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# Metering 101

MEUA

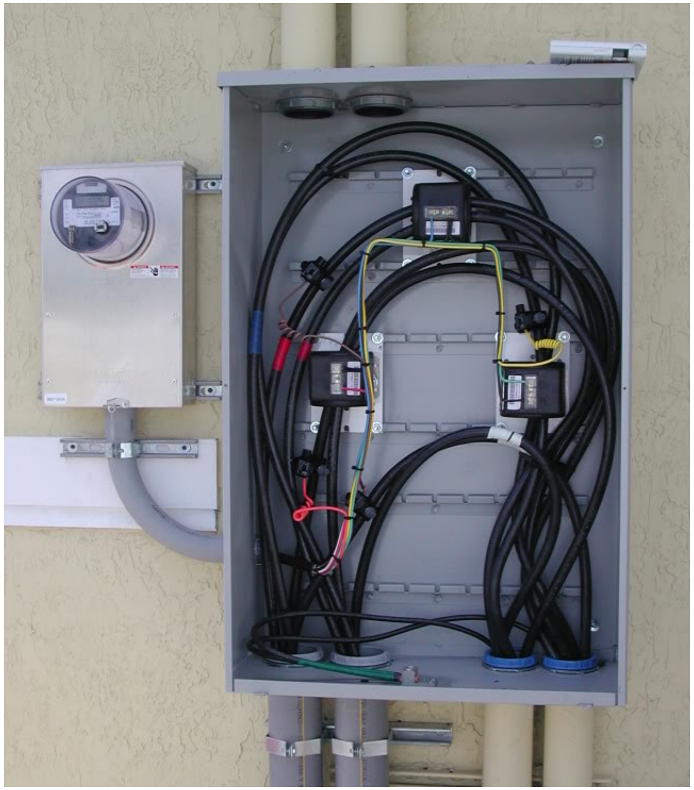
*MEUA*

March 12, 2024 2:15 – 3:00 PM

Perry Lawton, TESCO

# Topics Overview

- Meter Forms
- Current Transformers
- Site Verification & Safety



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# METER FORMS

*MEUA*

March 12, 2024 2:15 – 3:00 PM

Perry Lawton, TESCO

# AGENDA

- Meters 101 - Electro-Mechanical vs Solid-State
- Meter Forms
- Self-Contained vs Transformer Rated
- Blondel's Theorem
- Available References (Hardy's, UGLY's Elect Ref)
- Examples
- 1S, 2S, 9S, 16S

# METERS 101 - ELECTROMECHANICAL

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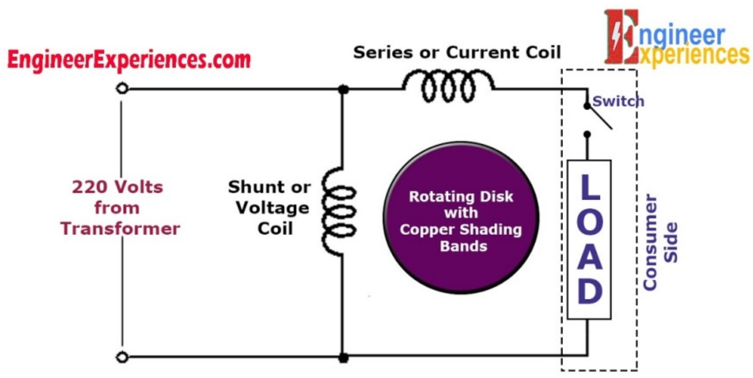
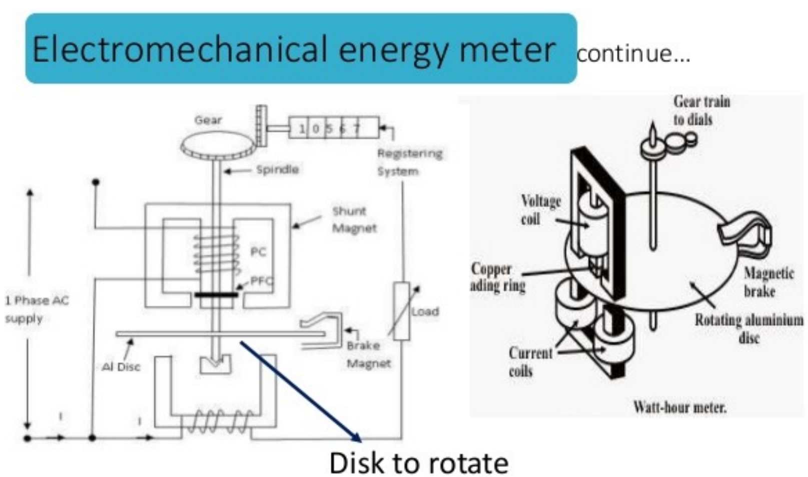



Equivalent Circuit of Electro-Mechanical Energy Meter

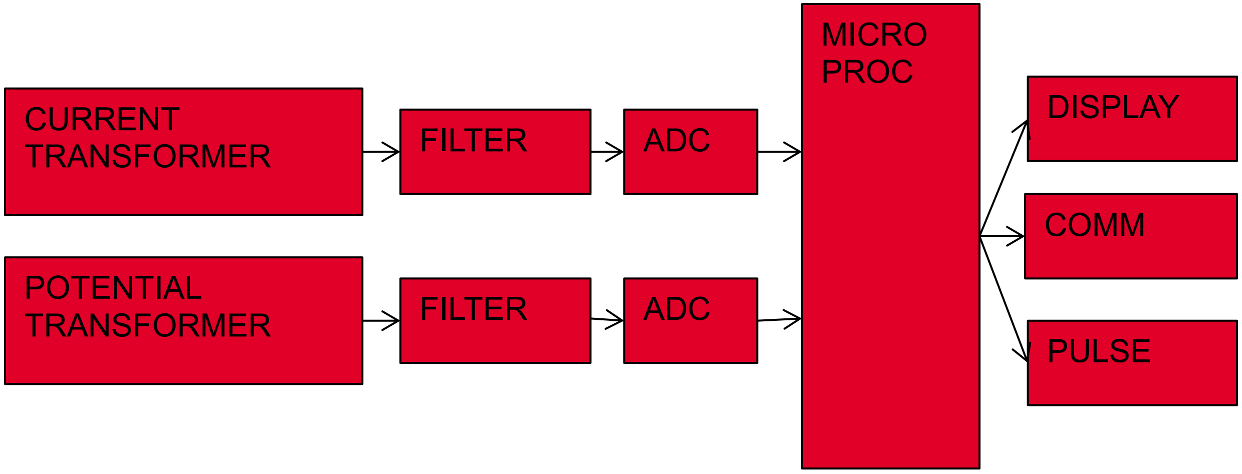



## Overview of Functionality

- The electromechanical induction meter operates through electromagnetic induction
- A non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter
- The disc is acted upon by two sets of induction coils, which form, in effect, a two phase linear induction motor.
- One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage
- The other coil produces a magnetic flux in proportion to the current.
- The field of the voltage coil is delayed by 90 degrees, due to the coil's inductive nature, and calibrated using a lag coil
- This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and instantaneous voltage
- A permanent magnet acts as an eddy current brake, exerting an opposing force proportional to the speed of rotation of the disc
- The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power or rate of energy usage
- The disc drives a register mechanism which counts revolutions, much like the odometer in a car, in order to render a measurement of the total energy used.
- The amount of energy represented by one revolution of the disc is denoted by the symbol Kh which is given in units of watt-hours per revolution.
- A Kh of 7.2 is typical. In this example, each full rotation of the disk is equivalent to 7.2Wh of energy.

