THE EASTERN SPECIALTY COMPANY

ST. LUCIA ELECTRICITY SERVICES LIMITED

Site Verification: Tools and Best Practices to Accurately Meter Complex, High Revenue Customers

Prepared by

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in conjunction with

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for the CARILEC CEO & Leadership Conference

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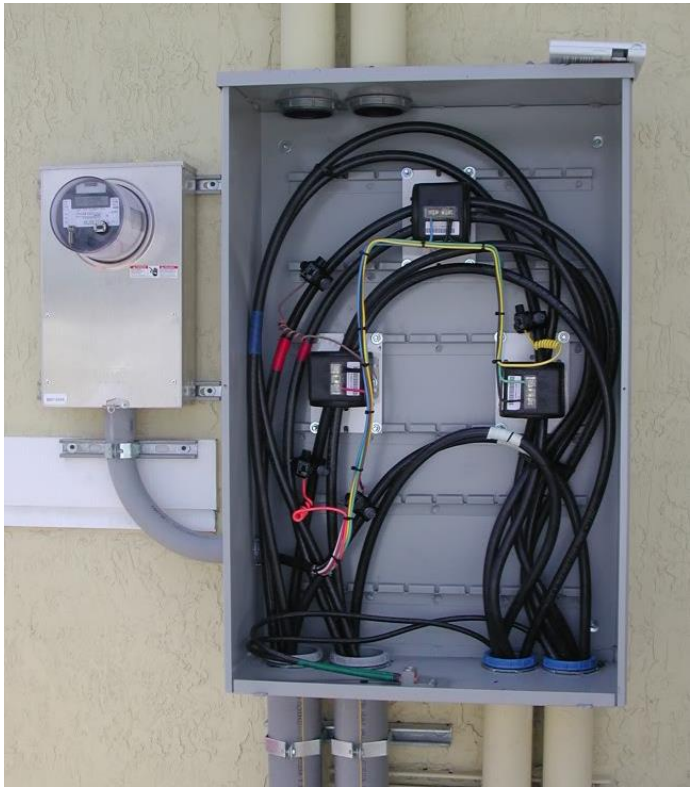
11:00 AM

CARILEC

An Association Of Electric Utilities

Topics We Will Be Covering

- System loss and what we can do to reduce this
- Why we should care about Transformer Rated metering
- Site Verification and not just meter testing
- Management Systems and utilizing AMI data to control and reduce billing errors



Site Verification for Transformer Rated Metering:
Why Should We Invest Our Limited Meter Service Resources Here

- These customers represent a disproportionately large amount of the overall revenue for every utility in North America.
- For some utilities the ten percent of their customers who have transformer rated metering services can represent over 70% of their overall revenue.
- While these numbers will vary from utility to utility the basic premise should be the same for all utilities regarding where Meter Services should focus their efforts
- This is perhaps one of the larger benefits that AMI can provide for our Utilities – more time to spend on C&I metering and less on residential

Easy Answer: Money.

Shop Testing

- Accuracy Testing
- Meter Communications Performance
- Software & Firmware Verification
- Setting Verification
- Functional Testing
- Disconnect/Reconnect Functionality
  and as left setting
- Ratio and accuracy testing
- Polarity checking
- Accuracy class determination

Shop Testing Programs

100% of all Transformers

- If not possible then sample testing of all and 100% of all those over a certain size for CT's and all VT's (generally not a large volume)

Transformer testing should include

- Ratio and accuracy testing
- Polarity checking
- Accuracy class determination

100% of all transformer rated meters

- If not possible then sample testing of all transformer rated meters and 100% of all those going into a certain size service and over

Meter testing should include:

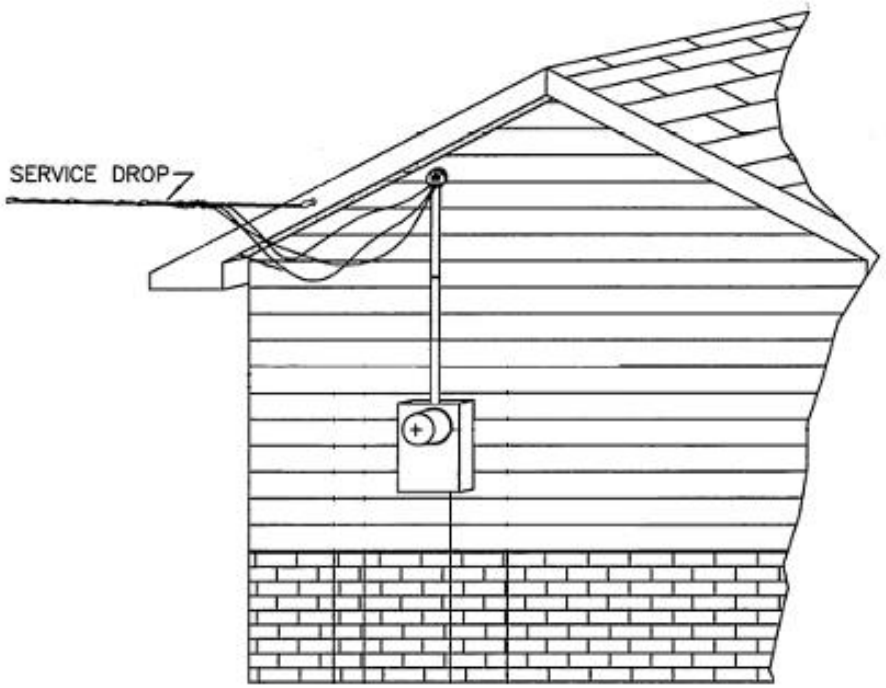
- Software & Firmware Verification
- Setting Verification
- Functional Testing
- Disconnect/Reconnect Functionality and as left setting

AMI Meter Population Management

- A Meter Farm is a representation of your meter population in the field
- The Meter Farm is designed to be a tool to measure base line performance of your meters
- Meter farms are typically located outside so meters are exposed to the same temperatures, sun and elements as your meter population.
- Meter Farms should include a simulation of the entire communication network back to the head end

