUEMS is not required to be physically marked per General Code paragraph G-S.1. Identification (b)(1).

3. Manufacturer's Model Identifier. Also see General Code paragraph G-S.1. Identification.

4. Serial Number Prefix. For an External Sensor (ES) NUEMS having its NTEP number clearly identified, conspicuously and indelibly marked on the ES NUEMS body, where the NTEP certificate contains the complete marking details (including a description of the location and purpose of specific markings), the associated NUEMS is not required to be physically marked per General Code paragraph G-S.1. Identification (c)(1).

5. Serial Number. Also see General Code paragraph G-S.1. Identification.

6. NTEP Certificate of Conformance Number and Prefix. Marked per General Code paragraph G-S.1. Identification.

*7. NUEMS Voltage Input Rating (V). The nominal voltage input(s) for the voltage channel of the ES NUEMS body (e.g.,* 120VAC, *600VAC, 120-480VAC, etc.). Multiple forms of the term such as "Rated Voltage," "Max Voltage," and "Reference Voltage" are permitted.*

*[Nonretroactive as of January 1, 2024]*

*8. Voltage Sensor Rating ($V_{nom}$). The nominal input at the voltage sensor. If a voltage sensor is not used this marking* is *not required. If a voltage sensor is used, a multiplier can be used in place of $V_{nom}$ and voltage sensor ratio. The Voltage Sensor Rating shall be prefaced with the abbreviation "$V_{nom}$".*

*[Nonretroactive as of January 1, 2024]*

*9. Voltage Sensor Ratio ($V_{rat}$). Ratio of sensor primary voltage to sensor output voltage. If a voltage sensor is not* used *this marking is not required. If a voltage sensor is used, a multiplier can be used in place of $V_{nom}$ and voltage sensor ratio. The Voltage Sensor Ratio shall be prefaced with the abbreviation "$V_{rat}$".*

*[Nonretroactive as of January 1, 2024]*

Example of Voltage Sensor Ratio Marking:
480V:120V

*10.* NUEMS *Current Input Rating ($I_{nom}$ ). The nominal current or voltage input for the current channel of the ES NUEMS body. The NUEMS Current Input Rating shall be prefaced with the abbreviation "$I_{nom}$".*

*The output of the current sensor must match the input configuration of the ES NUEMS body. This is determined by dividing Sensor Primary Current Rating (11) by the True Ratio (12). The computed quotient must match the NUEMS Current Input Rating (10).*

*[Nonretroactive as of January 1, 2024]*

Example 1:

Sensor Primary Current Rating = 200A

| **Table S.3.2.2.b.<br>Descriptors for Table S.3.2.2.a Device Identification and Marking Requirements - External Sensor (ES) NUEMS** |
|---|
| True Ratio = 100A:5A<br>Calculation: (200A) ÷ (100A/5A) = (200A) ÷ (20) = 10A<br><br>Example 2:<br>Sensor Primary Current Rating = 200A<br>True Ratio = 400A:0.3V<br>Calculation: (200A) ÷ (400A/0.3V) = (200A) * (0.3V/400A) = 60W/400A = 0.15V<br>NOTE: W=Watts=Amperes*Volts |
| *11. Sensor Primary Current Rating ($SI_{nom}$). The nominal current input through the sensor. The Sensor Primary Current Rating shall be prefaced with the abbreviation "$SI_{nom}$".*<br>*[Nonretroactive as of January 1, 2024]* |
| *12. Current Sensor Ratio. The ratio of sensor primary amperes to sensor output amperes or volts shall be physically marked on a NUEMS unless it is displayed electronically. This is to be expressed as xxxA:yyyA or xxxA:yyyV. The number of digits is the number needed to express the values. The Current Sensor Ratio must match the marked ratio of the sensor as required in Table S.3.3.a.*<br>*[Nonretroactive as of January 1, 2024]*<br><br>Examples of current sensor ratio markings include:<br>200A:5A<br>400A:0.3V |
| 13. Kh or Kt. Watthour constant or watthour test constant. |
| 14. Sensor Input Polarity. Sensor input connection with intended polarity shall be physically marked on the NUEMS when direction-sensitive. |
| 15. Bi-Directional. A NUEMS equipped to register the accumulation of energy in both directions (i.e., for delivered and received energy). |
| 16. Temperature Range if Narrower Than − 20 °C to + 50 °C (− 4 °F to + 122 °F): If the device is rated for use over a range that is narrower than and within − 20 °C to + 50 °C (− 4 °F to + 122 °F), this must be physically and/or electronically marked. |

