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ANSI C12.1 Overview and Intro to Meter Testing

Pennsylvania Rural Electric Association

PREA

March 4, 2025 11:15 AM – 12:30 PM

Tom Lawton and Perry Lawton

ANSI

- American National Standard Institute, Inc.
  - Not a government agency
  - Standards do not have force of Law
  - All compliance is voluntary
  - ANSI generates standards through the use of a sponsoring organization called the “secretariat” who actually publishes the Standard.
    - For C12.1 NEMA (National Electrical Manufacturer’s Association) is the secretariat.
    - NEMA has seven sections one of which is for Utility Products and Systems. All meter manufacturer’s and manufacturer’s involved in electric metering are members of NEMA or are eligible to be members.
    - Paul Orr has been the NEMA’s secretary assigned to C12 for over ten years providing continuity to the process. NEMA Manufacturing members determine which efforts will be funded and which will not be funded.

ANSI (CONT.)

- American National Standard Institute, Inc.
  - NEMA organizes committees to propose and review standards
  - Standards are republished approximately every five (5) years and abandoned if not updated or reaffirmed once every ten (10) years.
  - Standards codify consensus approaches in common practice
  - In recent years the ANSI committee has had to deal with breaking new ground as well as several controversial issues
    - This is unusual for the committee and the committee has responded by no longer being reluctant to address them, staying more on point during contentious debates, and moving through the work required in a far more efficient manner. Another example of how AMI is changing everything in our industry.

ANSI C12

- All ANSI Standards related to Electric Metering are in the ANSI C12 group of Standards
- C12 Main Committee
  - General makeup has expanded slightly over last few years
  - 30 voting members with representation from three groups (no one group can have more than 40%):
    - 12 - Manufacturers: Meter, Socket, Test Equipment, etc.
    - 10 - Users: Utilities
    - 8 - General Interest: PUC, UL, IEEE, Consultants, etc.
  - Meets twice a year in conjunction with EEI/AEIC Meter conference.

ANSI C12 (CONT.)

- C12 Main Committee
  - Has final approval for all activities on any C12 family standard
  - Establishes Subcommittees (SC) and Working Groups (WG) to address various standards and issues
  - Sub committees and Working Groups also meet twice a year in conjunction with EEI Transmission, Distribution and Metering Conference and also hold regular or ad hoc conference calls throughout the year as members put together drafts and other technical material for consideration at the next face to face meeting.

ANSI C12 (CONT.)

- C12 Subcommittees
  - Various subcommittees have been organized to review specific standards
  - This is where the work is really done
  - Each operates slightly differently
  - Each meets on a schedule of its own choosing
  - Most meet at EEI Biannual Transmission, Distribution and Metering Meetings
  - Communication WG meets more often and longer
  - Various subgroups meet frequently by teleconference

ANSI Standards Related to Electric Metering

ANSI C12 Standards Status – April 2019					
Designation	Final Action Date	Title	Responsible Subcommittee	Responsible NEMA Section	Project Action
ANSI C12.1-2014	2/1/2016	Electricity Metering, Code for	SC 1	8EI - 1TC	Published 3-30-16
ANSI C12.4-1984 (R2002, R2011)	5/19/2011	Registers, Mechanical Demand	SC 1	8EI – 1TC	Reaffirmed. Published Jan. 6, 2012 *Reaffirm or Revise?
ANSI C12.5-1978 (R2002, R2012)	5/19/2011	Meters, Thermal Demand	SC 1	8EI –1TC	Reaffirmed. Published Oct. 25, 2012 *Reaffirm or Revise?
ANSI C12.6-1987 (R2016)	01/12/17	Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals for	SC 15	8EI – 3TC	Published Jan 10, 2018
ANSI C12.7-2005 (R2014)	8/14/14	Requirements for Watthour Meter Sockets	SC 15	8EI – 3TC	Approved August 14, 2014 Published Feb. 23, 2015
ANSI C12.8-1981 (R2012)	5/19/2011	Watthour Meters, Test Blocks and Cabinets for Installation of Self-Contained “A” Base	SC 15	8EI – 3TC	Published Dec. 18, 2012 *Reaffirm or Revise? 2 – year BSR-11 Extension request submitted to ANSI Plan to have C12.8 withdrawn after figure needed from C12.8 is placed in C12.7.
ANSI C12.9-2014	9/17/14	Test Switches for Transformer-Rated Meters	SC 15	8EI – 3TC	Approved on Sept. 17, 2014 Published Mar. 12, 2015
ANSI C12.10-2011	6/28/2011	Physical Aspects of Watthour Meters – Safety Standard	SC 1	8EI –1TC	Approved June 28, 2011 Published Oct 2011. Revisions in discussion Meter Safety WG BSR 11 Extension until Mar 2020

ANSI Standards Related to Electric Metering (cont.)