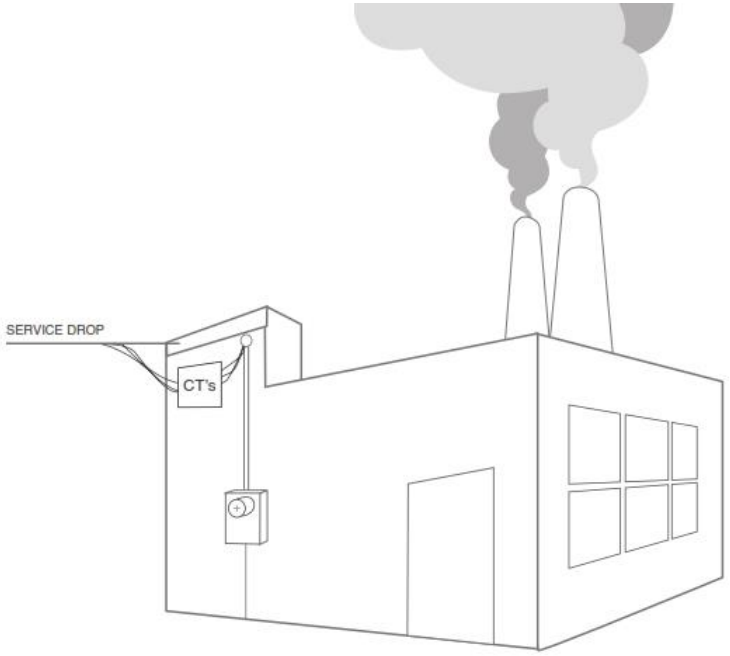
Self Contained Metering

- Typically found in residential metering
- Meters are capable of handling the direct incoming amperage
- Meter is connected directly to the load being measured
- Meter is part of the circuit
- When the meter is removed from the socket, power to the customer is interrupted



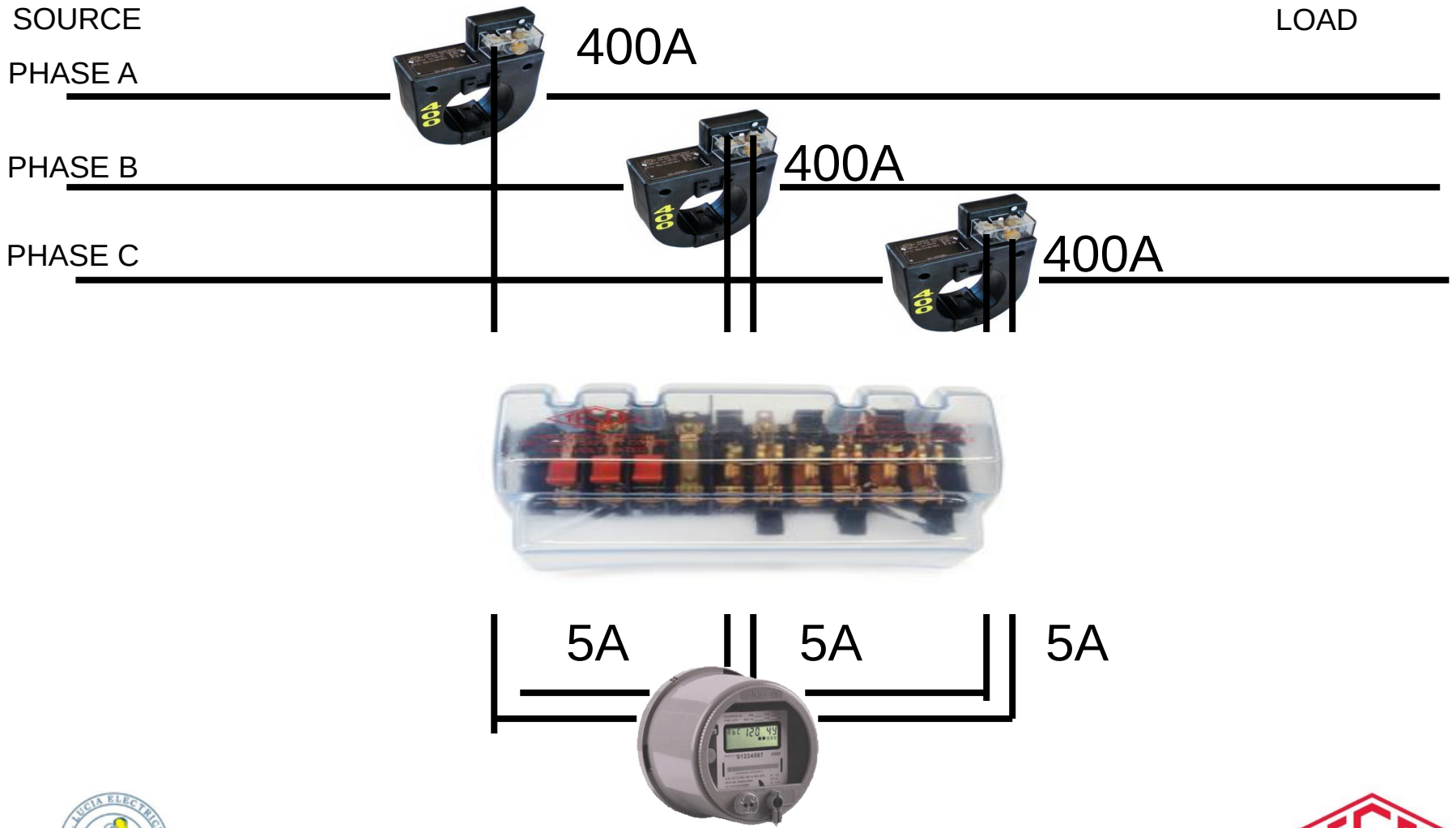
Transformer Rated Metering

- Meter measures scaled down representation of the load.
- Scaling is accomplished by the use of external current transformers (CTs) and sometimes voltage transformers or PTs).
- The meter is NOT part of the circuit
- When the meter is removed from the socket, power to the customer is not effected.



