Meter Testing Programs & Traceability

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Session Objectives

- Understand Types of Meter Testing
- Review Categories of Meter Testing
- Review Test Plans for Meters
- Review Florida Meter Testing Requirements
- Review Why Statistical Test Plans Are Best
- Review Changes for ANSI Testing Requirements
- Review Aspects of Traceability of Meter Test Results

Program Background

Meter Testing for new and in-service meters is specified in ANSI C12.1-2008, *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.

The face of the electric meter population throughout the country and especially throughout the state of Florida is changing as are the meter testing requirements. Several AMI programs have been completed and more have started throughout the State contributing to these changes.

Types of Meter Testing

- New meters have many tests specified in ANSI C12.1 and C12.20, usually performed by the meter vendors.
- With In-service meters, mainly meter consumption accuracy
  - Maybe Full Load, Light Load, Weighted Average Accuracy
  - In the Meter Shop (periodic in service testing requirements)
  - In the Field (customer inquiries & complaints)
- With AMI/Smart Grid, must consider meter device functional testing for in-service.

Impact of AMI & AMR

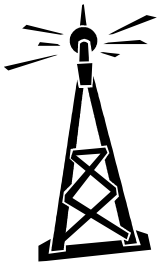
Test an installation and system and not just a meter!

Test programs for AMR & AMI systems 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.

Impact of AMI Devices

- New concept of what is a meter…<u>includes everything under the cover.</u>

- AMI communications modules and service disconnect switches.



- Need to applies sampling and testing requirements to these devices when part of the AMI meter.

Categories Of Meter Testing

- New Meters
  - Testing in the Meter Shop or Cross Dock

- In Service
  - Testing in the Meter Shop for State periodic requirements
  - Testing in the field for customer inquiries or complaints

- Retirement
  - Testing in the Meter Shop or Cross Dock

Current ANSI C12.1 Performance Requirements

ANSI C12.1-2008

American National Standard
for Electric Meters

Code for Electricity Metering

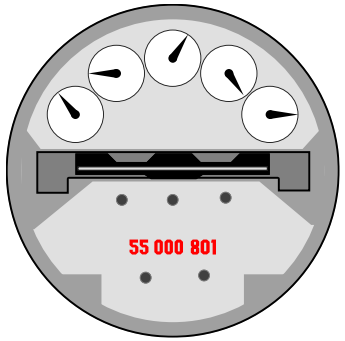
Secretariat:

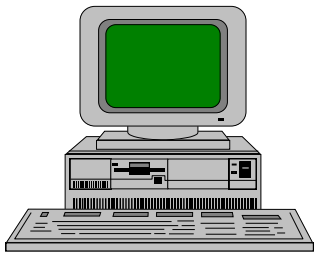
National Electrical Manufacturers Association

Approved June 27, 2008

American National Standards Institute, Inc.

Test Plans for Meters





Four test plan options available:

- Periodic
- Variable Interval
- Selective
- 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

Variable Interval Test Plans

- Variable Interval
  - Formula-based plan where percentage of meters to be tested is based on the formula. For example:

    Required Percentage = 4 + 0.133 (2X + Y)

    - X is percentage of meters tested > 102% in preceding year
    - Y is percentage of meters tested < 98% or > 102% in preceding year
    - If required percentage reaches 8%, then the meter group has to be put on a remedial action program.

Selective Test Plans

- Selective Plan
  - Not Specified In ANSI C12.1
  - Complex formula-based plan where the percentage of meters to be tested is based on one of four formulas depending on the value of X and Y. Fro example:
    - X is percentage of meters tested > 102% in preceding year
    - Y is percentage of meters tested < 98% or > 102% in preceding year
    - Minimum sample for a meter group is either 12.5% of the population or 200 meters, whichever is less.

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.