ANSI C12.11-2006 (R2014)	5/27/14	Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)	SC 15	8EI – 2TC (work completed by 8EI-3TC)	Approved May 27, 2014 Published July 29, 2014. *Reviewing started April 2016
ANSI C12.14-1982 (R1993)	8/14/2002	Electricity Meters, Magnetic Tape Pulse Recorders for	SC 1	8EI –1TC	Withdrawn 2002
ANSI C12.17-1991	8/14/2002	Cartridge-Type Solid-State Pulse Recorder for Electricity Metering	SC 1	8EI –1TC	Withdrawn 2002
ANSI C12.18-2006 (R2016)	3/16/17	Protocol Specification for ANSI Type 2 Optical Port	SC 17 WG4	8EI –1TC	Reaffirmation Approved by ANSI BSR on 8-23-16 Published 3-16-17
ANSI C12.19-2012	10/2/14	Utility Industry End Device Data Tables	SC 17 WG2	8EI –1TC	Published May 6, 2015 SC17 WG2 Draft Revision In Progress
ANSI C12.20-2015	1/24/17	0.1, 0.2 and 0.5 Accuracy Class	SC 20 Formerly SC16	8EI –1TC	ANSI Approved 1/24/17 Published April 27, 2017
ANSI C12.21-2006 (R2016)	3/27/17	Protocol Specification for Telephone Modem Communication	SC 17 WG4	8EI –1TC	Revise/reaffirm 2011 Updated (BSR 11 Extension to 2016) Action* BSR 8 PR filed 5-27-16 Reaffirmation Approved by ANSI BSR on 8-23-16 Published 3-27-17
ANSI C12.22-2012	1/9/09	Protocol Specification for Interfacing to Data Communication Networks	SC 17 WG1	8EI –1TC	BSR 9 Submitted March 29, 2015 Published July 15, 2015
ANSI C12.23-201X	On hold	AMR Device Compliance Test Standards	SC 17 WG3	8EI –1TC	MOU signed – Work on hold as of spring 2015
ANSI Registered C12.24 TR -2011	May 29, 2011	Definitions for Calculations of VA, VAh, VAR, and VARh for Poly-Phase Electricity Meters	SC20 & SC24	8EI-1TC	Published Oct 2011. (Reaffirm or revise – in REVIEW 4/16) Submit BSR-11 Extension filed 10/2016 (ext. not needed for TR)

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ANSI Standards Related to Electric Metering (cont.)

~~ANSI C12.25 (Placeholder)~~	~~Discussion~~	In Service Performance	~~SC 25 Lawton~~	~~8EI-1TC~~	~~Drafting Requirements. May be revision to existing ANSI Std~~ Included in C12.1 now
ANSI C12.26 (Placeholder)		Communication Interface Module	SC17	8EI-1TC	Inactive
ANSI C12.27 (Placeholder)		Meter Upgradeability	SC27	8EI-1 TC	Project on hold as of Fall 2014
ANSI C12.29 (Placeholder)		Field Testing of Metering Sites	SC29 Hardy	8EI-1TC	Discussion Phase -Working Group Active
ANSI Registered C12.30 TR	In progress	Test Requirements for: Metering Devices Equipped with Service Switches	SC1	8EI-1TC	Technical Report NEMA C&S approved. Registered February 16, 2014.
ANSI C12.31 (Placeholder)	New SC	VA Standard Subcommittee	SC 31	8EI-1TC	C12SC31 Formed St. Louis Oct 2014
ANSI C12.46 (Placeholder)	New SC	OIML	SC46	8EI-1TC	Developing Draft
C12-IEC 62056-5-3 ED3		ELECTRICITY METERING DATA EXCHANGE - THE DLMS/COSEM SUITE - Part 5-3:DLMS/COSEM application layer	USNC TC 13/C12	8EI-1TC	PINS filled April 2018 Passed Ballot. In comment resolution.
C12-IEC 62056-6-1 ED3		ELECTRICITY METERING DATA EXCHANGE - THE DLMS/COSEM SUITE - Part 6-1: Object Identification System (OBIS)	USNC TC 13/C12	8EI-1TC	PINS filled April 2018 Passed Ballot. In comment resolution.
C12-IEC 62056-6-2 ED3		ELECTRICITY METERING DATA EXCHANGE - THE DLMS/COSEM SUITE - Part 6-2: COSEM interface classes	USNC TC 13/C12	8EI-1TC	PINS filled April 2018 Passed Ballot. In comment resolution.

ANSI Standards Related to Electric Metering (cont.)

C12-IEC TS 62056-8-20 ED 1.0		ELECTRICITY METERING DATA EXCHANGE - THE DLMS/COSEM SUITE - Part 8-20: Mesh communication profile for neighborhood networks,	USNC TC 13/C12	8EI-1TC	PINS filled April 2018 Passed Ballot. In comment resolution.
C12-IEC 62056-9-7 ED 1.0		ELECTRICITY METERING DATA EXCHANGE – Communication profile for TCP-UDP/IP networks	USNC TC 13/C12	8EI-1	PINS filled April 2018 Passed Ballot. In comment resolution.