The Basic Components

9S Meter Installation with 400:5 CT's



Testing at Transformer Rated Sites

- ✓Meter Accuracy
- ✓Full Load
- ✓Light Load
- ✓Power Factor

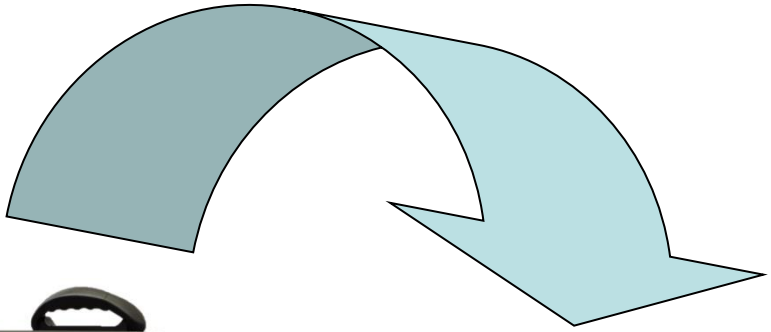
- ✓CT Health
- ✓Burden Testing
- ✓Ratio Testing

- ✓Full Site Verification

Meter Accuracy Testing

Meter Accuracy Testing in a Nutshell

- ✓ Full Load
- ✓ Light Load
- ✓ Power Factor
- ✓ Register Test



2990 Desktop Meter Test Station

2990 Desktop Meter Test Station
Catalog No. 2990

TESCO introduces a state-of-the-art meter accuracy testing in an affordable desktop configuration!

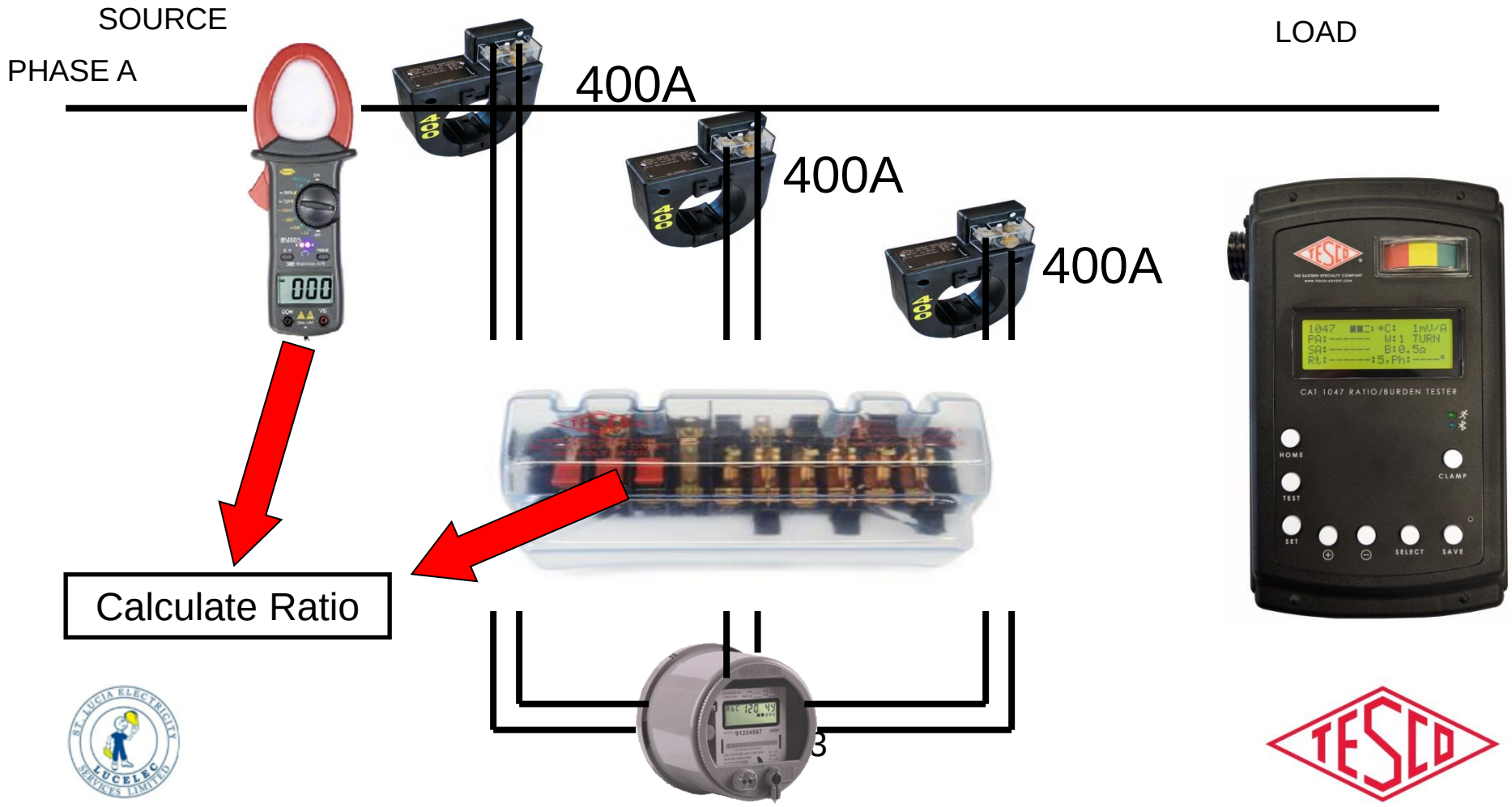
The 2990 revolutionizes meter testing by providing full series parallel meter testing in a small, budget-friendly desktop package.

A fully ANSI compliant test board, the 2990 offers complete testing of all meters under the widest range of test conditions.