**S.3.3. Device Identification and Marking Requirements – External Sensors.** – In addition to all the marking requirements of Section 1.10 General Code, paragraph G-S.1. Identification, each external sensor that is non-integral with the ES NUEMS body shall have the following conspicuously, legibly, and indelibly marked as shown in Table S.3.3.a. Device Identification and Marking Requirements – External Sensors and in Table S.3.3.b. Descriptors for Table S.3.3.a. Device Identification and Marking Requirements – External Sensors.

**Table S.3.3.a.**
**Device Identification and Marking Requirements – External Sensors**

| | Physical Marking on Sensor | Electronic Marking Display* |
|---|---|---|
| Manufacturer name, initials, trademark (1) | R | D |
| Model Prefix (2) | O | D |
| Model (3) | R | D |
| Serial Number Prefix "S/N" (4) | O | D |
| Serial Number (5) | R | D |
| *True Ratio (6)*<br>*[Nonretroactive as of January 1, 2024]* | R | D |
| Maximum Primary Current (7) | O | D |
| Rated Frequency (Hz) (8) | O | D |
| Maximum Safety Voltage Rating (9) | O | D |
| Polarity (10) | O | D |

R Required to be marked on the device
O Required to be marked on the device if information is not available on an electronic marking display
D Required when data is displayed on an electronic marking display.

*"Electronic Marking Display" includes, but is not limited to, displays of the required marking information through a NUEMS display or other secondary display connected to the NUEMS. If the information is provided via a secondary display then the display shall be provided by the device owner/operator as specified in UR.2.4.7. Devices for Viewing Marking Information Provided Via an Electronic Marking Display, External Sensor (ES) NUEMS. Also see S.3.4. Electronic Marking Display Security Protocol.

**Notes:**

- Numbers appearing in parentheses (e.g., (1)) following each marking requirement above correspond to numbered descriptors in Table S.3.3.b. Descriptors for Table S.3.3.a. Device Identification and Marking Requirements - External Sensors.
- For requirements and details on application, see Table S.3.3.b. Descriptors for Table S.3.3.a. Device Identification and Marking Requirements - External Sensors.

| **Table S.3.3.b.**<br>**Descriptors for Table S.3.3.a. Device Identification and Marking Requirements - External Sensors** |
|---|
| 1. Manufacturer's Identification. Marked per General Code paragraph G-S.1. Identification. |
| 2. Manufacturer's Model Prefix. The General Code paragraph G-S.1. Identification (b)(1) model prefix marking requirement for the sensor(s) may be met with a physical marking. Alternatively, the marking requirement may be satisfied through an electronic display provided that the NUEMS has its NTEP number clearly identified, conspicuously and indelibly marked on the ES NUEMS body, where the NTEP certificate contains the complete marking details (including a description of the location and purpose of specific markings). |
| 3. Manufacturer's Model. Also see General Code paragraph G-S.1. Identification. |
| 4. Serial Number Prefix. For a NUEMS having its NTEP number clearly identified, conspicuously and indelibly marked on the sensor(s), where the NTEP certificate contains the complete marking details (including a description of the location and purpose of specific markings), the associated sensor is not required to meet General Code paragraph G-S.1. Identification (c)(1). |
| 5. Serial Number. Also see General Code paragraph G-S.1. Identification. |
| *6. Voltage* Sensor *Ratio or Current Sensor Ratio. The ratio, in primary amperes or volts to secondary amperes or volts shall be physically marked on each sensor. This is to be expressed as xxxA:yyyA; or xxxA:yyyV; or xxxV:yyyV. The number of digits is the number needed to express the values.*<br>*[Nonretroactive as of January 1, 2024]*<br><br>Examples of current sensor ratio markings include:<br>200A:5A<br>400A:0.3V<br><br>Examples of voltage sensor ratio markings include:<br>480V:120V |
| 7. Maximum Primary Current. The maximum primary current at which the sensor can be safely and accurately operated. |
| 8. Rated Frequency. A sensor shall be marked with its rated frequency if other than 40Hz to 400Hz. |
| 9. Maximum Safe Operating Voltage. A sensor shall be marked with a Maximum Safe Operating Voltage if it is less than 600VAC.<br>Example of sensor maximum safe operating voltage ratings:<br>• 250 Vac<br>• 250 VAC<br>• 50 V<br>Note: The maximum safe operating voltage rating marking may not be higher than the voltage to which the device was verified during type evaluation. |
| 10. Polarity Marking. The sensor shall be marked to indicate proper orientation when the accuracy of the NUEMS is affected by orientation. |

