METERING LEADER SINCE 1904

THE EASTERN SPECIALTY COMPANY

UNDERSTANDING THE POWER MEASUREMENTS HANDBOOK

Prepared by Tom Lawton, TESCO
The Eastern Specialty Company

For Mid-South Meter School
Group 1
Monday, May 1, 2023 at 3:00 PM

A Tremendous Educational Resource

- The information found in the Power Measurements Handbook supports many presentations given at the Mid-South Meter School
- This book is a fantastic resource and will become your go-to reference source while in the field and even while in the shop
- The handbook won't replace a live instructor, but referencing the handbook will help you to recll your training in these and other meter schools.

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COURSES REFERENCED IN THE BOOK

Table of Contents

8:00am
Form Numbers and Wiring Diagrams
Keith Livesay - Morristown Utility Systems, John Turner - Appalachian Elec. Coop

Primary Metering
James Jackson - NES

Basic Vector Theory
Powermetrix

1:00pm
AC Circuit Theory
Powermetrix

1:00pm
Basic Instrument Transformer Theory
RYAN ALKIRE - GE

1:00pm
History of Metering
TESCO

10:00am
Basic Electricity
Tom Lawton - Tesco

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COURSES REFERENCED IN THE BOOK

Understanding the Rating Labels in Sockets
Milbank

Introduction to Polyphase Metering
Tom Lawton - TESCO

Instrument Transformer Accuracy Class
RyanAlkire - GE

UNDERSTANDING FORM 1S AND 2S METERS
MATT HEATH - BRIGHTRIDGE

Poly Phase Hands on Trouble Shooting Self Contained and CT Rated
NES Daniel Gilbert - Milan Public Utilities

Single Phase Hands on Trouble Shooting Self Contained and CT Rated
NES Daniel Gilbert - Milan Public Utilities

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COURSES REFERENCED IN THE BOOK

Wye Metering
Erik Larabee - Aclara

Delta Metering
Erik Larabee - Aclara

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COURSES REFERENCED IN THE BOOK

Basics of Grounding
Aclara - Dale Prashad

Testing and Maintenance of Substation Transformer
Omicron

Multi-Function and Time of Use Metering
Sensus

Recloser Control Testing
Omicron

Harmonics In Metering
Powermetrix

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METER TESTING 101

Questions to Answer

- Why do we test?
- How do we test?
- What types of meter tests are there?
- How do utility tests differ from customer request tests?
- What is In-Service Testing?
- How do we know meter tests are good?
- What do we do with the test data?

WHY DO WE TEST?

Our regulatory commissions typically require us to test meters for accuracy. Regulatory commissions typically take their lead from ANSI C12.1 American National Standard for electricity Metering.

State regulatory commissions focus on accuracy because they want electric utilities to ensure that no customer is being billed unfairly and that no subset of customers is being unfairly subsidized by the rest of the rate payers. Some states mandate only accuracy tests and others require demand and time of use accuracy tests.

Any tests beyond accuracy tests are tests that are simply good business practice.

ANSI
American National Standards Institute

FIELD TESTING

- Any testing performed in the field
- Can be performed
  - without removing the meter
  - through the use of an adapter
  - or by removing the meter and testing in a piece of field equipment or van mounted equipment with a meter socket for testing where the meter can be tested and returned to the customers socket in a minimum amount of time and without ever leaving the premises other than to return to the utility van.

COMPLAINT TESTING

Customers always have the right to request a meter test. This is a type of field testing.

Some utilities and some jurisdictions allow for testing at the customer site, others require a test in a laboratory environment.

Some allow the customer to witness the test and others require the utility commission to witness the test.

Utilities must show that the meter tests well and must demonstrate that they have a test program in place to ensure the meters in service are performing well.

General Meter Testing Requirements

- New Meters
  - Manufacturers tests
  - In-house tests on new shipments
- Return to Service Testing
- In-Service Meters
  - Periodic Tests
  - Selective, random, or statistical testing
- Retirement tests
- Testing of related metering equipment

New Meter Testing Programs

- Accept the Manufacturer's Test results
- Perform a Statistical Test of an incoming shipment
- Perform a 100% test of an incoming shipment

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RETURN TO SERVICE TESTING

- Meters to be returned to service must always (virtually every utility commission requires this) be accuracy tested before being returned to service.
- Best business practices also require that the meter is functionally tested as well.