ANSI C12 – SUB-COMMITTEES

Sub-Committee	Standards
C12 SC1	C12.1, C12.4, C12.5, C12.10
C12 SC15	C12.6, C12.7, C12.8, C12.9, C12.11
C12 SC16	C12.20, C12.24
C12 SC17	C12.18, C12.19, C12.21, C12.22, C12.23, C12.26
C12 SC29	C12.29 Standard for Field Testing of Metering Sites
C12 SC31	C12.31 VA Measurement Standard
C12 SC46	C12.46 American National Standard for Electricity Meters - 0.1, 0.2 and 0.5 Accuracy Classes for the Measurement of Active, Apparent and Reactive Power

ANSI C12 SC 1 (CONT.)

- C12.1 Code for Electricity Metering - Sub Committee Work
  - Demand Type Test working group – they are grappling with the reckoning of time for type testing. Demand type testing has never been defined to everyone's satisfaction (meter manufacturers and Utilities).
  - Working Group formed on creating a Standards Road map as some groups are languishing while others are moving ahead at full speed and we are not releasing everything we need as quickly as we need them.
  - C12.10 is being converted into a Stand alone safety document. This was going to be withdrawn in favor of UL 2735 that was to be drafted jointly by ANSI and UL. Instead UL created their own. Later an agreement was reached that UL 2735C would be drafted jointly and then once released would also become the new UL 2735. There are still over 70 comments to resolve in the updated 2735 so this is expected to take several more years. C12.10 should be ready as a standalone safety standard by 2020 (several drawings are being updated, then need to be reviewed and balloted)

ANSI C12 SC 1 (CONT.)

- C12.1 – Code for Electricity Metering Sub Committee Work
  - Temperature Rise working group. This was created several years ago to understand what level of temperature rise is to be expected in a meter and can be withstood by a meter and for what period of time. This goes back to hot sockets and their effect on meters. A great deal of data has been generated, L+G is leading this effort. The working group has agreed that based on this data and testing set up they are now need to develop a generic meter box that is not vendor specific that all meter manufacturer's can use to generate data that can be compared to each other and to the standard. This will hopefully be ready by the next meeting (Spring 2020, Orlando FL) and initial data presented.
  - In Service Testing Working group.
    - Provide guidance on the use of backdoor meters. Proposed and passed new wording to allow this but to still maintain a statistical comparison of back door meters with pre-selected meters.

ANSI C12 SC 1 (CONT.)

- C12.1 – Code for Electricity Metering Sub Committee Work
  - In Service Testing Working group (cont.)
    - Use of attributes vs variables for electronic meters given their non-normal test distribution. Proposed and passed wording to use only attribute testing for sample testing electronic meters. Also proposed and passed a fifth option for failed groups – performing a second tightened test on the group to confirm the initial results
    - Provide guidance on how best to set up an in-service test plan after an AMI deployment. Proposed a method where AMI analytics can be used in lieu of a test plan provided that a base line is statistically established showing that the analytics are not missing any unanticipated types of failures. Reworking and re-submitting with presentations by three utilities on how they have statistically been checking this methodology in parallel to their in service plans for several years.

ANSI C12 SC15

- C12.7 – Requirements for Watthour Meter Sockets
  - Working on the tolerance build up between fixed blade meter blades and fixed meter socket locations and how to prevent incompatibilities going forward
  - Incorporating Figure 4 from C12.8
- C12.8 – Test Block and Cabinets for Installation of Self contained “A” Base Watthour Meters
  - Published without change Dec 2012
  - Will be deprecated once Figure 4 is moved to C12.7 in its next release

ANSI C12 SC17

- C12.22 – Protocol Specification for Interfacing to Data Communication Networks
  - Last version is from 2012 but was actually published in 2015. This will be re-affirmed with editorial comments. Should be balloted shortly.

ANSI C12 SC20

- Sub Committee on Blondel Compliant Metering
  - There has been a great deal of discussion about Blondel Compliant Metering at ANSI.
    - L+G is proposing a way to modify 2S meters to allow them to act as a 12S and become Blondel Compliant
    - Discussion about the economical practicality of retrofitting 2S cabinets to be 12S cabinets
    - Discussion on providing guidance to recommend that utilities allow only 12S sockets going forward
    - NOTE: Table 2 was updated and Table 2A was added to the latest revision of ANSI C12.20 - 0.1, 0.2 and 0.5 Accuracy Class Metering to clearly list which meter forms and applications were Blondel Compliant and which were not.

ANSI C12 SC20 (CONT.)

- Sub Committee on Blondel Compliant Metering
  - Working group agreed on
    - the temperature range that the meters will operate in
    - Cleared up some ambiguity in the testing of the meters relative to the reference meters
    - Agreed that the standard would be revised and clearly stated that this is for type testing only
    - Still working on the voltage range over which the meters will remain accurate
    - Expecting to wrap up all work for the April meeting so this can be included in the next publication of C12.1 which is expected to be published by the end of 2020.

Working Group to Merge C12.1 and C12.20

- Determined that there is no longer a need for two standards as this is has now proven to become confusing at best and contradictory at worst.
  - This has proven to be a huge undertaking as many issues have been uncovered through this detailed editorial revision of both standards line by line

Working Group to Merge C12.1 and C12.20 (cont.)