**S.3.4. Electronic Marking Display Security Protocol.** – If an Electronic Marking Display is used as described in Table S.3.2.2.a. and Table S.3.3.a. protocols shall be in place to prevent tampering with the displayed markings and/or data.

**S.3.5. Abbreviations and Symbols.** – When using abbreviations or symbols on an ES NUEMS body, sensor, or indicator, the following shall be used.

| Symbol | Description |
|---|---|
| AC | Alternating Current (i.e., VAC) |
| Cl | Class |
| FM | Form |
| Hz | Hertz, Frequency or Cycles Per Second |
| $I_{nom}$ | NUEMS Current Input Rating |
| $K_h$ | Watthour Constant; Revolution or Pulse |
| $K_t$ | Watthour Test Constant |
| kWh | Kilowatt-hour |
| Rr | Register Ratio |
| $SI_{nom}$ | Sensor Primary Current Rating |
| TA | Test Amperes |
| V | Volts |
| $V_{nom}$ | Voltage Sensor Rating |
| $V_{rat}$ | Voltage Sensor Ratio |
| W | Wire (example 240V 3W) |
| Wh | Watthour |

**S.3.6. Abbreviations and Symbols.** – These are abbreviations that may occur but are not required to be used or limited to the listed abbreviations.

| Symbol | Description |
|---|---|
| Δ | Delta Power Supply |
| B | Burden |
| BIL | Basic Lightning Impulse Insulation Factor |
| IEEE | Institute of Electrical and Electronics Engineers |
| Mult By | Multiply By |
| PD | Printable Data |
| PTR | Potential Transformer Ratio (Same as VTR) |
| SD | Soft Data |
| VTR | Voltage Transformer Ratio |
| Y | WYE Power Supply |

## N. Notes

**N.1. NUEMS No-Load Test.** – A NUEMS no-load test shall be conducted by applying rated voltage to the NUEMS under test and no current load applied. This test shall be conducted during type evaluation and may be conducted during field testing as deemed necessary. The test duration shall be ten minutes.

**N.2. NUEMS Starting Load Test.** – A NUEMS starting load test shall be conducted by applying rated voltage at a load of 0.25% of the Current Class (CL) or the Sensor Primary Current Rating at unity power factor. The test shall be conducted during type evaluation and may be conducted during field testing as deemed necessary.

**N.3. NUEMS Minimum Test Duration.** – A NUEMS full load test shall consist of a minimum of 10 Kt or Kh output indications and a light load test shall consist of a minimum of one Kh or Kt output indication.

**N.4. NUEMS Test Loads.**

(a) Internal Sensor (IS) NUEMS shall be balanced-load tested, and may be single-element tested, for NUEMS accuracy at full and light loads.

(b) External Sensor (ES) NUEMS shall be single-element tested for system accuracy at full and light loads. NUEMS testing shall be accomplished by applying the test load to the sensor(s) with the voltage circuits energized. When it is not feasible to test the system by injecting a primary current, testing using customer load shall be sufficient for field verification.

(c) The reference voltage phases (A, B, or C) at the NUEMS shall be the same phase as the load.

**N.5. Test of a NUEMS.**

(a) The test load applied for a full load test shall be 15 % of either the Current Class (CL) or the Sensor Primary Current Rating.

(b) The test load applied for a light load test shall be conducted at 1.5 % to 3 % of either the Current Class (CL) or the Sensor Primary Current Rating.

(c) The test load applied for a full load test of a NUEMS for a 0.5 power factor lagging setting shall be 15 % of either the Current Class (CL) or the Sensor Primary Current Rating. This test shall be conducted during type evaluation and may be conducted during in-service (field) or laboratory testing as deemed necessary.