General Meter Testing Requirements

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

In-Service Testing Requirements - Nationally

- Of 51 jurisdictions (50 states and the District of Columbia):

  - 5 states mandate periodic testing and allow no alternative: AL, CO, MS, OR, & TX

  - 3 states allow for periodic testing or variable interval / selective testing but no other alternative: HI, NY, & RI

  - Of the remaining 43 jurisdictions, statistical sample testing is possible in all. Specifically:

    · 7 states normally require periodic testing but allow waivers for statistical sample testing programs: CT, DE, MO, NH, NJ, ND, & OK

    · 16 states directly allow for statistical sample testing programs, normally with pre-approval by the commission: AR, FL, IL, IN, IA, KY, ME, MI, NM, NC, PA, SC, TN, UT, WV, and WI

    · 5 states prescribe no specific plan but require an in-service testing plan to be filed with the commission: AK, AZ, MD, WA, & WY

    · 15 jurisdictions have no specific in-service testing requirements. In-service testing plans are simply incorporated into rate or tariff filings or otherwise filed with the commission: CA, DC, GA, ID, KS, LA, MA, MN, MT, NE, NV, OH, SD, VT, & VA

In-Service Testing Requirements - Nationally

- **Of states allowing for statistical sample testing:**

  - 8 specifically reference MIL-STD 414 or ANSI/ASQC Z1.9 as a suitable plan:

    FL, IL, IN, MI, TN, WA, WV, & WI

  - 8 specifically reference ANSI C12.1 or ASA C12 as the guidance for in-service testing plans:

    AZ, AR, CT, IA, NM, OH, PA, & UT

  - One state allows for statistical sample testing but only using ANSI/ASQC Z1.4: MD

  - Of the remaining 26 jurisdictions, no specific guidance is given for the choice of statistical sample testing plans:

    AK, CA, DC, DE, GA, ID, KS, KY, LA, ME, MA, MN, MO, MT, NE, NV, NH, NJ, NC, ND, OK, SC, SD, VT, VA, & WY

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.

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.

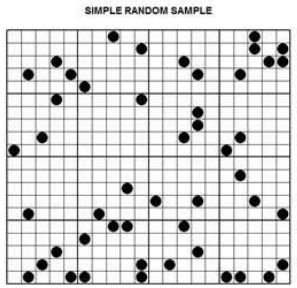
Suitably Sized Samples

- The sample size for each group must be large enough to provide a statistically valid sample or the group's population.
- The larger the group's population, the greater the savings for statistical testing over periodic testing and the more statistically reliable the testing.
- AMI implementation generally results in larger group populations. The larger the population, the more suitable for statistical testing.

Random Sample Selection

- Every item within the group or population has an equal chance of being selected as part of the sample for testing.

- Random sample selection is critical to providing for a statistically valid sample.



Population Fits the Statistical Model

- The statistical model being used for the sampling/testing plan needs to match the actual distribution of the population.
- In most circumstances, one is looking at a normal or Gaussian distribution (i.e. a Bell curve).
- This can be checked using a histogram plot and normality test. For mechanical and electromechanical meters, a normal distribution fits the actual data very well.
- For electronic or solid-state meters, the meters are highly accurate and recent analysis shows that the test data may not be normal.

Statistical Testing Plan w/ AMR & AMI

- By definition AMR & AMI meters no longer have a pair of human eyes checking the installation each month. Statistical testing allows the Utility to quickly identify which areas may have a problem.

- Potential problems that could be caught by aggressive testing.
  - A faulty batch of meters
  - Design or premature equipment failures
  - Poor installation due to a poorly trained crew
  - Location related failures
  - Energy Diversion

Statistical Sampling and Revenue Protection

- One of the significant benefits to the statistical sampling of AMR & AMI meters is the potential to spot energy diversion more readily.
- Statistical testing of meters will indicate the overall health of the meter population. Coupled with historical revenue information and meter tamper flags statistical testing can become a powerful tool for combating energy diversion.
- Utilities will be in a better position to spot trends toward energy diversion more readily and on a closer to real time basis.

Statistical Testing with AMI

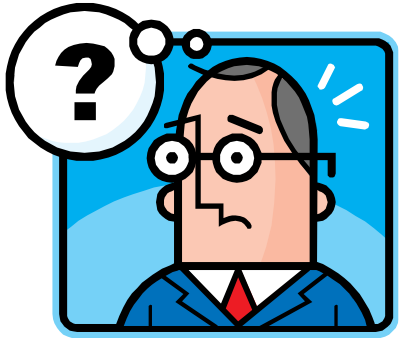
Statistical testing to monitor AMI programs will also point out

- design or manufacturing deficiencies
- installation or post-installation problems (some of which may or may not be energy diversion).

All should be pursued and the root cause understood!

Why Do All of this Testing?

Installation of AMI programs move at seemingly breakneck speeds with all focus on schedule. At the same time, problems and exceptions seem to be pouring out of the woodwork. Upper management wants to hear about project milestones and budgets and not about the problems. Especially not any publicly embarrassing problems associated with an AMI installation.