# Overview of Functionality

- Potential and Current is scaled down and conditioned with transformers and filters
- ADC's (analog to digital converters) digitize the signals
- A micro-processor or DSP executes the calculations
- Resulting data is displayed, sent externally via the communication circuits, and used for the calibrated pulse output



# METER FORMS

**ANSI C12.10**

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# METER FORMS

1S

14S

39S

17S

2S

3S

12S

35S

4S

25S

10S

76S

46S

45S

66S

11S

32S

6S

5S

26S

16S

9S

13S

15S

24S

56S

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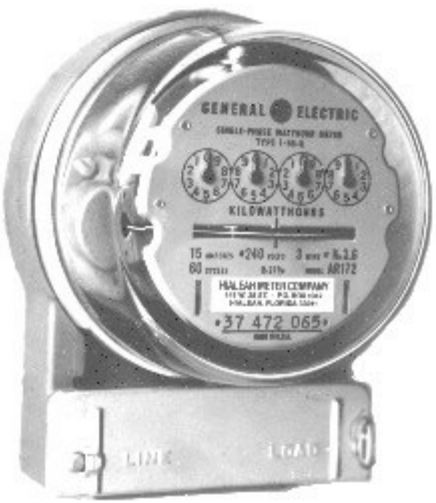
# Meter Forms





# METER FORMS

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14S 39S 17S

1S

2S

3S 12S 35S

4S

25S

10S

76S 46S

66S

45S

11S 32S

6S

5S 26S

16S

9S 13S

56S

15S 24S

# Meter Forms

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SELF-CONTAINED

1S 14S 12S 2S 25S 16S 17S 13S 15S 32S

TRANSFORMER-RATED

39S 3S 36S 7S 29S 76S 5S 35S 4S 46S 8S 26S 11S 66S 45S 6S 9S 56S 10S 24S

# SELF-CONTAINED

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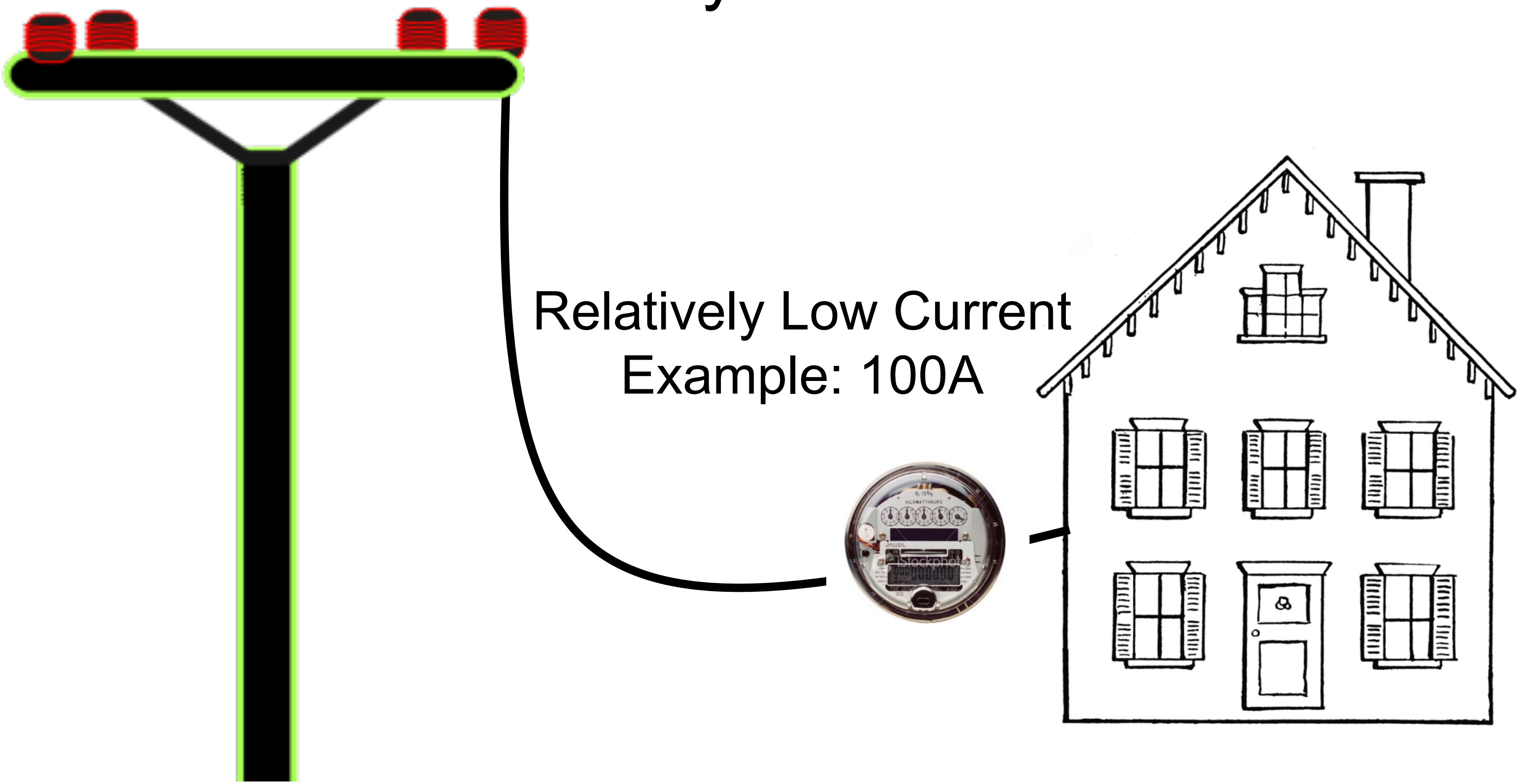
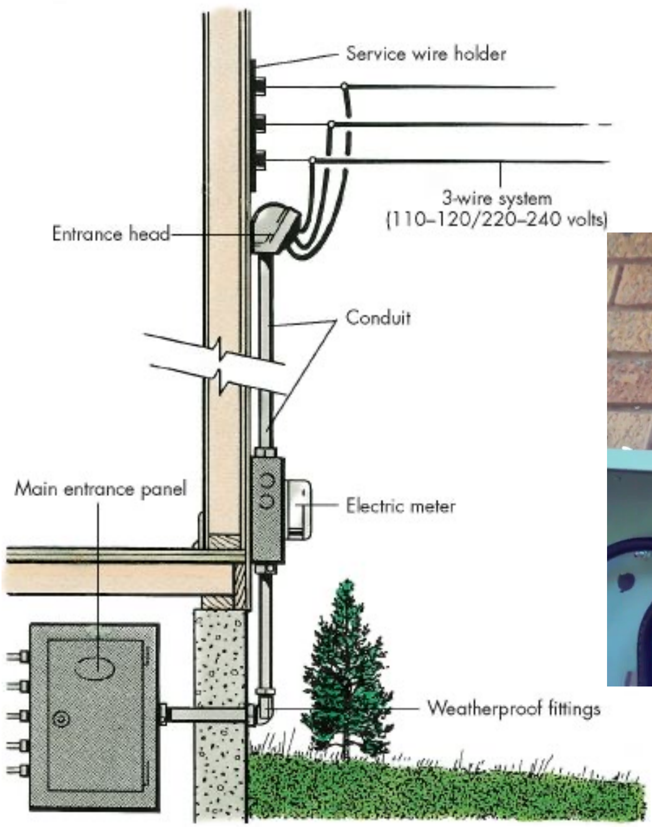
## Primarily Residential