(d) The test load applied for a light load test for a 0.5 power factor lagging setting shall be conducted at 3 % to 6 % of either the Class (CL) or the Sensor Primary Current Rating. This test shall be conducted during type evaluation and may be conducted during in-service (field) or laboratory testing as deemed necessary.

(e) All tests shall be made at the rated voltage ± 10 %.

**N.6. Repeatability Tests.** – When conducted, tests for repeatability shall include a minimum of three consecutive tests at the same load, similar time period, etc. and be conducted under conditions where variations in factors are reduced to minimize the effect on the results obtained.

## T. Tolerances

**T.1. Tolerances, General.**

(a) The tolerances apply equally to errors of underregistration and errors of overregistration.

(b) The tolerances apply to all electric energy measured at any load within the rated measuring range of the device.

(c) Where sensors or other components are used, the provisions of this section shall apply to the entire NUEMS.

**T.2. No-Load Test.** – A NUEMS shall not indicate more than one $K_t$ or $K_h$.

**T.3. NUEMS Starting Load Test.** – The $K_t$ or $K_h$ output indications shall continue to advance. The purpose of this section is to verify that the NUEMS accumulates energy at the starting load.



**T.4. Load Test Tolerances.** – Tolerances for NUEMS shall be as shown in Table T.4. Tolerances for NUEMS. When it is not feasible to test the system by injecting a primary current, tolerances specified under "Tests Conducted at 0.5 Lagging Power Factor" shall apply.

**Table T.4.**
**Tolerances for NUEMS**

| | Tests Conducted at Unity Power Factor | Tests Conducted at 0.5 Lagging Power Factor |
|---|---|---|
| Acceptance Tolerances | 1.0 % | 2.0 % |
| Maintenance Tolerance | 2.0 % | 3.0 % |

**T.5. Repeatability** . – When multiple load tests are conducted at the same load condition, the range of the load test results shall not exceed 25 % of the absolute value of the maintenance tolerance and the results of each test shall be within the applicable tolerance.

## UR. User Requirements

**UR.1. Selection Requirements.**

**UR.1.1. Customer Indicating Element, Accessibility.** – For systems in which the primary indicating element is not reasonably accessible to the customer, one of the following shall be provided.

(a) Console display which is accessible to the customer on which the customer can unambiguously select the NUEMS output associated with this load.

(b) Remote display which is provided to customer as a part of the system.

(c) At the option of the customer, an application that provides readings in real time.

**UR.1.2. NUEMS Required.** – When a tenant is not directly served by the serving utility, and charges for electric energy are not included in the fixed periodic rent charges, a dedicated NUEMS that measures only the energy used at the discretion of the tenant shall be used.

**UR.1.3. Suitability of Equipment.** – A NUEMS shall be suitable for use on its electrical system.

**UR.1.3.1. Service Applications**. – A NUEMS shall accurately measure all loads 5 percent or greater of the electric service capacity of the tenant. Service capacity shall be determined by the master thermal overload protectors to the tenants' service or by the rated capacity of the wiring and its circuits used to provide power from the service panel to the tenant.

$$Annual\ Max = \sum_{phases} \left[\frac{Phase\ Voltage * Current\ Class}{1000}\right] * Hours\ per\ Year$$

**NOTE:** Current Class is equivalent to Sensor Primary Current Rating.

**UR.1.3.2. Quantity-Value Division.** – The configured quantity-value division shall not exceed the minimum increment to be used in billing.

**UR.1.4. Sensors.** – Each sensor output shall be correctly matched to the corresponding ES NUEMS body input.

**UR.2. Installation Requirements.**

**UR.2.1. Manufacturer's Instructions.** – A device shall be installed in accordance with the manufacturer's instructions, and the installation shall be sufficiently secure and rigid to maintain this condition.

**UR.2.2. Load Range.** – A device shall be installed so that the current and voltage will not exceed the maximum continuous ratings of the NUEMS. If necessary, means to limit current and/or voltage shall be incorporated in the installation.

**UR.2.3. Regulation Conflicts and Permit Compliance.** – If f any provision of this section (UR.2. Installation Requirements) is less stringent than that required of a similar installation by the National Electrical Code®, as amended and adopted by the Local Authority having Jurisdiction, the installation shall be in accordance with the National Electric Code.