- The work has progressed extremely fast (under a year and a half) and is expected to be ready for balloting in April and should be published later in 2020 or 2021 depending on type testing issues such as (cont.);
  - Disturbances test for memory corruption due to rapid power cycling such as during dropout/reclosure events
  - Extended temperature operating ranges
  - True poly phase loading
  - Harmonics testing
  - Auxiliary device influences (requiring accuracy testing with any communication devices active)
  - Voltage range to be accurate over
  - Temperature range to be accurate over

ANSI C12 SC29

- Field Testing of Metering Installations for Accuracy
  - This will be published as a Technical Report
  - After being released and receiving comments some version of this is expected to be worked into Section 5 of ANSI C12.1 in the 2025 to 2026 time frame (next revision after the one being worked on).
  - This Technical Report is more stringent than what is presently in the standard so the reception by utilities to this is mixed at this time, some welcoming the additional guidance and some not welcoming the additional guidance.

ANSI C12 SC29 (CONT.)

- Field Testing of Metering Installations for Accuracy
  - The Technical Report will provide some guidance on acceptable testing under all three types of field testing and what to look for if the installation fails accuracy testing. The three modes of testing defined are;
    - Voltage and current supplied by test equipment
    - Site voltage, equipment provided current
    - Site voltage and current (customer load)
  - This will not be an ANSI Standard at this time but only a Technical Report that Utilities may use at their own discretion. Would not carry the force of law if a Utility commission pointed to ANSI C12 as their default Code for Electricity in their State

ANSI C12 SC31

VA and VAR Metering Standard

- Establish a legal definition for VA and VAR
- VA being addressed first in order to “Fast Track” the result.
  - Definitions agreed upon
  - Initial draft completed
- Discussion about L+G’s proposal of using “source VA” vs Vector VA and Arithmetic VA and the actual load the customer has
- There is future potential to promote VA and active energy (watts) as the primary metering quantities, but even if this were to gain traction this would be in the relatively distant future. However once ANSI can agree on the definition to use for VA this will become a metering option with some revenue implications, even if this is simply used to point out metering issues at particular customer locations.

ANSI C12.46

- Sub-Committee to Develop a Replacement for C12.1 and C12.20
  - Adopts the structure of OIML IR-46
  - Addresses Active, Reactive, and Apparent Energy as well as all meter accuracy classes
  - Same group working on the merger of C12.1 and C12.20 is working on this
  - Expected Publication 2020 or 2021

ANSI C12.46 (CONT.)

- Sub-Committee to Develop a Replacement for C12.1 and C12.20 (cont.)
  - At times the R46 tests are being used as they are close to the ANSI tests. There are ANSI C12.1 and C12.20 tests that are not in R46 so they are being added. This will make the new C12.46 and the new C12.1 (merged C12.1 and C12.20) compatible clearing the way for C12.46 to eventually become the new C12.1 and make the United States compliant with our OIML Standards commitments.
  - The Roadmap working group will develop a time line for C12.46 to supersede C12.1

ANSI C12.DC SC 32

- Sub-Committee to Develop an ANSI Standard for DC Metering
  - This is becoming more an more of an issue as DC Superchargers, although relatively small in number are drawing significant amounts of power
  - There is also the potential to use nothing but DC in residential homes in the not so distant future

ANSI Sub-Metering Working Group

- Sub-Metering is also becoming more prevalent and with the official acceptance of sub-metering the need to provide guidance on this area has become necessary
- Working on guaranteeing the system level accuracy given the preponderance of different equipment.
- Regulators want to know how you test these meters and installations
  - One difficulty is that the transformers may be located many floors away from the meter.
  - Another is that the meter may be installed within the power lines and not readily accessible.
- There are few actual metrology issues

IEEE P1704 – Utility Industry End Device Communications Module

- ANSI also maintains a presence and contributes to Standards that are related to but not covered entirely within the ANSI C12.1 purview.
- This standard will provide a method for providing space for communication modules and USB as the connection method to the Comm module from the meter (vs. RJ11). Micro B USB 2.0 adapter.
- This standard is in editorial and then will go to balloting. The Standard should be published late next year (2020).

OIML R46

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

- The International Organization of Legal Metrology was formed in 1955. By Treaty 86% of the world's population is covered and 96% of the world's economy.
- The Group works with the International Bureau of Weights and Measures and the International Organization for Standardization (ISO) to ensure compatibility between each organizations work.
- Once again this organization has no legal authority to impose solutions on the members but the recommendations are typically used by the member states as part of their own domestic law.

OIML R46 (CONT.)

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

- Latest meeting was held in Europe this past May.
- ANSI voted to have a representative from NIST lead the delegation and TESCO's CTO emeritus Bill Hardy to go as the technical liaison as he is heading or an active participant in each of the relevant working groups for ANSI
- They did not get through the entire document to resolve differences but they made continued progress.
- There will be more sub groups to work on this and there will be another meeting in 2Q 2020 most likely.
- They will work on Electric Vehicles as one of the sub groups.
- There is also a new standard D31 to cover how software verification is done on a wide array of items including electric meters. R46 will need to reference how we comply with D31 going forward.