Relatively Low Current
Example: 100A



# Primarily Residential

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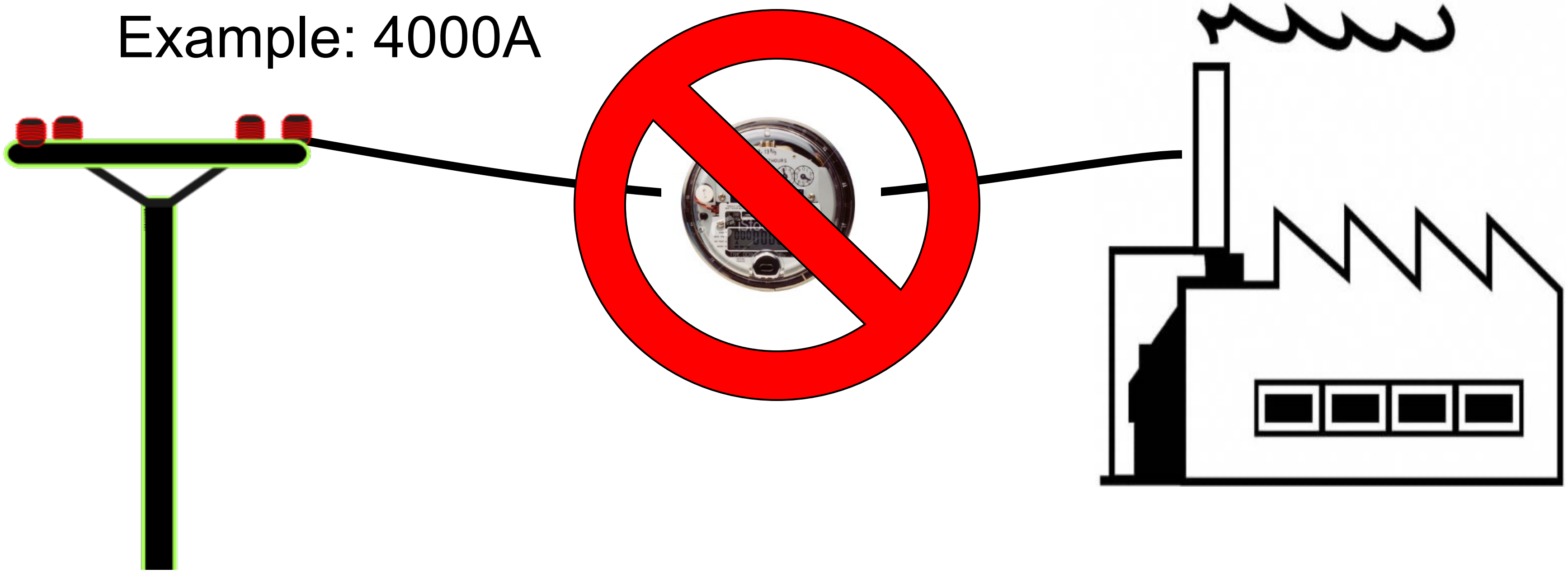
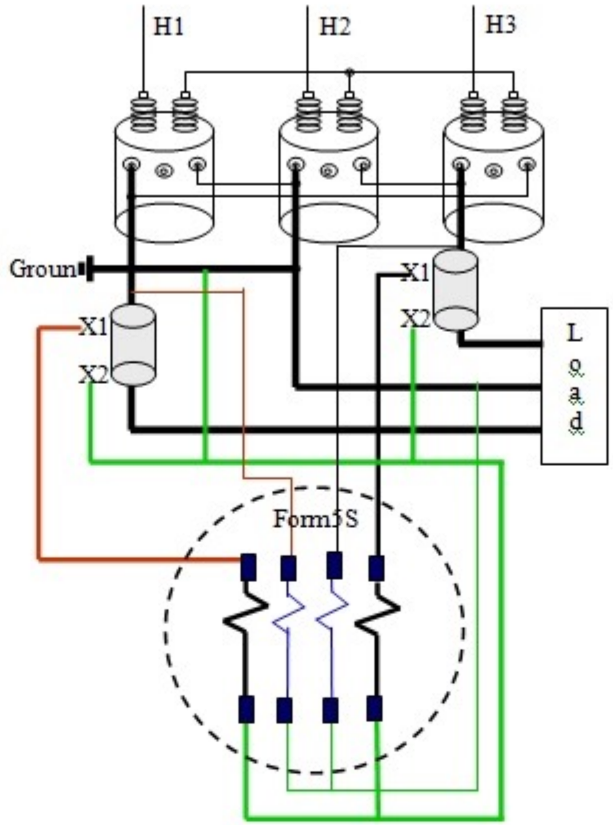
# Primarily Commercial/Industrial

Relatively High Current
Example: 4000A

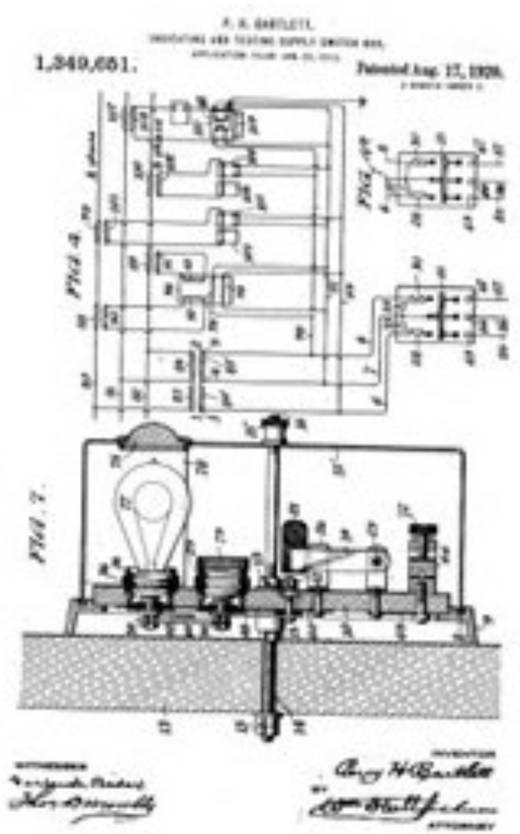


# Transformer-Rated Meters

Primarily Commercial/Industrial




# Safety Test Switch




- August 17, 1920
- **TESCO** founders Joseph Seaman and Burleigh Currier, along with Percy Bartlett
- Isolates the meter from the service during testing

# Safety Test Switch

# DIAGRAM EXAMPLE

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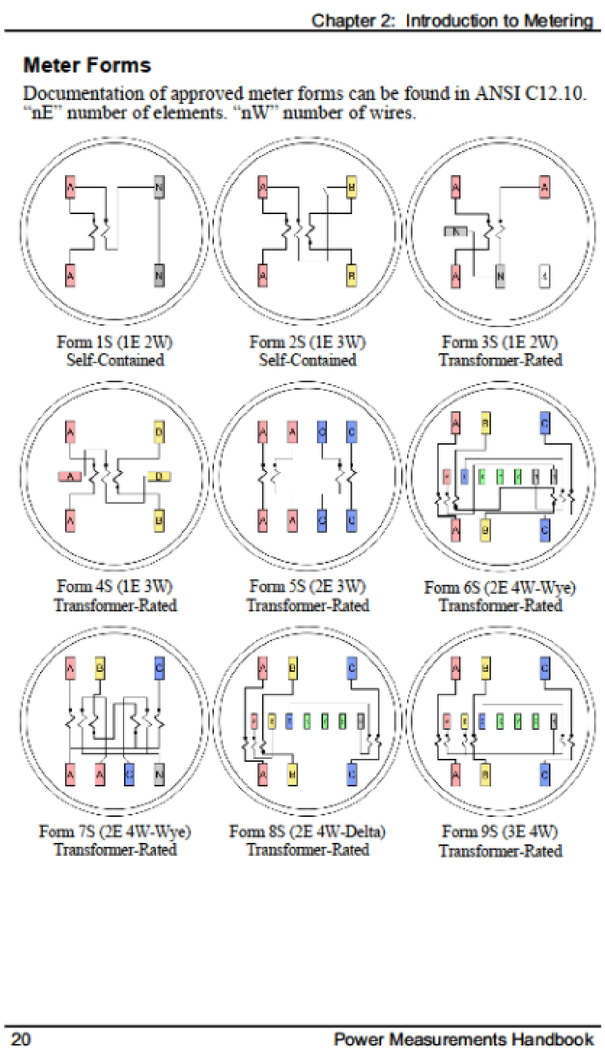


**Meter Forms**

Documentation of approved meter forms can be found in ANSI C12.10. "nE" number of elements. "nW" number of wires.