The installer of any new NUEMS service shall obtain all necessary permits and shall conform to all applicable regulations.

**UR.2.4. NUEMS Installation Requirements.**

**UR.2.4.1. Certification.** – It is the responsibility of the owner of a NUEMS to obtain written approval for each metered load service from the serving utility, public utility commission, or other entity with jurisdiction over electric utilities in the location the NUEMS is to be installed.

The required approval shall meet the requirements of that entity and shall identify the address, space, or number, of the premise served by the NUEMS connection; be signed by an agency representative; and shall clearly state the:

- the installation meets all installation and accessibility requirements for similar installation governed by the presiding entity.
- installation is on a tariff schedule that qualifies for electric meter use,
- billing format, rates, and charges conform to all applicable tariff rules,
- date of such determination, and
- designee's name and title if performed by a designee, and the name and title of the presiding entity authorizing the designee to make the determination.

The approval shall be provided to the local Weights & Measures authority prior to a NUEMS being used for commercial purposes.

**UR.2.4.2. NUEMS Test Features.** – All NUEMS shall be provided with test features to facilitate common tests methods used in the electrical submetering industry.

**UR.2.4.3. Safety Mechanism.** – NUEMS installations that are equipped with current sensors with a current output that is not self-limiting shall have a mechanism installed to allow the NUEMS, or its components, to be connected to or removed for safe testing without the risk of dangerous voltages that can result from secondary open circuit current sensors.

**UR.2.4.4. Metered Circuits (Submeter Load Service).** – For NUEMS with separate line and load service connections, all electricity used by a tenant shall be taken exclusively from the load service of the tenant's NUEMS. This service and its associated NUEMS shall accurately measure the tenant's load and be capable of being used only at the discretion of the tenant.

**UR.2.4.5. Dedicated Tenant NUEMS Service.** – A NUEMS shall serve only the space, lot, building, room, suite, stall, slip, or any other termed premise occupied and/or used by the tenant.

**UR.2.4.6. NUEMS Tenant Premise Identification.** – Tenant premise identification shall be clearly and permanently shown on or at the NUEMS, and on all separate components of a NUEMS, including, but not limited to, current sensor(s), modem(s), and transmitter(s) if equipped. Remote indications and all printed indications shall be readily identifiable and readily associated with the tenant's premise. Printed indications shall also include time and date information. For field configured systems the information shall be after actual configuration is established.

**UR.2.4.7. Devices for Viewing Marking Information Provided Via an Electronic Marking Display, External Sensor (ES) NUEMS.** – When required markings are provided via an electronic display the owner/operator of the NUEMS is responsible for providing means for viewing this information on the site at the time of inspection or on request. See also Table S.3.2.2.a. Device Identification and Marking Requirements for External Sensor (ES) NUEMS.

**UR.2.4.8. External Sensors and Test Output.** – The NUEMS shall be installed in such a way that the test output and external sensors are both located within proximity of each other which will allow for testing by a single inspector from a reasonable test position.

**UR.3. Use of Device.**

**UR.3.1. Recorded Representations.** – A record, either printed or electronic, providing the following information on electrical energy usage shall be available at the end of the billable interval:

(a) the total quantity of the energy delivered with unit of measure;

(b) the total computed price of the energy sale;

(c) the unit price of the energy.

For systems capable of applying multiple unit prices for energy during the billable interval, the following additional information is required:

(1) A schedule of the rate time periods and the unit price applied for each;

(2) the total quantity of energy delivered during each;

(3) the total purchase price for the quantity of energy delivered during each rate time period.

**UR.4. Submitting a NUEMS for Testing.** – Each NUEMS Submitted for inspection shall have all necessary components assembled, connected, and configured as intended for use. Components may include, but are not limited to, the ES NUEMS body, sensor(s), indicator(s), etc.".