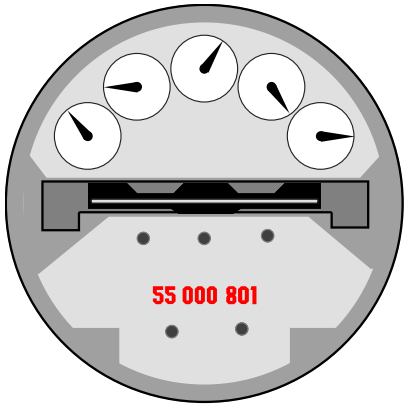
In Service Testing

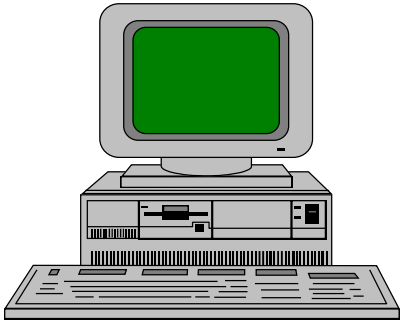
Meter Testing for new and in-service meters is specified in ANSI C12.1-2015, *American National Standard for Electric Meters, Code for Electricity Metering*. Most utility commissions use this Standard a reference or the basis for their meter testing requirements.

TEST PLANS FOR METERS

Four test plan options available:

- Periodic
- Statistical





PERIODIC TEST PLANS

- Periodic
  - Varies by State
  - Example provided by ANSI C12.1:
    - Each Electro Mechanical meter is tested once every 8 years
    - All other Meters are tested every 16 years
    - Appendix D provides details for other meters & devices
    - No guidance for AMI meters
  - Generally, average of 12.5% of population tested per year

8 Years

16 Years

STATISTICAL TEST PLANS: THE BEST APPROACH

ANSI C12.1-2001 Code for Electricity Metering Guidance

Paragraph 5.1.4.3.3 Statistical sampling plan

"The statistical sampling plan used shall conform to accepted principles of statistical sampling based on either variables or attributes methods. Meters shall be divided into homogeneous groups, such as manufacturer and manufacturer's type. The groups may be further divided into subdivision within the manufacturer's type by major design modifications."

NOTE - Examples of statistical sampling plans can be found in ANSI/ASQC Z1.9, the ANSI version of MIL-STD-414 and ANSI/ASQC Z1.4, the ANSI version of MIL-STD-105.

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WHY USE A STATISTICAL TESTING PLAN

- Focuses testing on the proper meters
- Minimizes number of meters to be tested; usually requires less than 30% of what a periodic testing plan requires
- Provides data and analysis tools for use in understanding what is happening with installed meters or for use in the purchasing of new meters

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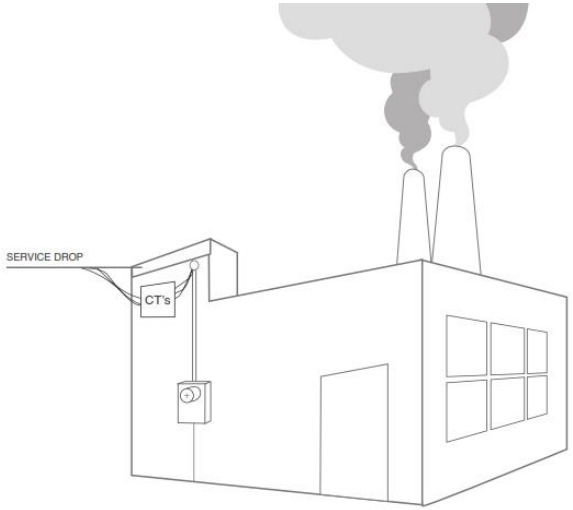
HOMOGENEOUS POPULATION(S)

- The groups or populations being sampled and tested are made up of the same or similar items, items which operate in the same way and were made in the same manner.
- For electric meters, this has traditionally been interpreted as being meters of a specific meter type from a manufacturer (i.e. AB1, J5S, MX, etc.).
- AMR & AMI programs have helped to make the overall populations more homogenous. This makes a utility with AMR & AMI meters better prepared to take advantage of a statistical sampling plan.

TESTING OF A METER VS TESTING A SITE

Test an installation and system and not just a meter!

Test programs may need to involve testing and checking the meter performance as well as checking and testing the installation. This more extensive test check list needs to be done especially for the higher revenue C&I customers.



ALWAYS TEST THE SITE AND NOT JUST THE METER

Test an installation and system and not just a meter!

But even for a residential service you are never simply doing a meter test. You are always doing a site test. Sometimes a customer complaint test is valid – but often not because the meter was bad – because the installation was bad.

What are you looking for?