Metrology

- The science of measurement
- Ensures that commerce and trade is fair and accurate
- Process relies on **standards** and traceability to the SI

Reference Standards

- Measurement Device
- Higher accuracy class than the DUT
- Traceability path to a national lab and SI

NIST and SI

- NIST – National Institute of Standards and Technology
- Division of the Commerce Department
- Gaithersburg VA (near DC)
- House and maintain “THE volt” and “THE ohm”

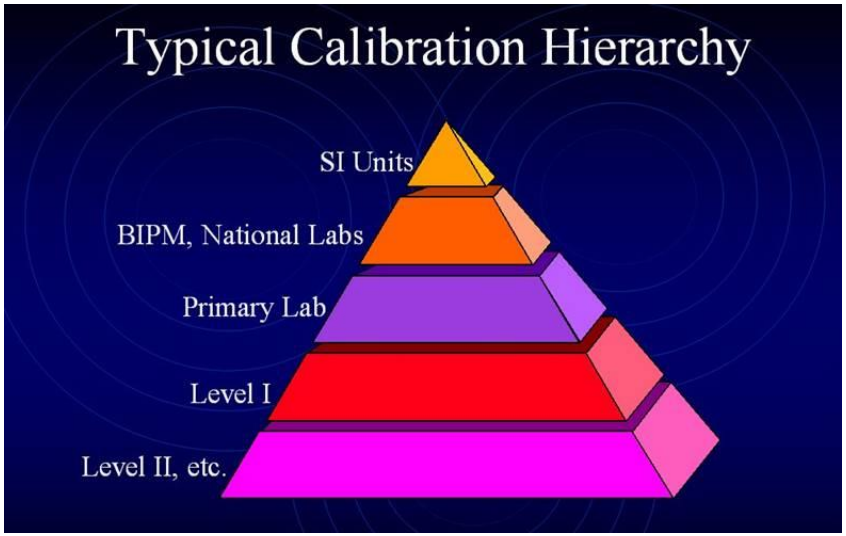
NIST
National Institute of
Standards and Technology

NIST and SI

- 7 base units (meter, kilogram, second, ampere, kelvin, mole and candela) and 22 derived units. The base units are derived from constants of nature.
- Maintained by the BIPM (Bureau International des Poids et Measures – Internation Bureau of Weights and Measures) – Metre Convention 1875

NIST

NRC



PTB

NMIJ

Metrology – Apple Example

NIST TRACEABILITY PATH

Metrology – Accuracy Classes

NIST TRACEABILITY PATH

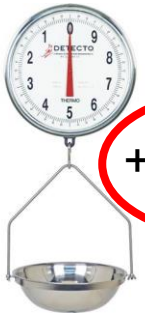
NIST

Metrology – Accuracy Ratios

NIST TRACEABILITY PATH

NIST

+/- .05LBS



+/- .2LBS

.2 : .1

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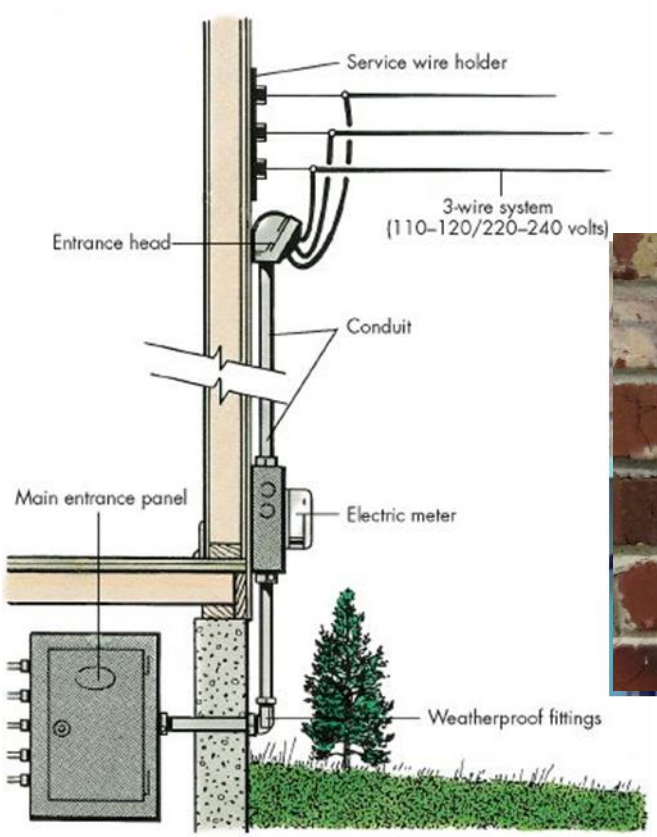
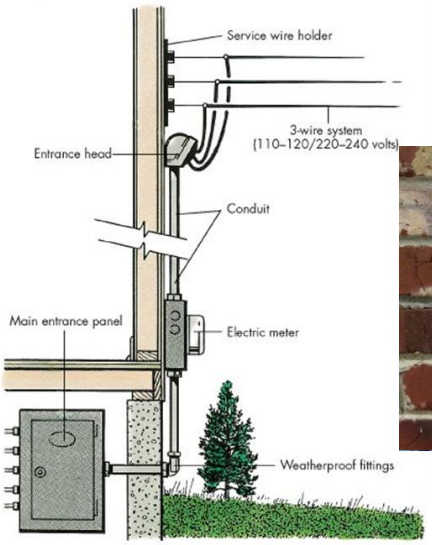
2 : 1