- The new waveform generator has all waveforms called out in ANSI C12.20-2015 (pub. 4/2017).
- All common electromechanical and solid state meters up to 50 amps can be tested with the 2990
- 0.04% TESCO Standard Traceable through NIST

Fundamentals of Polyphase Field Meter Testing and Site Verification

Ratio of Primary Current to Secondary Current



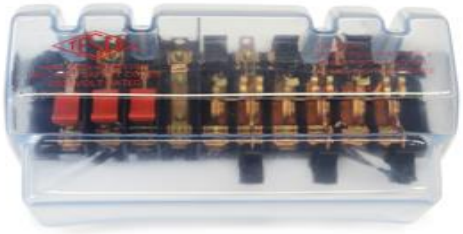
The Importance of CT Testing and Site Verification in the Field

- One transformer in three wired backwards will give the customer a bill of 1/3rd the actual bill.
- One broken wire to a single transformer will give the customer a bill of 2/3rd the actual bill
- One dual ratio transformer inappropriately marked in the billing system as 400:5 instead of 800:5 provides a bill that is ½ of the actual bill. And the inverse will give a bill double of what should have been sent. Both are lose-lose situations for the utility.
- Ensure all shorting blocks have been removed

Fundamentals of Polyphase Field Meter Testing and Site Verification

Functionality with Burden Present on the Secondary Loop

PHASE A



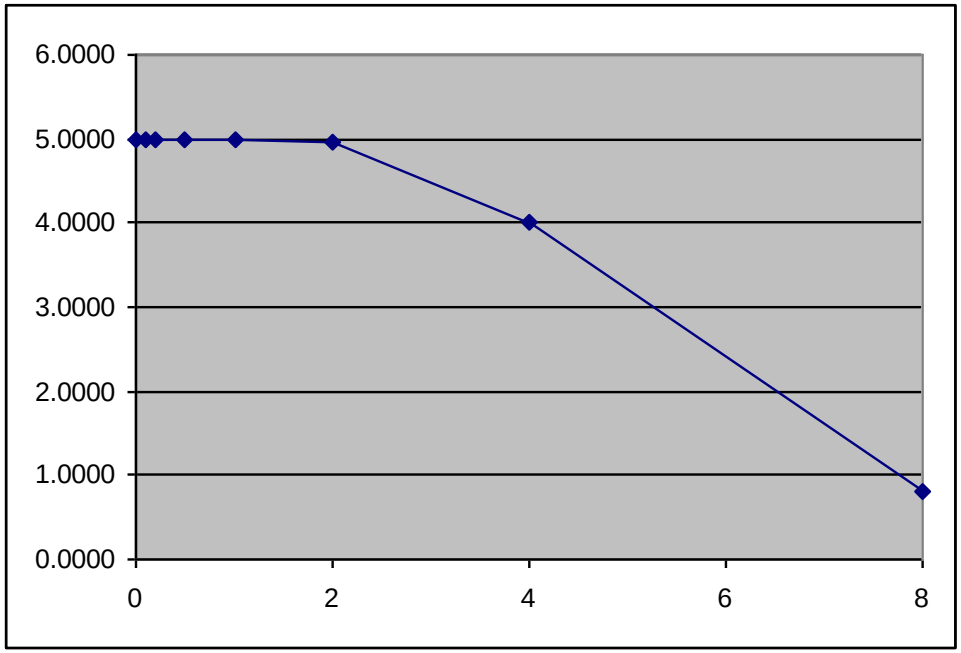
- Some burden will always be present – junctions, meter coils, test switches, cables, etc.
- CT's must be able to maintain an accurate ratio with burden on the secondary.

Slid

Fundamentals of Polyphase Field Meter Testing and Site Verification

Functionality with Burden Present on the Secondary Loop

0.3% @ B0.1, B0.2, B0.5

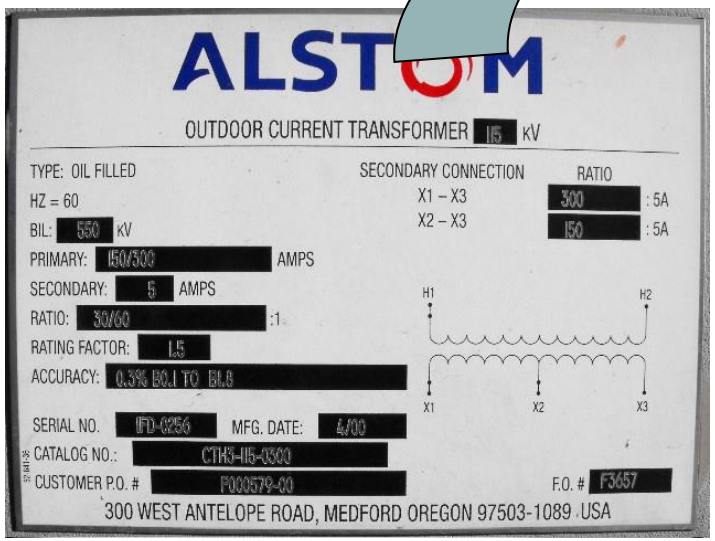


Initial Reading = 5Amps
0.3% x 5A = 0.015A
5A – 0.015 = 4.985A

Burden	Reading
0	5.0000
0.1	4.9999
0.2	4.9950
0.5	4.9900
1	4.9800
2	4.9500
4	4.0000
8	0.8000