Form 1S (1E 2W) Self-Contained

Form 2S (1E 3W) Self-Contained

Form 3S (1E 2W) Transformer-Rated

Form 4S (1E 3W) Transformer-Rated

Form 5S (2E 3W) Transformer-Rated

Form 6S (2E 4W-Wye) Transformer-Rated

Form 7S (2E 4W-Wye) Transformer-Rated

Form 8S (2E 4W-Delta) Transformer-Rated

Form 9S (3E 4W) Transformer-Rated



## References

- Power Measurements Handbook, Dr. Bill Hardy
- UGLY's Electrical References
- Meterman's Handbook
- Manufacturer's websites

# DIAGRAM EXAMPLE

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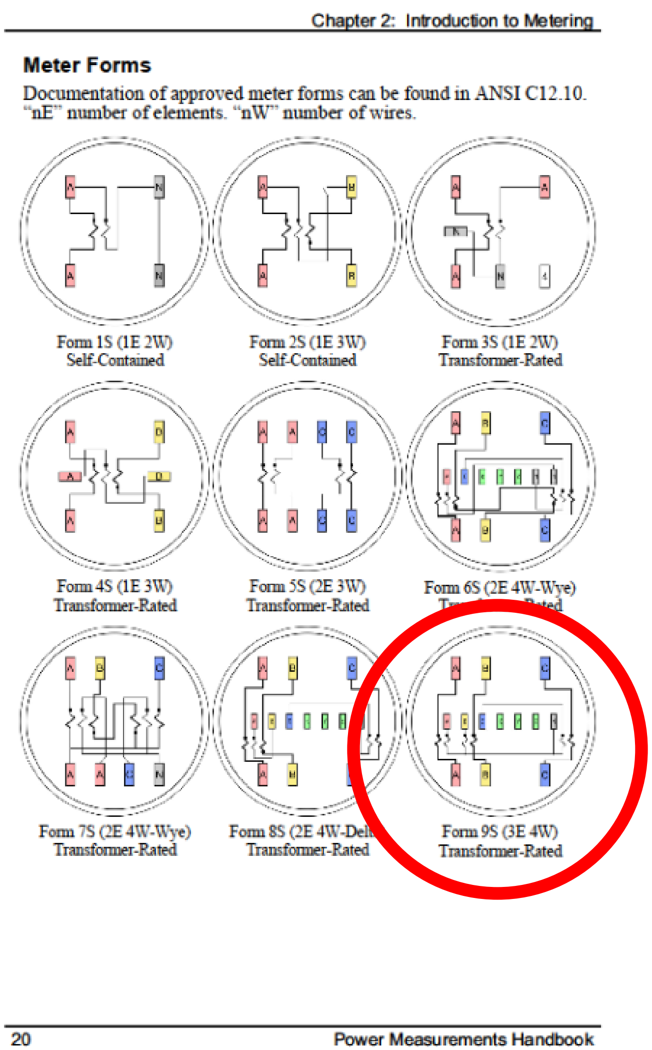
Chapter 2: Introduction to Metering

**Meter Forms**

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Form 1S (1E 2W) Self-Contained

Form 2S (1E 3W) Self-Contained

Form 3S (1E 2W) Transformer-Rated

Form 4S (1E 3W) Transformer-Rated

Form 5S (2E 3W) Transformer-Rated

Form 6S (2E 4W-Wye) Tr[illegible]Rated

Form 7S (2E 4W-Wye) Transformer-Rated

Form 8S (2E 4W-Del[illegible] Transformer-Rated

Form 9S (3E 4W) Transformer-Rated

20 Power Measurements Handbook

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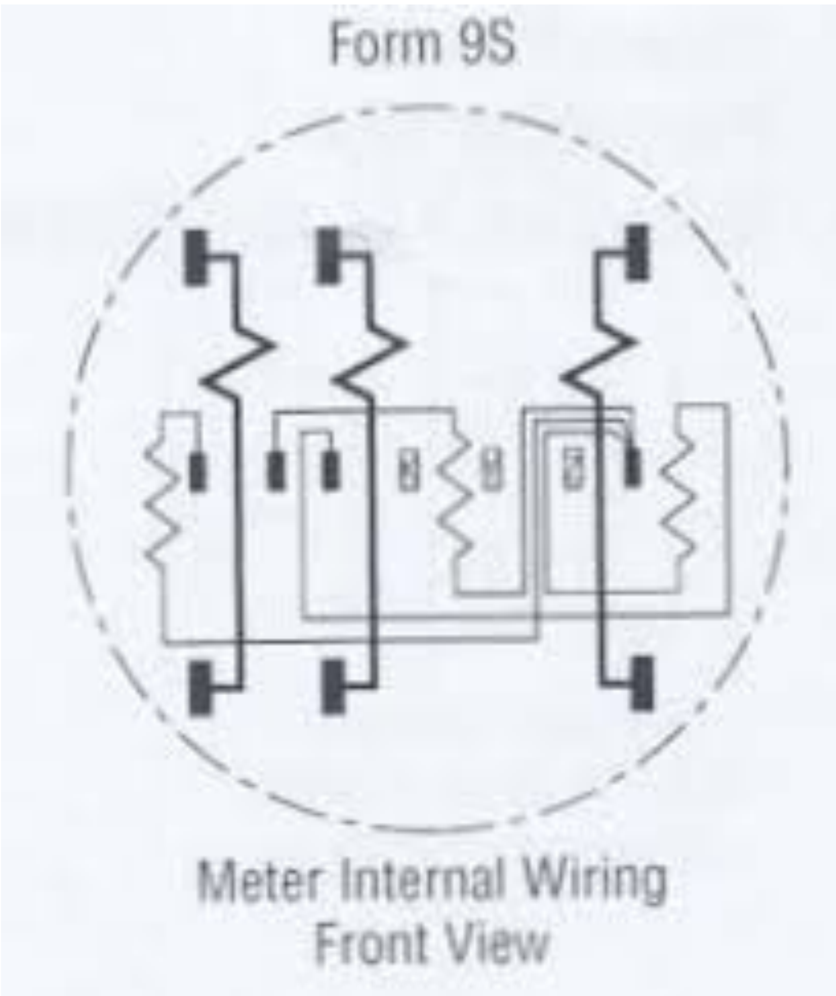
# DIAGRAM EXAMPLE




- 3 Current Coils
- 3 Potential Coils

# Blondel's Theorem

- French Electrical Engineer Andre Blondel
- Attempt to simplify electrical measurements and validation of the results
- Paper submitted to the International Electric Congress in Chicago in 1893.