# Appendix D. Definitions

**The following definitions are proposed for addition to NIST Handbook 44 Appendix D, Definitions at the time when the status of this Tentative Code is changed from "tentative" to "permanent." Until such time that the status of the code is designated as "permanent," these proposed definitions will remain in this section of the Tentative Code.**

**The specific code to which the definition applies is shown in [brackets] at the end of the definition. Definitions for the General Code [1.10] apply to all codes in Handbook 44.**

## A

**active energy.** – The integral of active power with respect to time. Typically measured in units of kilowatt-hours (kWh), or watt-hours.

$$E(T) = \int_0^T v(t) \cdot i(t) \cdot dt \qquad \textit{Eq. 1}$$

Where T is much greater than the period of the AC line frequency. [3.41]

**alternating current (AC).** – An electric current that reverses direction in a circuit at regular intervals. [3.40, 3.41]

**ampere.** – The practical unit of electric current. It is the quantity of current caused to flow by a potential difference of one volt through a resistance of one ohm. One ampere is equal to the flow of one coulomb of charge per second. One coulomb is the unit of electric charge equal in magnitude to the charge of 6.24 x $10^{18}$ electrons. [3.40, 3.41]

**audit trail.** – An electronic count and/or information record of the changes to the values of the calibration or configuration parameters of a device. [1.10, 2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 5.54, 5.56(a), 5.58]
(Added 1993)

## B

**balanced load.** – Balanced load is used to indicate equal currents in all phases and relatively equal voltages between phases and between each phase and neutral (if one exists); with approximately equal watts in each phase of the load. [3.41]

**basic lightning impulse insulation level (BIL).** – A specific insulation level expressed in kilovolts of the crest value of a standard lightning impulse. (Example: BIL = 10 Kv) [3.41]

**bidirectional.** – A NUEMS equipped to register the accummulation of energy in both directions (i.e., for delivered and received energy. A bidirectional NUEMS shall fall into at least one of the following categories:

(a) Single register or net meter that displays the difference between the delivered and received energy; or

(b) Separate register(s) for delivered or received. [3.41]

**burden (B).** – The impedance of the circuit connected to the instrument transformer's secondary winding. (Example: B = 21 Ohms Max) [3.41]

## C

**calibration parameter.** – Any adjustable parameter that can affect measurement or performance accuracy and, due to its nature, needs to be updated on an ongoing basis to maintain device accuracy, e.g., span adjustments, linearization factors, and coarse zero adjustments. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 5.54, 5.56(a), 5.58]

(Added 1993)

**configuration parameter.** – Any adjustable or selectable parameter for a device feature that can affect the accuracy of a transaction or can significantly increase the potential for fraudulent use of the device and, due to its nature, needs to be updated only during device installation or upon replacement of a component, e.g., division value (increment), sensor range, and units of measurement. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 5.54, 5.56(a), 5.58]

(Added 1993)

**current.** – The rate of the flow of electrical charge past any one point in a circuit. The unit of measurement is amperes or coulombs per second. [3.40, 3.41]

**current class (CL).** – For self-contained meters, the manufacturer's designated maximum rated current a NUEMS can measure continuously without damage and without exceeding limits of accuracy. (Example: CL 200) [3.41]

**current sensor.** – A device able to measure and output analog or digital representations of one or more currents. Examples of current sensors are current transformers, low-voltage current transducers, and Rogowski coils. [3.41]

## E

**electronic marking display.** – A device used for the electronic visual presentation of marking requirements. [3.41]

**element.** – A combination of a voltage-sensing unit and a current-sensing unit, which provides an output proportional to the quantities measured. Meters can include multiple elements based on service type. For mechanical meters, this is also referred to as a "stator." *(OWM is seeking written permission from National Electrical Manufacturers Association (NEMA) to reprint . Oral permission was received.)* [3.41]

**energy flow.** – The flow of energy between line and load terminals (conductors) of a NUEMS. Flow from the line to the load terminals is considered energy delivered. Energy flowing in the opposite direction (i.e., from the load to line terminals) is considered as energy received. [3.41]

**equipment, commercial.** – Weights, measures, and weighing and measuring devices, instruments, elements, and systems or portion thereof, used or employed in establishing the measurement or in computing any basic charge or payment for services rendered on the basis of weight or measure. As used in this definition, measurement includes the determination of size, quantity, value, extent, area, composition (limited to meat and poultry), constituent value (for grain), or measurement of quantities, things, produce, or articles for distribution or consumption, purchased, offered, or submitted for sale, hire, or award. [1.10, 2.20, 2.21, 2.22, 2.24, 3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 4.40, 5.51, 5.56(a), 5.56(b), 5.57, 5.58, 5.59]