Fundamentals of Polyphase Field Meter Testing and Site Verification

Functionality with Burden Present on the Secondary Loop

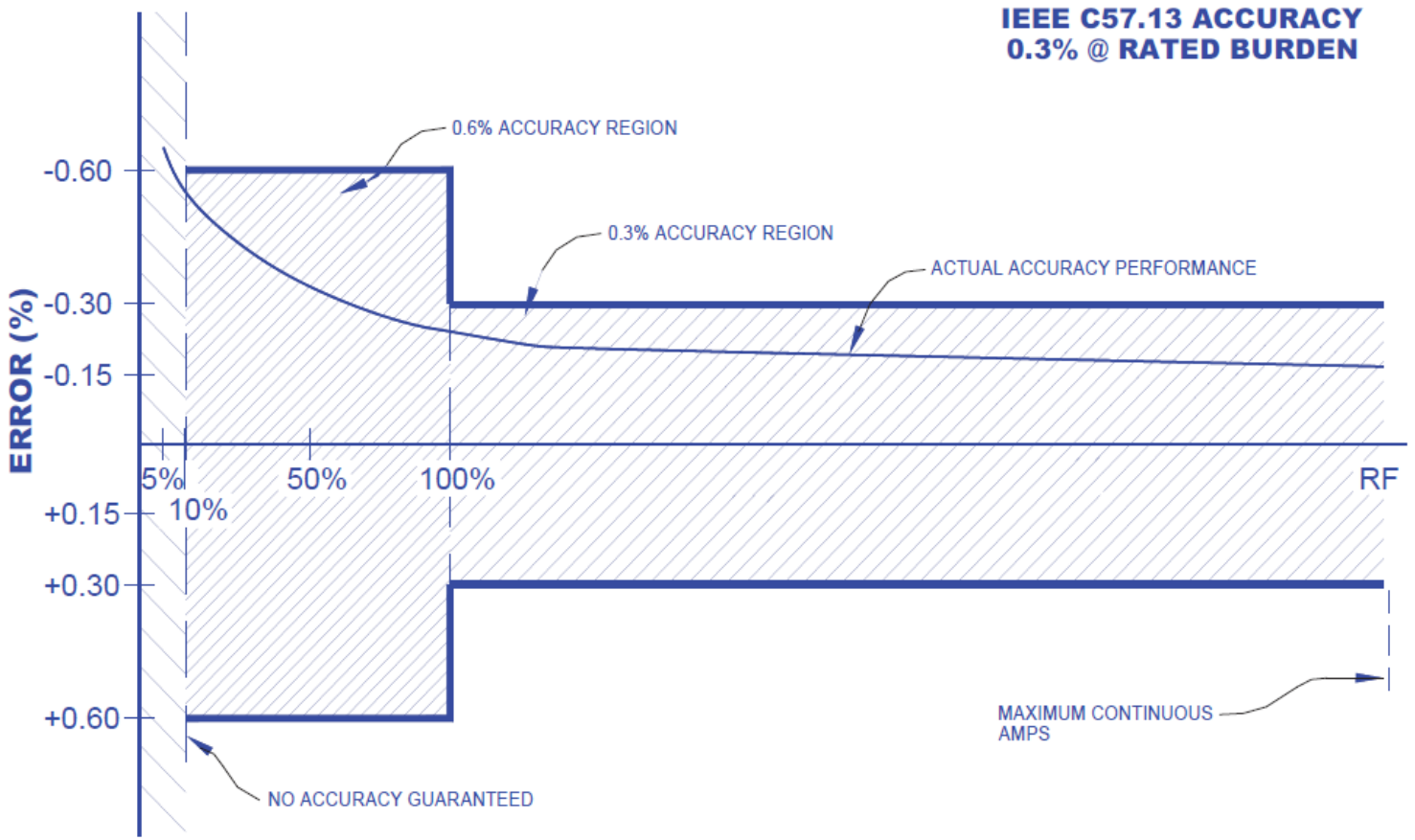


Example Burden Spec:
0.3% @ B0.1, B0.2, B0.5

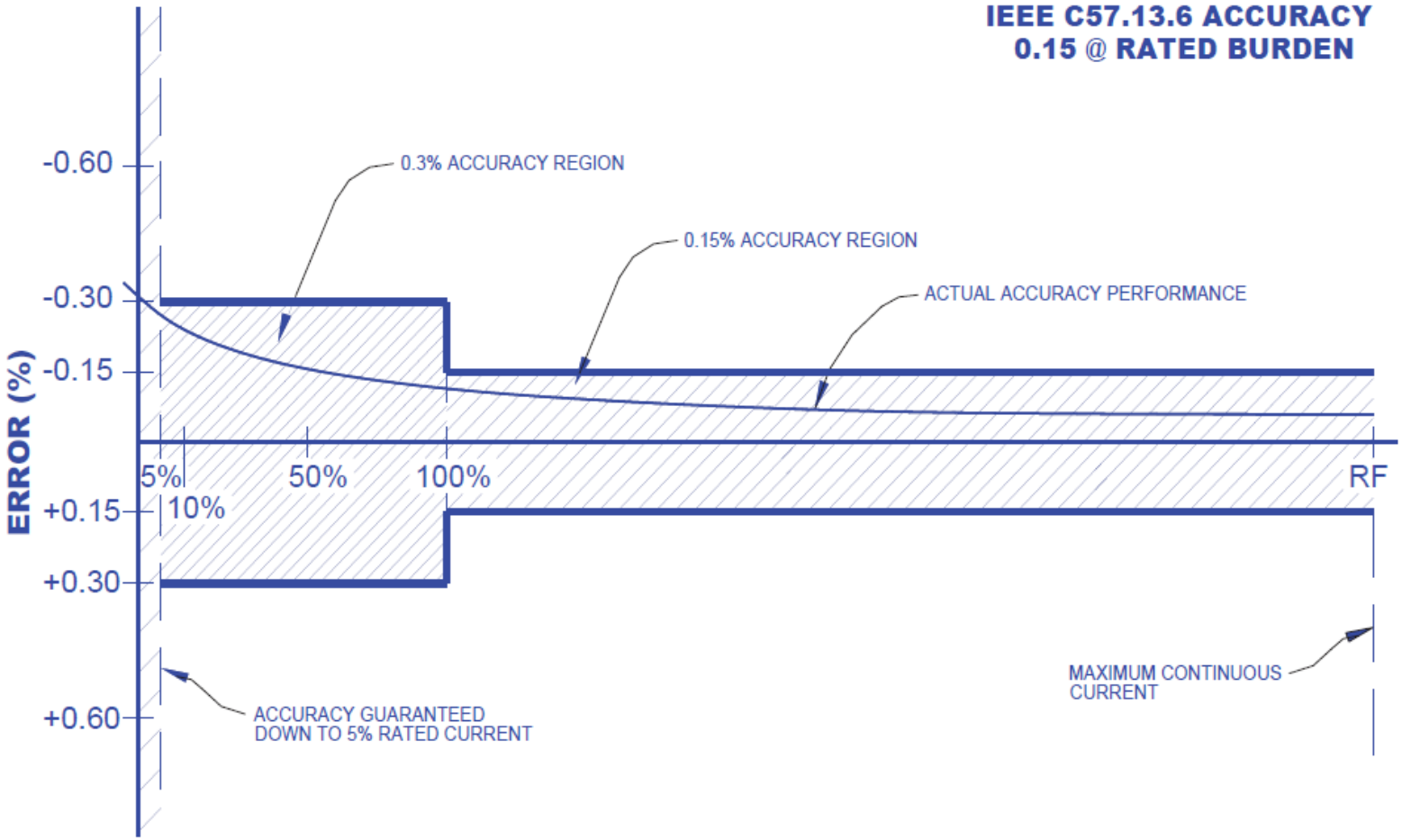
or

There should be less than the 0.3% change in secondary current from initial (“0” burden) reading, when up to 0.5 Ohms of burden is applied

CT 0.3 Accuracy Class



CT 0.15 Accuracy Class



Using the Tools at LUCELEC

- About 15 years ago we begun to identify metering errors such as reversed CT's using testing equipment that provided phasor diagrams.

- Not long after we transitioned to solid state meters which helped minimize billing errors by programming the multiplier into the meter.

Real Time Fixes at LUCELEC

- One of the disadvantages of the technology back then was the time lag—the errors were only picked up at the time of billing
- However, with the implementation of AMI system the time lag has collapsed and as such, these defects are reported as alarms in near real time
- In addition the interval data from solid state C&I meters helped deal with billing queries
- We have kept pace with the advancements in metering through training and investing in the technology to improve our operations.

Using the Tools at LUCELEC to Attack Line Loss

- In 2018 we acquired TESCO's DESK TOP STATION (DTS) 2990 and Current Transformer Ratio Test Set 1047 to be use for on site verification and testing.
- The DTS 2990 has a phantom load which allows on site testing even when the customers low is very low
- Other test equipment used relied on the customer's load for testing
- Hence, when the load was too low the meter test had to be rescheduled or the meter had to be taken in house for testing

Tools at LUCELEC

- CT Ratio Test Set 1047 has augmented our on site testing of CTs by providing a solution to test CTs on HV Metered Customer

- Using the CT Ratio Test Set 1047 we are now able to conduct on site testing and verification with a greater sense of assurance.

- When the CTs are not tested in the field you are making the assumption that the ratios are correct and this may not always be the case

- Experience has taught us that errors can be costly and for this reason, site verification must be done thoroughly and periodically

Real Time Fixes at LUCELEC

- These tools were purchased to allow us to augment our best practices and add new capabilities.

- TESCO's DTS 2990, 1047 Transformer Tester and Honeywell-Elster's AMI System have revolutionized our metering capability.

Potential List of Tasks to be Completed During a Site Verification of a Transformer Rated Metering Site

- Double check the meter number, the location the test result and the meter record.
- Perform a visual safety inspection of the site. This includes utility and customer equipment. Things to look for include intact down ground on pole, properly attached enclosure, unwanted voltage on enclosure, proper trimming and site tidiness (absence of discarded seals, etc.).