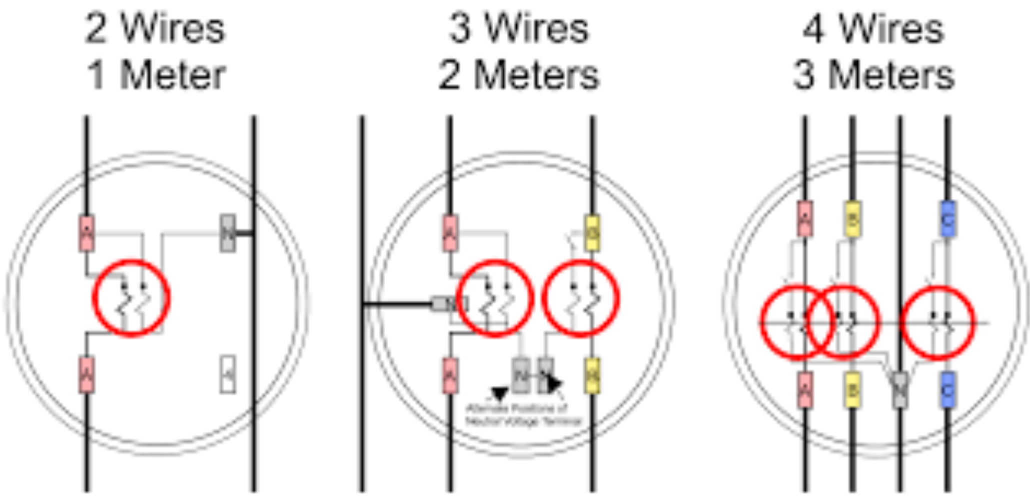
$$E = n - 1$$

*The theorem states that the power provided to a system of N conductors is equal to the algebraic sum of the power measured by N watt-meters. The N watt-meters are separately connected such that each one measures the current level in one of the N conductors and the potential level between that conductor and a common point. In a further simplification, if that common point is located on one of the conductors, that conductor's meter can be removed and only N-1 meters are required.*

# BLONDEL'S THEOREM

Blondel Compliant

$$E = n - 1$$




1S 12S 9S

*The theorem states that the power provided to a system of N conductors is equal to the algebraic sum of the power measured by N watt-meters. The N watt-meters are separately connected such that each one measures the current level in one of the N conductors and the potential level between that conductor and a common point. In a further simplification, if that common point is located on one of the conductors, that conductor's meter can be removed and only N-1 meters are required.*

# Blondel's Theorem

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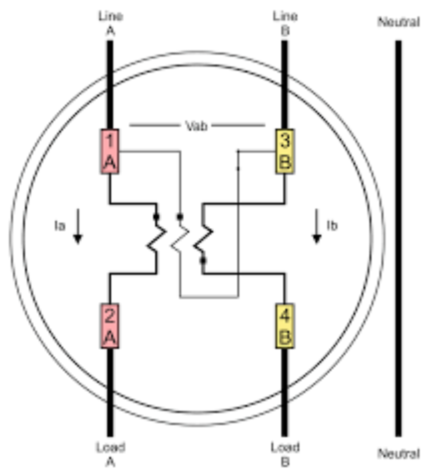
Non-Blondel Compliant

$$E = n - 1$$




2S

*The theorem states that the power provided to a system of N conductors is equal to the algebraic sum of the power measured by N watt-meters. The N watt-meters are separately connected such that each one measures the current level in one of the N conductors and the potential level between that conductor and a common point. In a further simplification, if that common point is located on one of the conductors, that conductor's meter can be removed and only N-1 meters are required.*

## Why is non-Blondel metering bad?

- Makes assumptions about the service
- Example: balanced voltages
- Assumptions might not be true
- When these assumptions are not true, then there are power measurement errors even if the meter is working perfectly.

*The theorem states that the power provided to a system of N conductors is equal to the algebraic sum of the power measured by N watt-meters. The N watt-meters are separately connected such that each one measures the current level in one of the N conductors and the potential level between that conductor and a common point. In a further simplification, if that common point is located on one of the conductors, that conductor's meter can be removed and only N-1 meters are required.*

# Blondel's Theorem

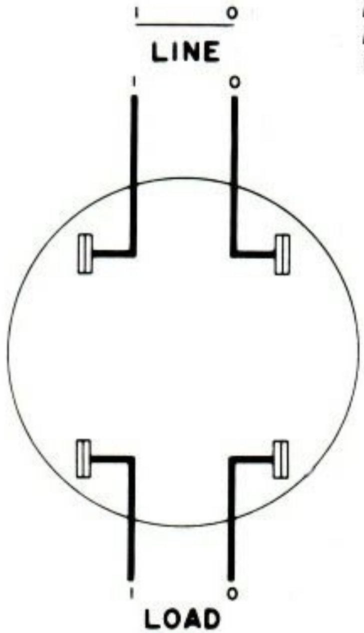
## Why are non-Blondel meters used?

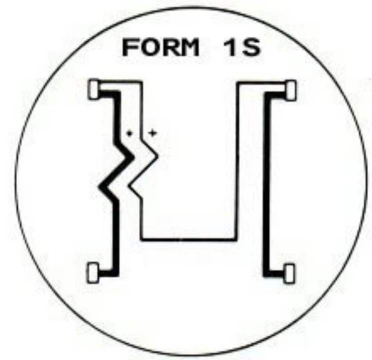
- Fewer elements (meters) = lower cost
- Especially true for electro-mechanical meters
- Fewer CT's and PT's = lower cost
- Less wiring and cheaper sockets

*The theorem states that the power provided to a system of N conductors is equal to the algebraic sum of the power measured by N watt-meters. The N watt-meters are separately connected such that each one measures the current level in one of the N conductors and the potential level between that conductor and a common point. In a further simplification, if that common point is located on one of the conductors, that conductor's meter can be removed and only N-1 meters are required.*

# Metering Examples

All sockets are viewed from the front.
All meters are viewed from the front,
not from the base.




**FORM 1S**
1ø, 2 W CIRCUIT
1 Stator, 2 W Meter, Self-Contained

# METERING EXAMPLES

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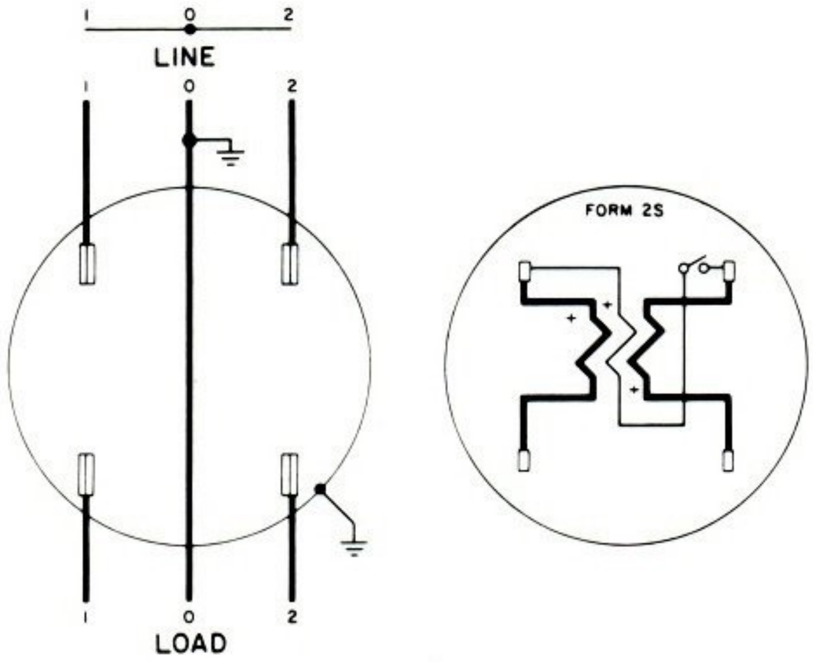