- Anything out of the ordinary
  - Energy diversion
  - Corrosion or foreign material in the box
  - Broken wires
  - Loose connections
  - Worn sockets
  - Disconnect sleeves left in the box
  - Meters improperly installed
  - Incorrect meter at the site – wrong form or possibly the wrong number

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METER TESTING TRACEABILITY

- Test equipment to NIST standards
- Tracking number of meters to be tested per State Commission requirements
- Tracking meter test data
  - Meter Records
  - Meter Data Management System (MDMS)

METER TESTING TRACEABILITY

- *Traceability is defined as ability to link the results of the calibration and measurement to related standard and/or reference (preferably national or international standard) through an unbroken chain of comparisons.*

- Calibration is typically performed by measuring a test unit against a known standard or reference.

- Master standard (i.e. gages) are kept by National Measurement Institute (NMI) of each country.

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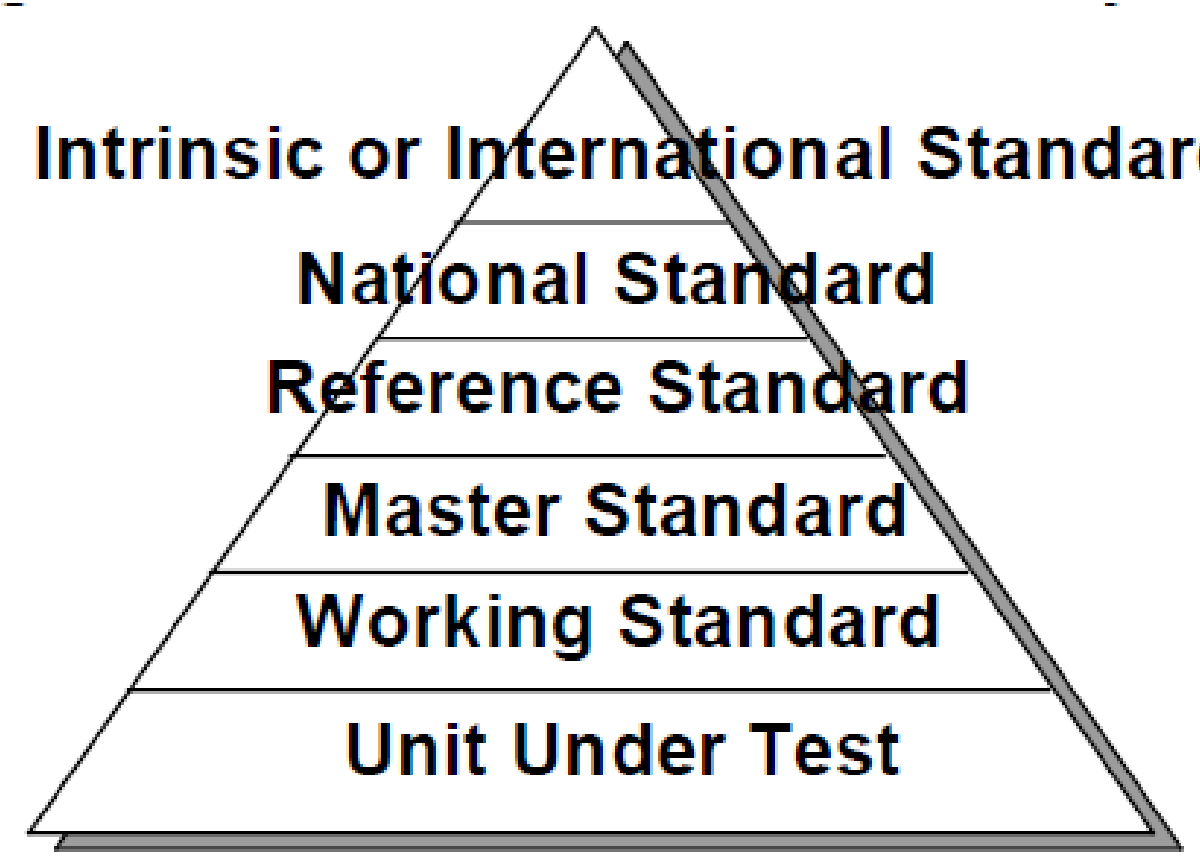
METER TESTING TRACEABILITY

- National Institute of Standards and Technology (NIST) provides internal tracking numbers, which are often used as evidence of traceability.

- **WARNING!** NIST does not certify or guarantee that calibration and measurements are correct, nor does it provide any kind of certification of accuracy and calibration. NIST only provides certifications for the work performed by them.

METER TESTING TRACEABILITY - STANDARDS



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METER TESTING TRACEABILITY - STANDARDS

- *National Standard*
  In the US, this is maintained by NIST, in Canada by NRC. Not all countries have a National Standards group and even the US does not have a group for every item of interest to an electric utility (e.g. voltage transformers)

- *Reference/Master Standard*
  Item of highest metrological quality located at a site where calibration is being conducted.