- Visually inspect for energy diversions (intentional and not). This includes broken or missing wires, jumpers, open test switch, unconnected wires and foreign objects on meters or other metering equipment. Broken or missing wires can seriously cause the under measurement of energy. A simple broken wire on a CT or VT can cause the loss of 1/3 to 1/2 of the registration on either 3 element or 2 element metering, respectively.
- Visually check lightning arrestors and transformers for damage or leaks.
- Check for proper grounding and bonding of metering equipment. Poor grounding and bonding practices may result in inaccurate measurements that go undetected for long periods of time. Implementing a single point ground policy and practice can reduce or eliminate this type of issue.
- Burden test CTs and voltage check PTs.

Site Verification Checklist (cont.)

- Verify service voltage. Stuck regulator or seasonal capacitor can impact service voltage.
- Verify condition of metering control wire. This includes looking for cracks in insulation, broken wires, loose connections, etc.
- Confirm we have a Blondel compliant metering set up.
- Compare the test switch wiring with the wiring at the CTs and VTs. Verify CTs and VTs not cross wired. Be sure CTs are grounded in one location (test switch) only.
- Check for bad test switch by examining voltage at the top and bottom of the switch. Also verify amps using amp probe on both sides of the test switch. Verify neutral connection to cabinet (voltage).
- Check rotation by closing in one phase at a time at the test switch and observing the phase meter for forward rotation. If forward rotation is not observed measurements may be significantly impacted as the phases are most likely cancelling each other out.
- Test meter for accuracy. Verify demand if applicable with observed load. If meter is performing compensation (line and/or transformer losses) the compensation should be verified either through direct testing at the site or by examining recorded pulse data.
- Loss compensation is generally a very small percentage of the overall measurement and would not be caught under utilities normal high/low checks. However, the small percentages when applied to large loads or generation can really add up overtime. Billing adjustments can easily be in the $million range if not caught early.

Site Verification Checklist (cont.)

- Verify metering vectors. Traditionally this has been done using instruments such as a circuit analyzer. Many solid state meters today can provide vector diagrams along with volt/amp/pf and values using meter manufacturer software or meter displays. Many of these desired values are programmed into the meters Alternate/Utility display. Examining these values can provide much information about the metering integrity. It may also assist in determining if unbalanced loads are present and if CTs are sized properly. The vendor software generally has the ability to capture both diagnostic and vector information electronically. These electronic records should be kept in the meter shop for future comparisons.

- If metering is providing pulses/EOI pulse to customers, SCADA systems or other meters for totalization they also should be verified vs. the known load on the meter. If present test/inspect isolation relays/pulse splitters for things like blown fuses to ensure they are operating properly.