Accuracy Ratio

Electric Meter Testing



Electric Meter Testing



Meter Accuracy Testing – A Comparison Test

POTENTIAL SOURCE

CURRENT SOURCE

ENERGY REFERENCE STANDARD

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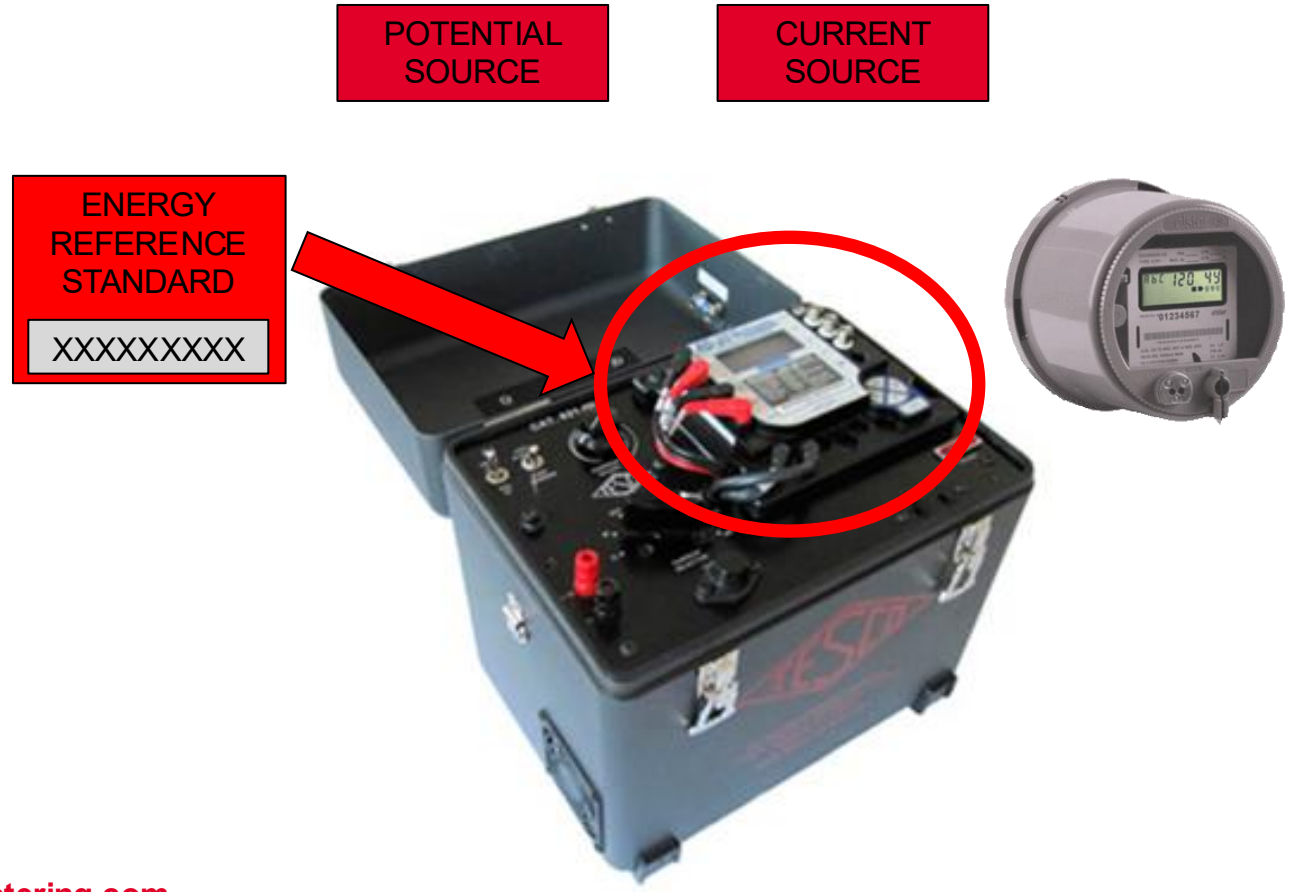
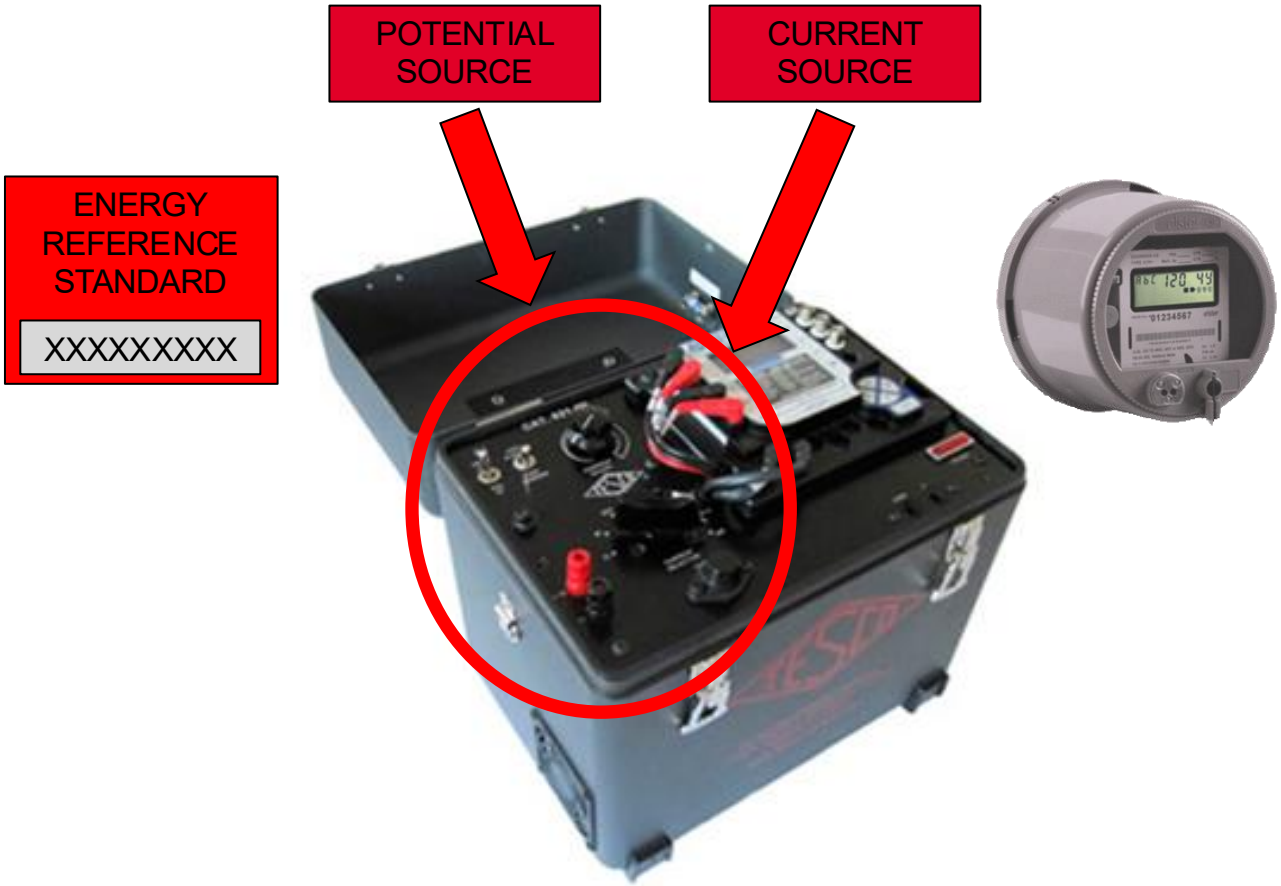
Meter Accuracy Testing – A Comparison Test