  Transfer Standard
  Lower level of Reference Standard and used for calibration of lower level calibration requirements measuring devices.

- *Working Standard*
  Lower level of Reference Standard and used for calibration of lower level calibration requirements measuring devices. Should be compared to Master Standard or Reference Standard on regular basis; used for daily checks comparisons of the calibrated devices.

TEST EQUIPMENT CALIBRATION

Primary Requirement: Traceable to NIST Standards

- Meter Test Boards, Field Test Kits calibrated to a known master standard maintained at Meter Shop.
  - ✓ Some periodicity such as monthly or quarterly
- Reference or Master standard calibrated by outside vendor traceable to NIST or directly by NIST.
  - ✓ Usually annually

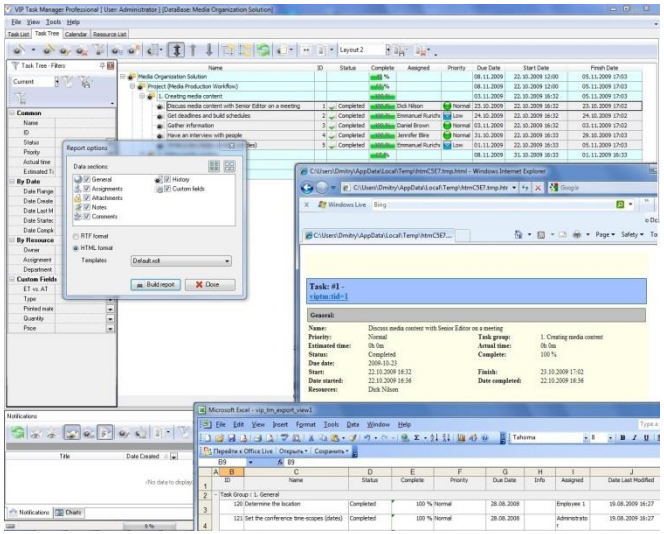
TRACKING METER RECORDS

- AMI programs help to update and overhaul meter record systems.
- Having the records for the entire meter population updated allows for a better chance that test data is available to answer questions and that any meter may be selected as part of the sample for testing.

METER TEST DATA TRACKING

Test data should be tracked throughout meter life
  – Certification testing, first article, acceptance testing, in-service (field & shop), retirement

- Meter test data should be linked to meter record data such as meter form, amps, voltage, display type, etc.
- Best time to start to develop the program is before the meters are being installed.
- Accuracy test data is usually collected automatically as new meters are tested in meter shops or cross docks.



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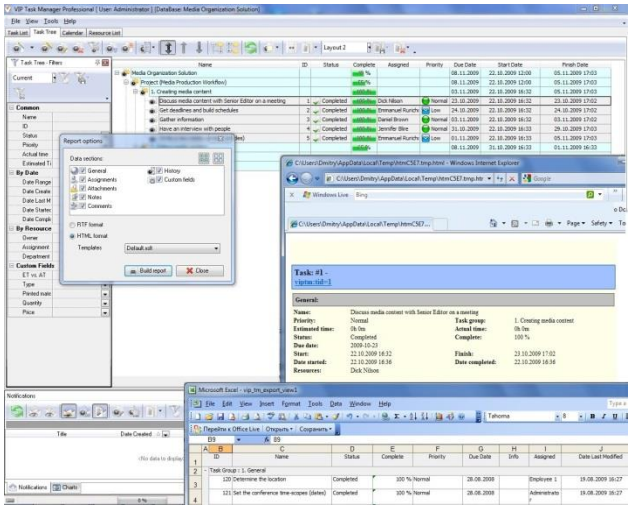
METER TEST DATA TRACKING

- Need to consider tracking non-accuracy functional testing (meter software configuration, service disconnect testing, voltage, etc.)
- Use installation reports to determine if there is any initial concerns about the meters being installed.
- Typical reports that should be available:
  - Failed Meter Report, Project to Date
  - Electric Meters on Network Report



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METER TEST DATA TRACKING SYSTEM

- System should track meter test results for ease of future reference or for response to public or Utility Commission inquiries.
- Maybe part of Meter Data Management System (MDMS) or a separate Meter Records system.
- Requires discipline in collecting & entering data, especially field tests.

QUESTIONS TO ANSWER

- Why do we test?
- How do we test?
- What types of meter tests are there?
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- What is In-Service Testing?
- How do we know meter tests are good?
- What do we do with the test data?

QUESTIONS?

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This presentation can also be found under Meter Conferences and Schools on the TESCO website:
www.tescometering.com