(Added 2008)

**ES NUEMS body.** – The element of the NUEMS that calculates the electricity usage using the signals from the external sensor. [3.41]

**external sensor.** – Any voltage sensor or current sensor not located inside of the meter body NUEMS itself and not inside the sealed enclosure containing the NUEMS. [3.41]

**event counter.** – A nonresettable counter that increments once each time the mode that permits changes to sealable parameters is entered and one or more changes are made to sealable calibration or configuration parameters of a

device. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 5.54, 5.56(a), 5.56(b), 5.57, 5.58]
(Added 1993)

**event logger.** – A form of audit trail containing a series of records where each record contains the number from the event counter corresponding to the change to a sealable parameter, the identification of the parameter that was changed, the time and date when the parameter was changed, and the new value of the parameter. [2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 5.54, 5.56(a), 5.56(b), 5.57, 5.58]
(Added 1993)

## F

**form designation (FM).** – An alphanumeric designation denoting the circuit arrangement for which the NUEMS is applicable and its specific terminal arrangement. The same designation is applicable to equivalent NUEMS for all manufacturers. (Example: FM 2S) [3.41]

## H

**hertz (Hz).** – Frequency or cycles per second. One cycle of an alternating current or voltage is one complete set of positive and negative values of the current or voltage. [3.40, 3.41]
(Added 2022)

## I

**internal sensor.** – Any voltage sensor or current sensor located inside of the meter body NUEMS itself or inside the sealed enclosure containing the NUEMS. [3.41]

## K

**kilowatt (kW).** – A unit of power equal to 1,000 watts. [3.40, 3.41]
(Added 2022)

**kilowatt-hour (kWh).** – A unit of energy equal to 1,000 watthours. [3.40, 3.41]
(Added 2022)

## L

**line service.** – The service terminals or conductors connecting the (NUEMS) to the power source. [3.41]

**load service.** – The service terminals or conductors connecting the (NUEMS) to the electrical load (e.g., vehicle, tenant, etc.). [3.41]

**load, full.** – A test condition with rated voltage, current at 100% of test amps level, and power factor of 1.0. [3.40, 3.41]
(Added 2022)

**load, light.** – A test condition with rated voltage, current at 10% of test amps level, and power factor of 1.0. [3.40, 3.41]
(Added 2022)

## M

**master meter, electric.** – A (NUEMS) owned, maintained, and used for commercial billing purposes by the serving utility. All the electric energy served to a submetered service system is recorded by the master meter. [3.41]

**meter, self-contained.** – A meter in which the terminals are arranged for connection to the circuit being measured without using external instrument transformers. [3.41]

**metrological components. –** Elements or features of a measurement device or system that perform the measurement process or that may affect the final quantity determination or resulting price determinations. This includes accessories that can affect the validity of transactions based upon the measurement process. The measurement process includes determination of quantities; the transmission, processing, storage, or other corrections or adjustments of measurement data or values; and the indication or recording of measurement values or other derived values such as price or worth or charges. [3.40, 3.41]

(Added 2022)

## N

**nominal current.** – The manufacturer's designated maximum rated current a NUEMS can measure continously without damage and without exceeding limits of accuracy. [3.41]

**nominal voltage.** – The manufacturer's designated maximum rated voltage a NUEMS can measure continously without damage and without exceeding limits of accuracy. [3.41]

**non-integral.** – Used to describe external sensors that can be disconnected from the meter body. [3.41]

**non-utility electricity measuring system (NUEMS).** – An electricity measuring system comprised of all the metrologically relevant components required to measure electrical energy, store the result, and report the result used in non-utility sales of electricity wherein the sale is based in whole or in part on one or more measured. [3.41]

## O

**ohm.** – The practical unit of electric resistance that allows one ampere of current to flow when the impressed potential is one volt. [3.40, 3.41]

(Added 2022)

## P

**percent error.** – Percent error is calculated as follows:

percent error = (NUEMS reading – standard reading)/standard reading x 100

[3.41]

**power factor (PF).** – The ratio of "active power" to "apparent power" in an AC circuit. It describes the efficient use of available power. [3.40, 3.41]

(Added 2022)