Why Do All of this Testing?

- Statistical testing will allow you to more readily identify where the problems are and where there were simply anomalies.

- The testing will help differentiate between training and equipment problems.

Why Do All of this Testing?

- The testing will also help to identify potential weak areas in the system that may bear closer scrutiny as the system goes into service

- Putting a good testing system into place during the implementation will help to keep you on schedule, on budget, and out of trouble during the installation and will ensure that there will be a good system in place with the self discipline and understanding to administer the system.

Summary

AMR & AMI provides the Utility with the opportunity to get even more and better business information from their installed meter base. Statistical Sampling of these in-service meters can help to point up deficiencies in the installed system during installation as well as shortly after system implementation.

The sampling can help to identify potential energy diversion and can help catch design inadequacies in the meters. Once a problem is identified additional statistical testing can help to zero in on a problem and help to identify potential solutions.

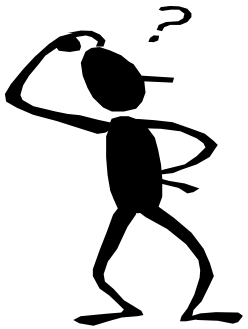
Summary

Statistically testing the installed meter population will allow the utility to more fairly meter the entire population without unfairly charging any one customer and without unfairly subsidizing any group of customers.

Statistical sampling plans are also lower cost plans to use than the traditional periodic plans.

Current ANSI C12.1 Section 5 Issues

- Acceptance testing of new meters is not mentioned.
- Statistical sampling plans are not adequately defined.
- Post deployment or performance monitoring of newly certified meters not covered.



Updating ANSI C12.1 Section 5

- Consider new meters
- Consider AMI devices

- Consider new metering device acceptance testing
- Provide definition of Statistical Sampling plans
- Consider performance monitoring of newly certified meters

Recommended Changes

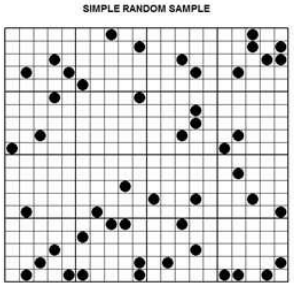
New Meters & Metering Devices

- New meters are covered by sampling and testing requirements.
- As-found, as-left, returned to service tests.
- Accuracy classes in C12.20 (0.2% and 0.5%) referenced.

Recommended Changes

Statistical Sampling Plans

- In-service statistical sampling plans should be developed using:
  - ANSI/ASQ Z1.9 Sampling Procedures and Tables for Inspection by Variables
  - ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- Provides guidance on how to handle sample failures.
- Similar to some State Commission requirements.



Recommended Changes

New Metering Device Acceptance Testing

- Sampling and testing of new meter shipments
- Uses ANSI Z1.4 (attributes) or ANSI Z1.9 (Variables) for sample size and acceptance criteria.
- Specifies an Acceptable Quality Limit (AQL) of 1% or less.

Recommended Changes

Performance Monitoring of Newly Certified Meters

- Evaluate newly certified meters after installation…. Different than in-service.

- Use statistical sampling plan.

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.

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 and the internal number does mean that the test unit calibrated is indeed valid. NIST only provides certifications for the work performed by them.