Meter Accuracy Testing – A Comparison Test



Meter Accuracy Testing – A Comparison Test

POTENTIAL SOURCE

CURRENT SOURCE

ENERGY REFERENCE STANDARD

XXXXXXXXX

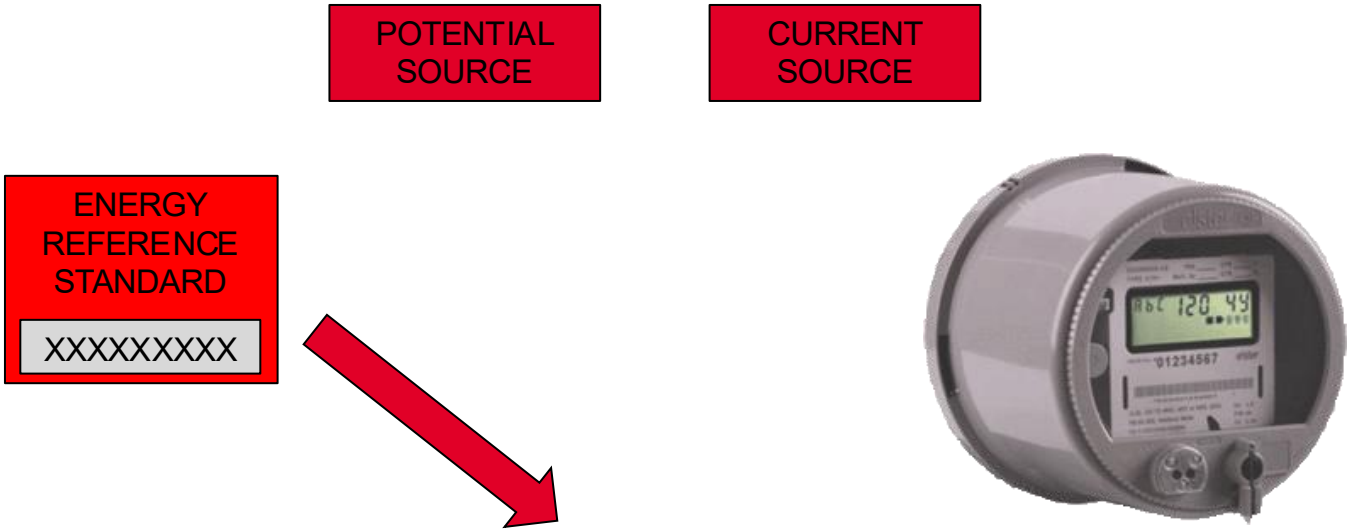
Watthour Meter

- Measures Electrical Energy (kWh)