1ø, 3 W CIRCUIT
1 Stator, 1ø, 3 W Meter, Self-Contained

BCM
Bay City Metering
P: 212-575-0785

# Metering Examples

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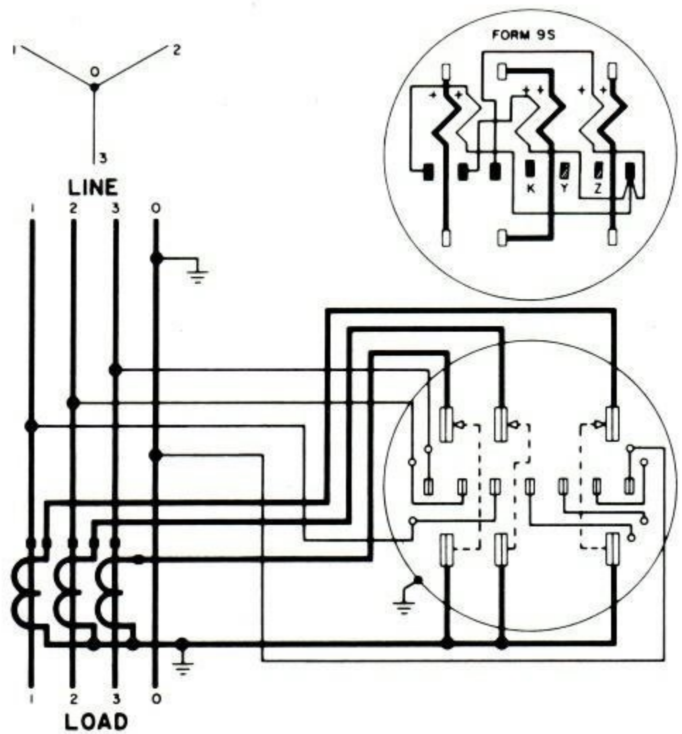


3ø, 4 W, Y CIRCUIT
3 Stator, 3ø, 4 W, Y Meter with 3-2 W CT's

BCM
Bay City Metering
P: 212-575-0785

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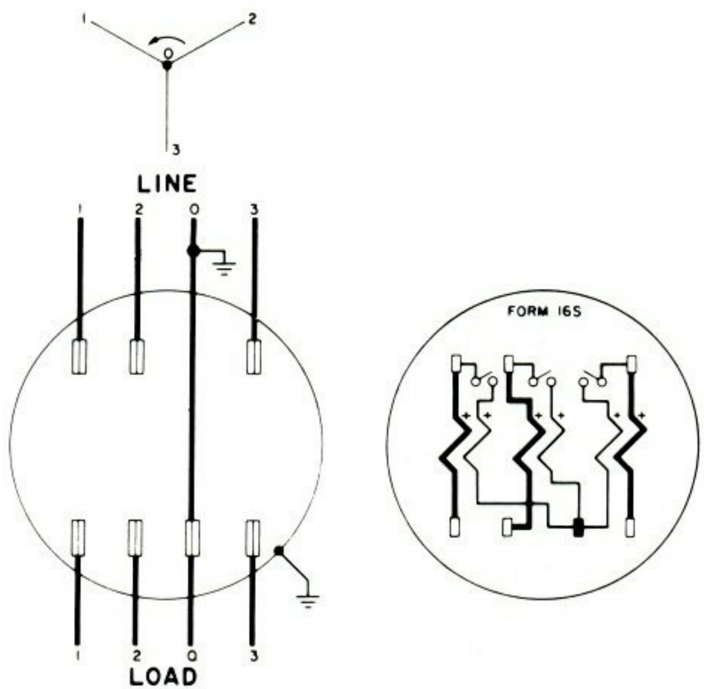
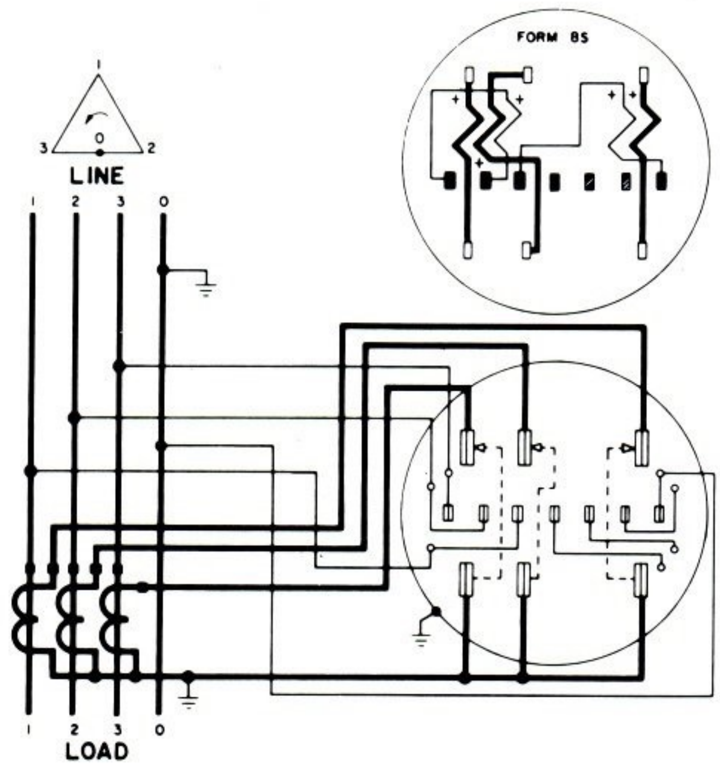
# Metering Examples




3ø, 4 W, Y CIRCUIT
3 Stator, 3ø, 4 W, Y Meter, Self-Contained

BCM
Bay City Metering
P: 212-575-0785

# METERING EXAMPLES




3ø, 4 W, Δ CIRCUIT

2 Stator, 3ø, 4 W, Δ Meter with 3-2 W CT's

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# Current Transformers

*3/12/24*

2:15 – 3:00 PM

Perry Lawton, TESCO

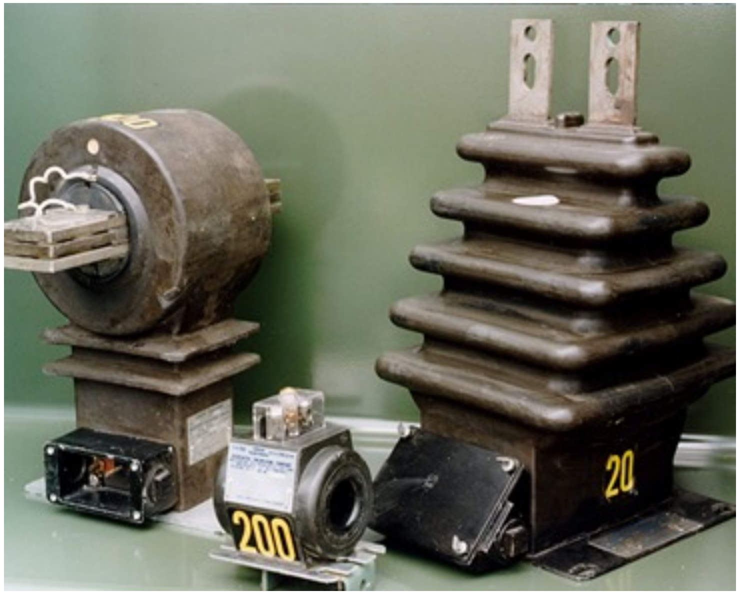
# DEFINITIONS

- **Instrument Transformer**: A transformer that reproduces in its secondary circuit in a definite and known proportion, the voltage or current of its primary circuit with the phase relation substantially preserved.
- **Current Transformer**: An instrument transformer designed for the measurement or control of current. Its primary winding, which may be a single turn or bus bar, is connected in series with the load. It is used to reduce primary current by a known ratio to within the range of a connected measuring device.
- **Potential Transformer**: An instrument transformer designed for the measurement or control of voltage. Its primary winding is connected in parallel with a circuit. It is used to reduce primary voltage by a known ratio to within the range of a connected measuring device.