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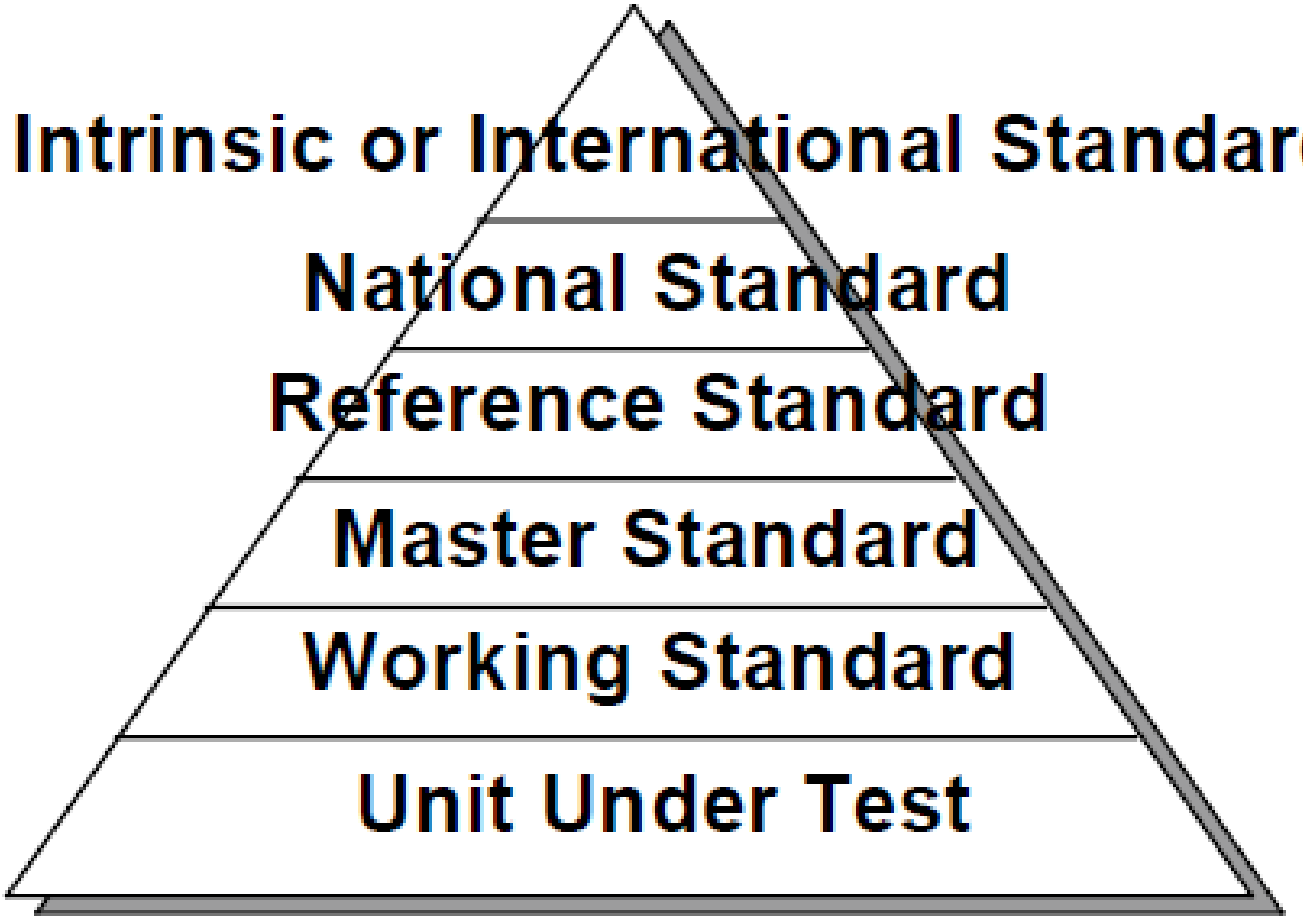
Meter Testing Traceability - Standards



Meter Testing Traceability - Standards

- *National Standard*

  In US, it is maintained by NIST, and it is a standard formed by

  one or many groups within one country (or only few countries = adapted).

- *Reference or Master Standard*

  Item of highest metrological quality located at a site where calibration is being conducted.

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

- *Working Standard (working master)*

  Should be compared to Master Standard or Reference Standard on regular basis; Used for daily checks comparisons of the calibrated devices.

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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

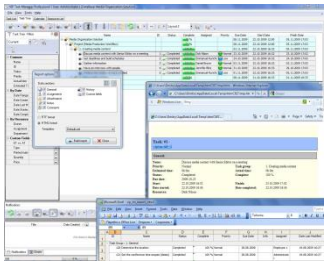
AMI programs help to update and overhaul meter record systems. Having the records for the entire meter population updated allows for a better chance that test data is available to answer questions and that any meter may be selected as part of the sample for testing.

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.

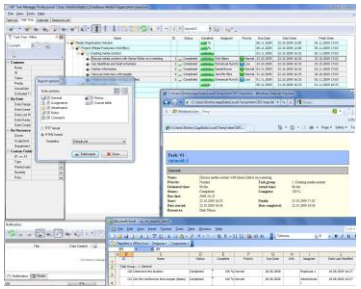


Meter Test Data Tracking

- 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



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 that is part of a system such as ADM.

- Requires discipline in collecting & entering data, especially field tests.

Questions?

Please feel free to call or e-mail any questions

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