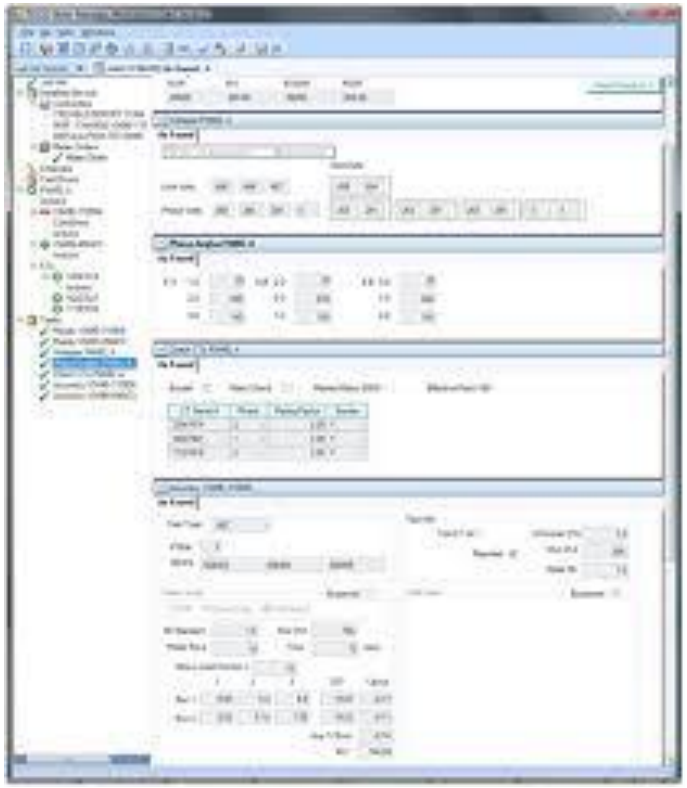
- Verify meter information including meter multiplier, serial number, dials/decimals, Mp, Ke, Primary Kh, Kr and Rate. Errors in this type of information can also cause a adverse impact on measured/reported values.

- Verify CT shunts are all opened.

- Look for signs of excessive heat on the meter base e.g. melted plastic or discoloration related to heat.

Meter Manager Software

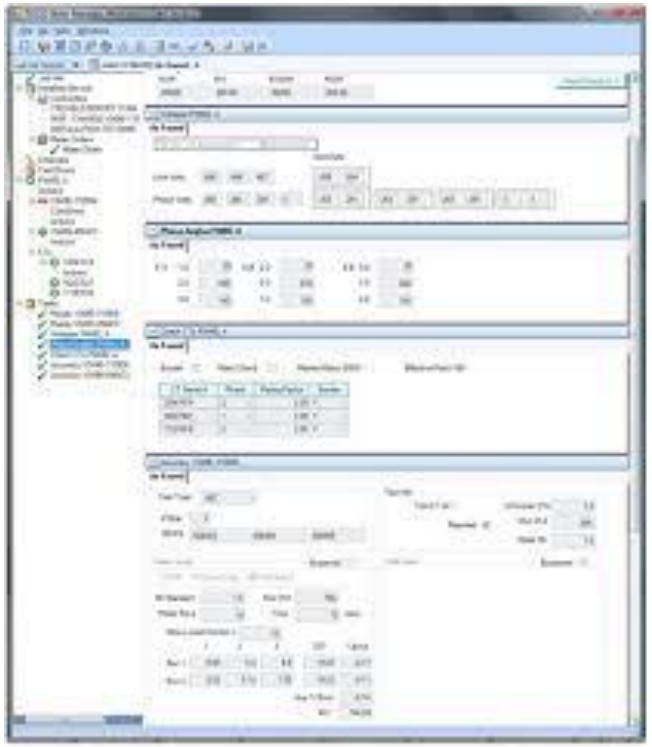
- Over the past four years we have added over 25 million meters managed along with CT's, PT's, AMI hardware, rubber goods, tools as well as user defined materials.
- Our team has been built out along with the product and over the past three years we have performed two 5 Million plus end point installations with both meeting every milestone and both going on time and on budget.
- Meter Manager is considered a "Best of Breed" and is being used as a bolt on to SAP, Maximo, and Oracle CC&B.
- Meter Manager is a Scalable Enterprise Ready system that has High Availability, Load Balancing, and seamless Fail Over.
- Larger users have nearly a thousand active users.
- One application replaced a deeply embedded system that had been installed for over 30 years and had over 70 interfaces. This utility paid an independent party over six figures to perform a sophisticated security penetration analysis. After completing the testing, hacking and analysis a single recommendation was made and implemented for what was defined as a "small vulnerability."



Meter Manager Software

Basic Modules of Meter Manager:

- Meter Shop
- Meter Inventory
- Meter Records
- Random Testing
- In-Service Testing
- PPE Inventory and Testing
- Tool Inventory and Testing
- Field Verification Module
- Tool Life Cycle Asset Management for Everything Metering
  - Track both installed and uninstalled meters



TESCO Meter Manager Software at LUCELEC

In 2017 LUCELEC commissioned TESCO's meter tracking system in an effort to better manage and control the meters issued to contractors and staff.

TESCO Meter Manager Software

Manual Data Entry provided challenges for:

- Purchasing and Stores
- Customer Service Department
- T&D Department

Meter Manager Software in Use

The metering related problems are as follows:

Purchasing & Stores

- Prior to this, a Clerk manually enters the serial number of all meters issued.

- This process whilst necessary, is time consuming.

Customer Service Department

Delays in the Billing of customers due to errors resulting from manual data entry by contractors, linemen and clerks.

Examples of these issues were:

- Incorrect meter number assigned to customer
- Meters found on the distribution network with no account in CU
- Accounts in CU without a meter on the distribution network
- In some instances some accounts were not be billed due to unresolved meter related issues thus contributing to revenue loss

Transmission & Distribution Department

- One of the major challenges of the T&D Department is to be able to account for the meters issued to crews.

- Unused meters are not always returned, and since meters are issued by a diverse group, for example, Trouble Call Service Crews, Customers Care, contractors, Metering, and T & D South, tracking the location of all meters tedious.