**primary indicating or recording elements.** – The term "primary" is applied to those principal indicating (visual) elements and recording elements that are designed to, or may, be used by the operator in the normal commercial use of a device. The term "primary" is applied to any element or elements that may be the determining factor in arriving at the sale representation when the device is used commercially. (Examples of primary elements are the visual indicators for meters or scales not equipped with ticket printers or other recording elements and both the visual indicators and the ticket printers or other recording elements for meters or scales so equipped.) The term "primary"

is not applied to such auxiliary elements as, for example, the totalizing register or predetermined-stop mechanism on a meter or the means for producing a running record of successive weighing operations, these elements being supplementary to those that are the determining factors in sales representations of individual deliveries or weights. (Also see "indicating element" and "recording element.") [1.10, 3.40, 3.41]

**R**

**reactive power.** – For sinusoidal quantities in a two-wire circuit, reactive power is the product of the voltage, the current, and the sine of the phase angle between them, using the current as the reference. [3.41]

**register ratio ($R_r$).** – The number of revolutions of the gear meshing with the worm or pinion on the rotor shaft per complete rotation of the fastest (most sensitive) wheel or dial pointer. [3.41]

**remote configuration capability.** – The ability to adjust a weighing or measuring device or change its sealable parameters from or through some other device that is not itself necessary to the operation of the weighing or measuring device or is not a permanent part of that device.[2.20, 2.21, 2.24, 3.30, 3.31, 3.32, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, 5.54, 5.56(a), 5.58]

(Added 1993)

**retail device.** – A measuring device primarily used to measure product for the purpose of sale to the end user. [3.30, 3.32, 3.37, 3.39, 3.40, 3.41]

(Amended 1987, 2004, 2019, and 2022)

**S**

**sensor ratio.** – The stated ratio of the primary circuit current or voltage compared to the secondary circuit current or voltage. (Example: CSR = 200 : 0.1) [3.41]

**serving utility.** – The utility distribution company that owns the master meter and sells electric energy to the owner of a submeter system. [3.40, 3.41]

(Added 2022)

**starting load.** – The minimum load above which the device will indicate energy flow continuously. [3.40, 3.41]

(Added 2022)

**submeter.** – A meter or meter system downstream of the electric master meter. [3.40, 3.41]

(Added 2022)

**T**

**tenant.** – The person or persons served electric energy from a non-utility electricity-measuring system (NUEMS). [3.41]

**test amperes (TA).** – The full load current (amperage) specified by the device manufacturer for testing and calibration adjustment. (Example: TA 30). [3.40, 3.41]

(Added 2022)

**thermal overload protector.** – A circuit breaker or fuse that automatically limits the maximum current in a circuit. [3.40, 3.41]

(Added 2022)

**U**

**unit price.** – The price at which the product is being sold and expressed in whole units of measurement. [1.10, 2.20, 3.30, 3.31, 3.32, 3.37, 3.39, 3.40, 3.41]

(Added 1992)

**utility.** – A corporation, person, agency, authority, or other legal entity or instrumentality aligned with distribution facilities for delivery of electric energy for use primarily by the public. Included are investor-owned electric utilities, municipal and State utilities, Federal electric utilities, and rural electric cooperatives. A few entities that are tariff based and corporately aligned with companies that own distribution facilities are also included.

A list of recognized utilities in the U.S. can be found at the U.S. Energy Information Administration (EIA) at: **https://www.eia.gov/electricity/data/eia861** [3.41]

**V**

**volt.** – The practical unit of electromotive force. One volt will cause one ampere to flow when impressed across a resistance of one ohm. [3.40, 3.41]

(Added 2022)

**W**

**watt.** – The practical unit of electric power. In an alternating-current circuit (AC), the power in watts is volts times amperes multiplied by the circuit power factor. [3.40, 3.41]

(Added 2022)

**watthour (Wh).** – The practical unit of electric energy, which is expended in one hour when the average power consumed during the hour is one watt. [3.40, 3.41]

(Added 2022)

**watthour constant ($K_h$).** – The expression of the relationship between the energy applied to the meter and the output indication, expressed as "watthours per revolution" or "watthours per output indication." [3.41]

**watthour test constant ($K_t$).** – The expression of the relationship between the energy applied to the meter and the output indication, expressed as "watthours per output indication," when the meter is in test mode [3.41]