# THREE TYPES OF ITS

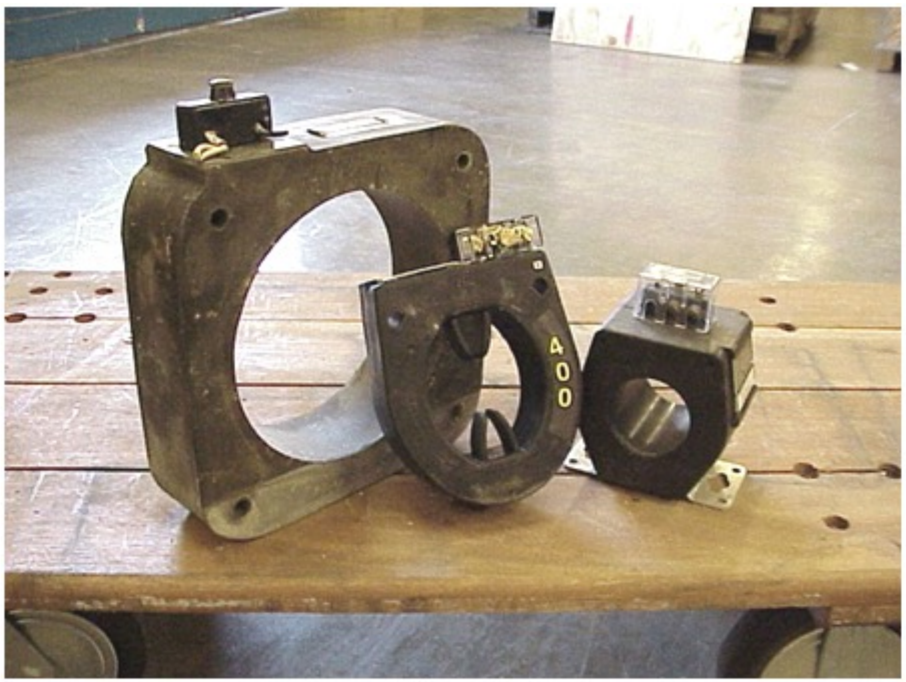
- Three basic types of instrument transformers:

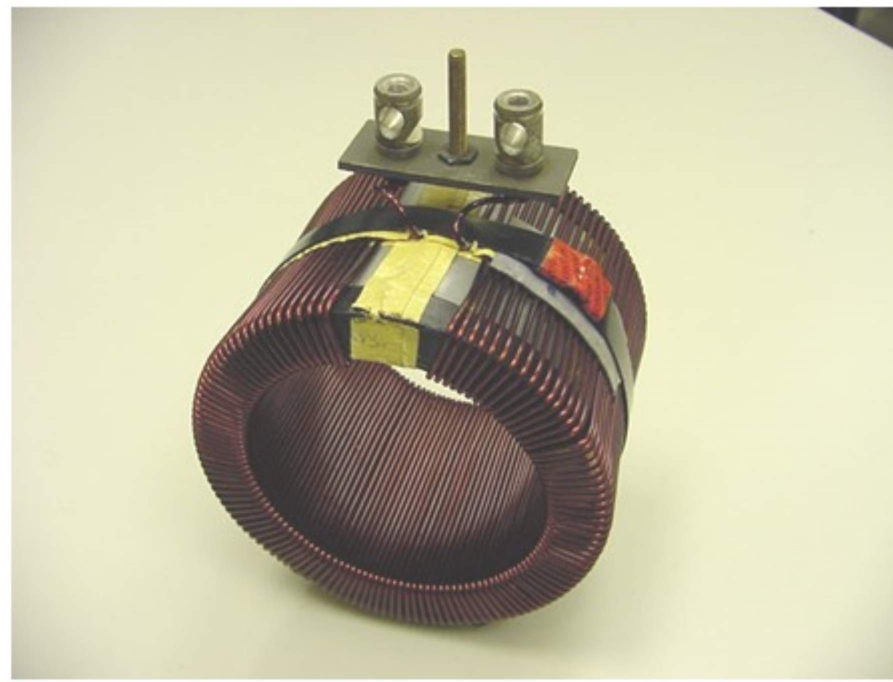
1. Window type (applies to CT's only)
2. Bar type (applies to CT's only)
3. Wound type (applies to CT's and PT's)



# Window Type CT (Passthrough)

- Definition: A current transformer that has a secondary winding insulated from and permanently assembled on the core, but has no primary winding as an integral part of the structure. (The secondary winding of all CT's is intended for connection to the meter or other measuring device.) The line conductor can be passed through the window to provide the primary winding.



# Bar Type CT

- <u>Definition</u>: A current transformer that has a fixed, insulated straight conductor in the form of a bar, rod, or tube that is a single primary turn passing through the magnetic circuit and that is assembled to the secondary core and winding.


# Wound Type CT

- Definition: A current transformer that has a primary winding consisting of one or more turns mechanically encircling the core. The primary and secondary windings are insulated from each other and from the core and are assembled as an integral structure.



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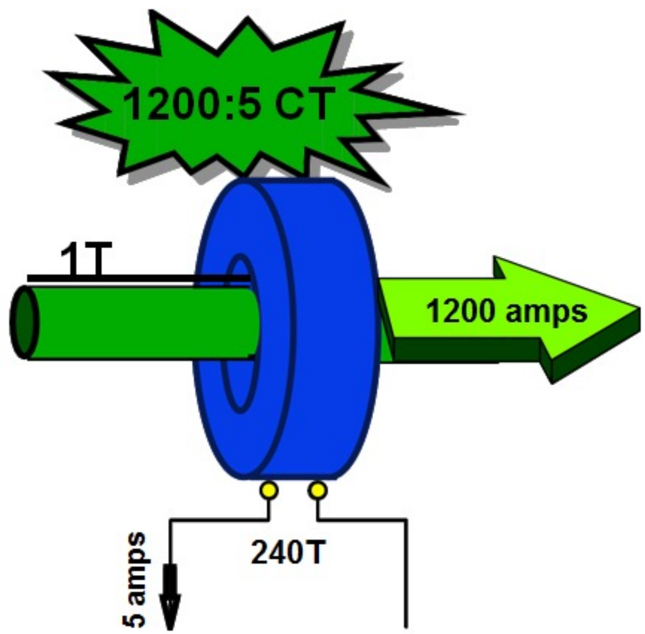
# Current Transformer Ratio

- A current transformer's ratio is typically expressed with a secondary rating of 5 amps.
- The current transformer illustrated here would have a ratio of 1200 to 5.
- 1200 amps flowing through its primary winding (line wire) would cause 5 amps to flow to the meter