Other Reasons for Revising Work Practices

- Cost of smart meter significantly higher than electromechanical meter
- Increase in cases of meter tampering and unaccounted meters
- For the reason list, revised our work practices and use Meter Management Technology to improve the management and control of meters

Meter Manager Module

- The TESCO's Meter Inventory Module is used in conjunction with Cayenta Utilities (LUCELEC's Customer Information System (CIS) to track the meters in inventory, meters issued to contractors, and LUCELEC Staff.

- All meters are scanned before being issued and when they are returned, thus allowing the data to be automatically entered into the inventory records.

Meter Manager Module

Meter Management Software generates several reports which can be used for tracking meters:

- Container List
- Meter Checked In, Active in CIS
- Meters Checked Out Details
- Meter Checked Out Summary
- Meter Checked Out Not Installed
- Meters Removed in CIS not Checked In

Meter Manager Module

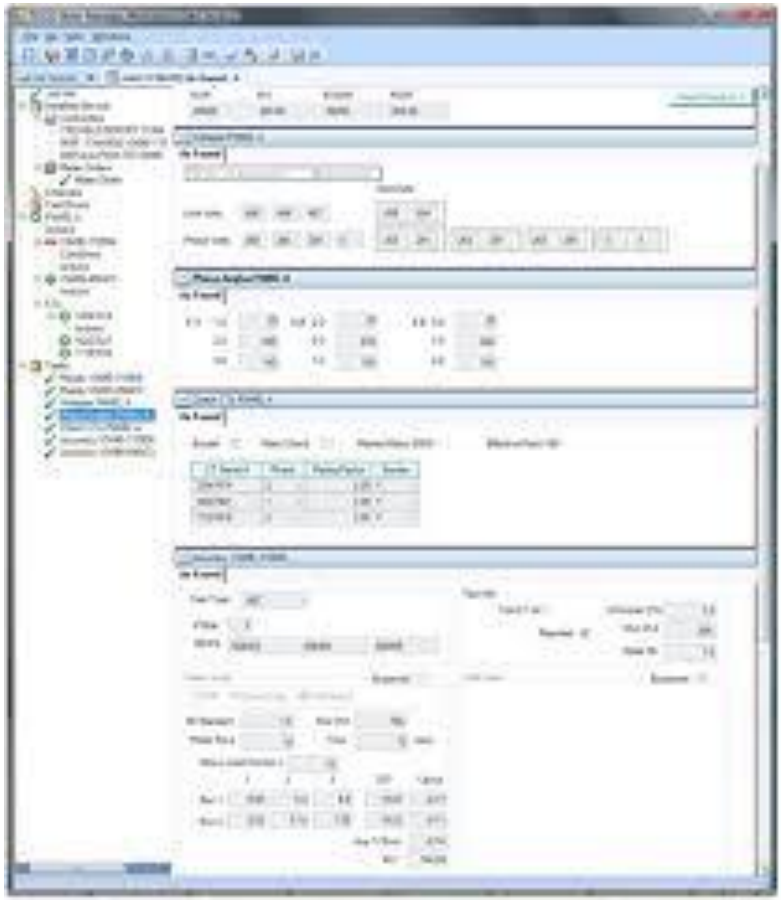
One of the important Lessons Learned:

Stakeholders Engagement and Support is critical for a successful transition

Meter Manager Software

New Ways in Which Meter Manager is being used:

- Meter Manager will be used on tablets to manage an AMI Field Deployment starting in the first quarter of 2019. This will be the largest utilization to date of the Site Verification module.
- Meter Manager is being used as the system of record for CT and VT site information for a multi-million meter utility. Their MDM queries Meter Manager for transformer information to check on billing. Unusual wiring parameters for specific sites are stored in meter manager along with all CT and PT ratios so billing multipliers can be calculated and periodically checked as a system against the billing system to ensure that clerical errors do not lead to billing errors.



Using AMI Data

- AMI data can provide actual usage.
- Site Verification data can provide a correlation to the Transformers installed at the installation.
- Not a very difficult analysis to determine how often any one particular installation is operating outside of the operational parallelogram for the installed transformers.
- This allows the utility to replace these transformers with transformers that operate more accurately over a larger range of operating conditions. This is especially true as no utility can ever know who the next tenant in a building will be or how they will utilize the service or even how an existing company's needs will change over time.
- Look for missing current on a single leg or intermittent data.

Self Contained

- Use AMI analytics on self-contained services to determine where there are problems
- Look for technical and non-technical losses through these analytics
- Minimize the use of field resources in checking these services
- Free up as many field and shop resources as possible to check on and be as proactive as possible with your Transformer Rated services

Summary

- Use your AMI analytics to determine where there are misses:
  - No draw on one leg
  - Intermittent draw on one leg
  - Performing outside the rated range for the installed transformers
  - Reversed polarity
- Start checking for field issues all over again.
- Reduce the resources spent on self-contained metering by leveraging your AMI data as much as possible and creating new systems and procedures to replace older processes that did not have the availability of this type of data.

Reduce “Line Loss”

Why?

Because the Transformer Rated Services are where the money is!!!!

Periodic Site Inspections…..

….Can Discover or Prevent:

- Billing Errors
- Bad Metering set-up
- Detect Current Diversion
- Identify Potential Safety Issues
- Metering Issues (issues not related to meter accuracy)
- AMR/AMI Communications Issues
- The need for Unscheduled Truck Rolls due to Undetected Field Related Issues
- Discrepancies between what is believed to be at a given site versus the actual setup and equipment at the site

….And REDUCE LINE LOSS

Summary

- In closing, the lesson I would like to resonate with you is, **“Site verification and Testing Saves Time and Money.”**
- Remember the utility has a responsibility and a duty of care to ensure that all meters are registering accurately.
- And so, it is important that we get it right every time. We must strive for consistency to safeguard the integrity of the billing process.
- Some of the measures we have put in place to achieve this are: we developed a Metering Policy and we adhere to the program for on-site testing and in-house testing.

Questions and Discussion

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