Potential (V) * Current (I) = Power (W)

Power Over Time = Energy (kWh)

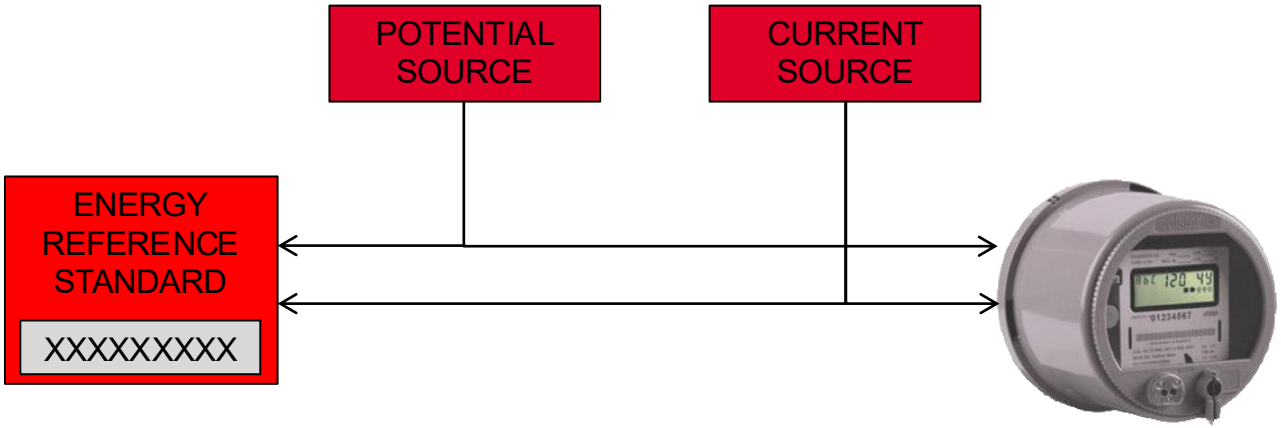
Meter Accuracy Testing – A Comparison Test



Energy Reference Standard

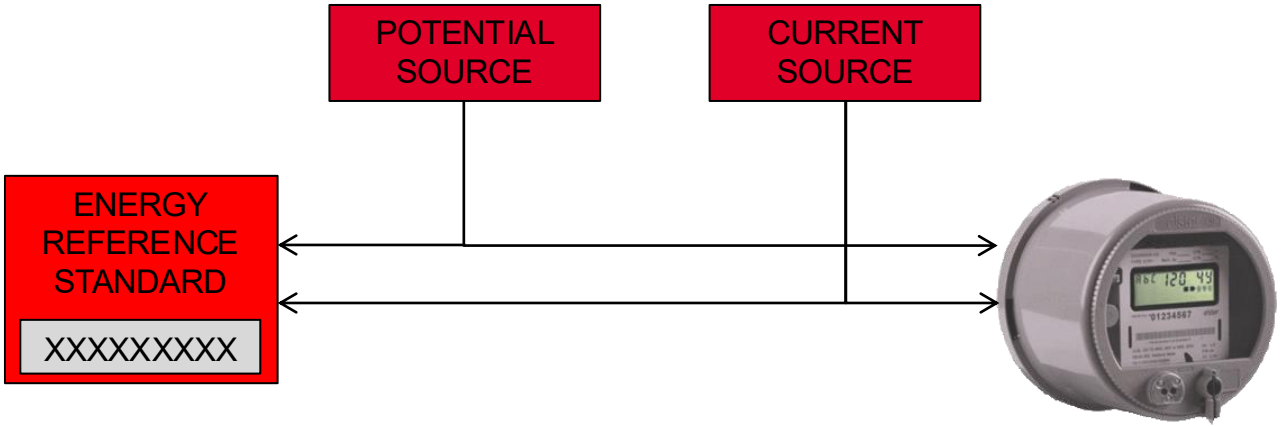
- Measures Electrical Energy (kWh)
  - Higher Accuracy Class
    - Traceability to SI

Meter Accuracy Testing – A Comparison Test



- Apply the Same Voltage and Current to the Standard and Meter for a Defined Period of Time
  - Standard and Meter Should Measure the Same Energy
    - The Difference is the Error of the Meter

Meter Accuracy Testing – A Comparison Test



Example:

Standard Registers 100kWh / Meter Registers 101.38

Then the Error of the Meter is 1.38%

Questions and Discussion

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