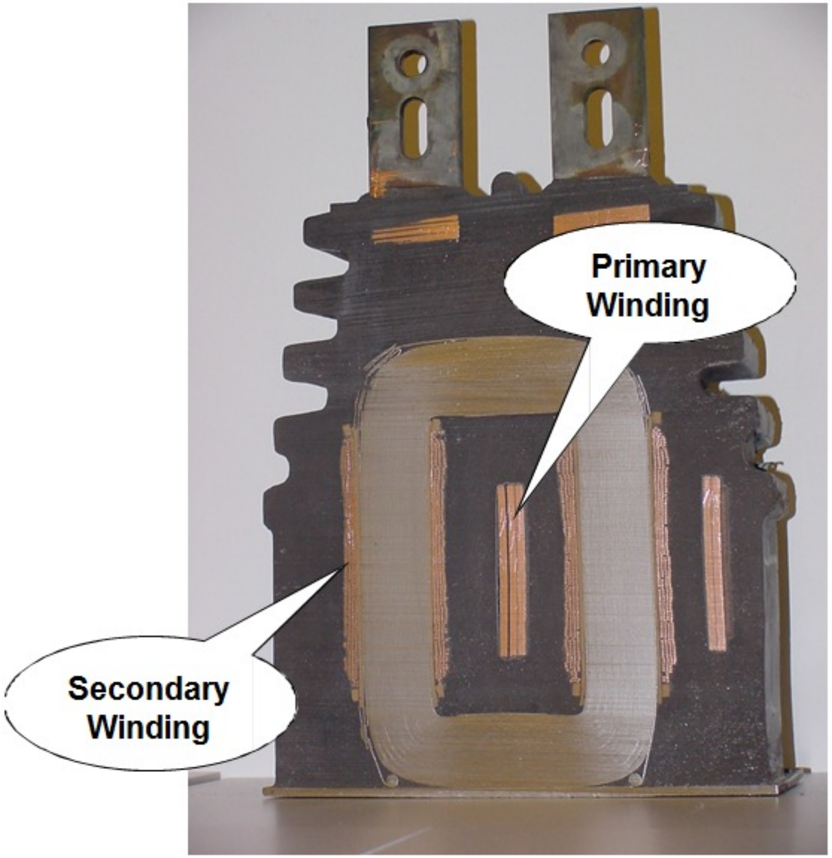
# CURRENT TRANSFORMER TURNS RATIO

- A current transformer will have few primary turns and many secondary turns.
- The window-type CT to the right will have one primary turn (the customer's line wire) and 120 secondary turns.
- The turns ration is 120:1


$$\frac{Primary\ \ current}{Secondary\ \ current} = \frac{Secondary\ \ turns}{Primary\ \ turns} = Turns\ \ Ratio$$

# Current Transformer Turns Ratio

- The wound-type current transformer to the right has two primary turns.
- The conductor making up the primary winding consists of multiple layers of thin copper strapping approximately four inches wide.
- The secondary winding consists of many turns of small copper wire.



# BURDEN

- Burden is the term used to refer to the load on the secondary circuit of instrument transformers.
- An instrument transformer's "rated burden" is the load which may be imposed on the transformer secondary circuit by associated meter coils, leads and other connected devices without causing an error greater than the stated accuracy classification.
- Current transformer rated burdens are normally expressed in ohms impedance such as B-0.1, B-0.2, B-0.5 or B-1.8.
- Potential transformer rated burdens are normally expressed in volt-amperes at a designated power factor. This VA rating is typically represented by the letters W, X, M, Y, Z, or ZZ. For example, the letter "Y" designates a burden of 75 VA @ .85 power factor.

# Accuracy of Instrument

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- Two sources of error determine the accuracy of instrument transformers:
    - (1) Ratio error
    - (2) Phase angle error
- The "accuracy classification" of instrument transformers includes a correlation between ratio correction factor and phase angle so as to show the overall effect on meter registration.
- The ratio correction factor (RCF) is the ratio of the true ratio to the marked ratio.
- The phase angle of an instrument transformer is the phase displacement, in minutes, between the primary and secondary values.
- The transformer correction factor (TCF) is the correction for overall error due to both ratio error and phase angle.
- ANSI has established accuracy classes for both current and potential transformers. Typical classifications are 0.3% error for metering, and 0.6% to 1.2% error for indicating instruments. (ANSI C57.13)

# ACCURACY IS BURDEN DEPENDENT

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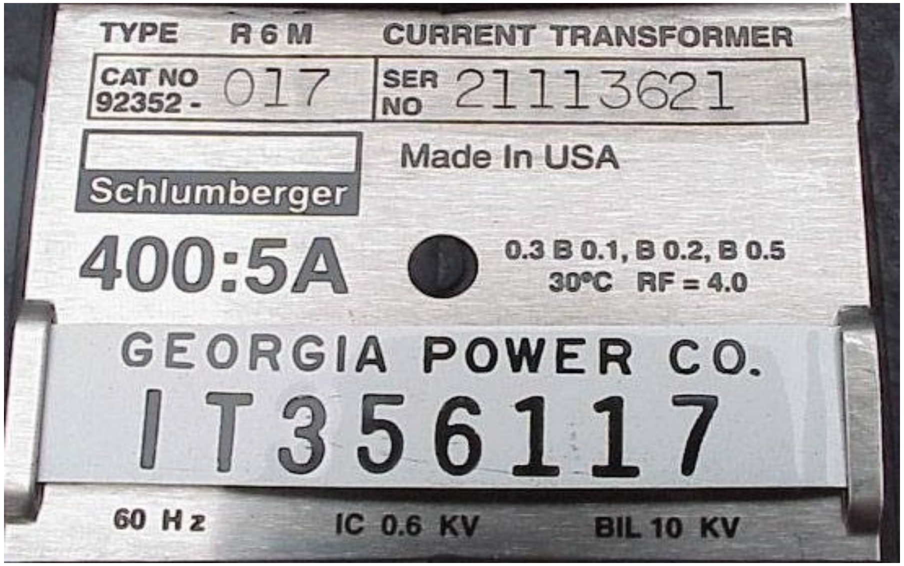
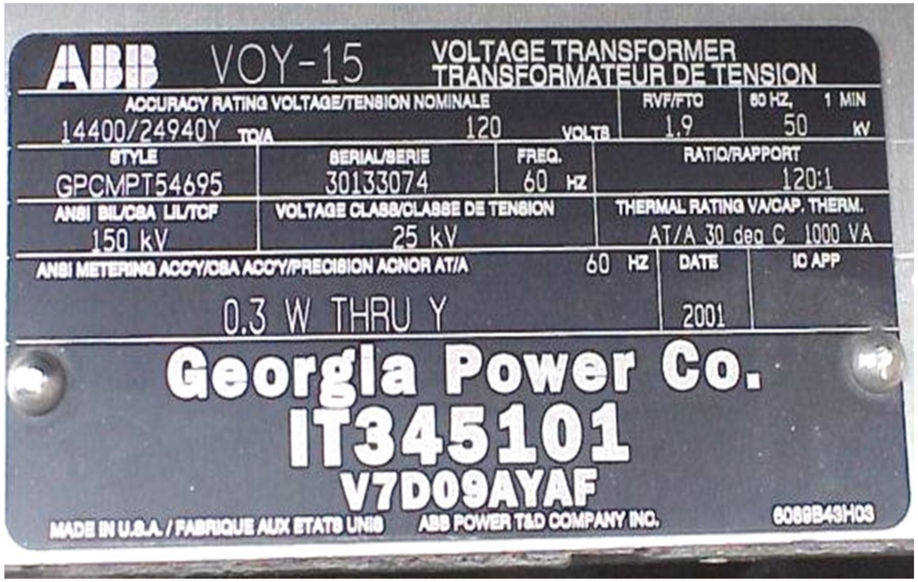
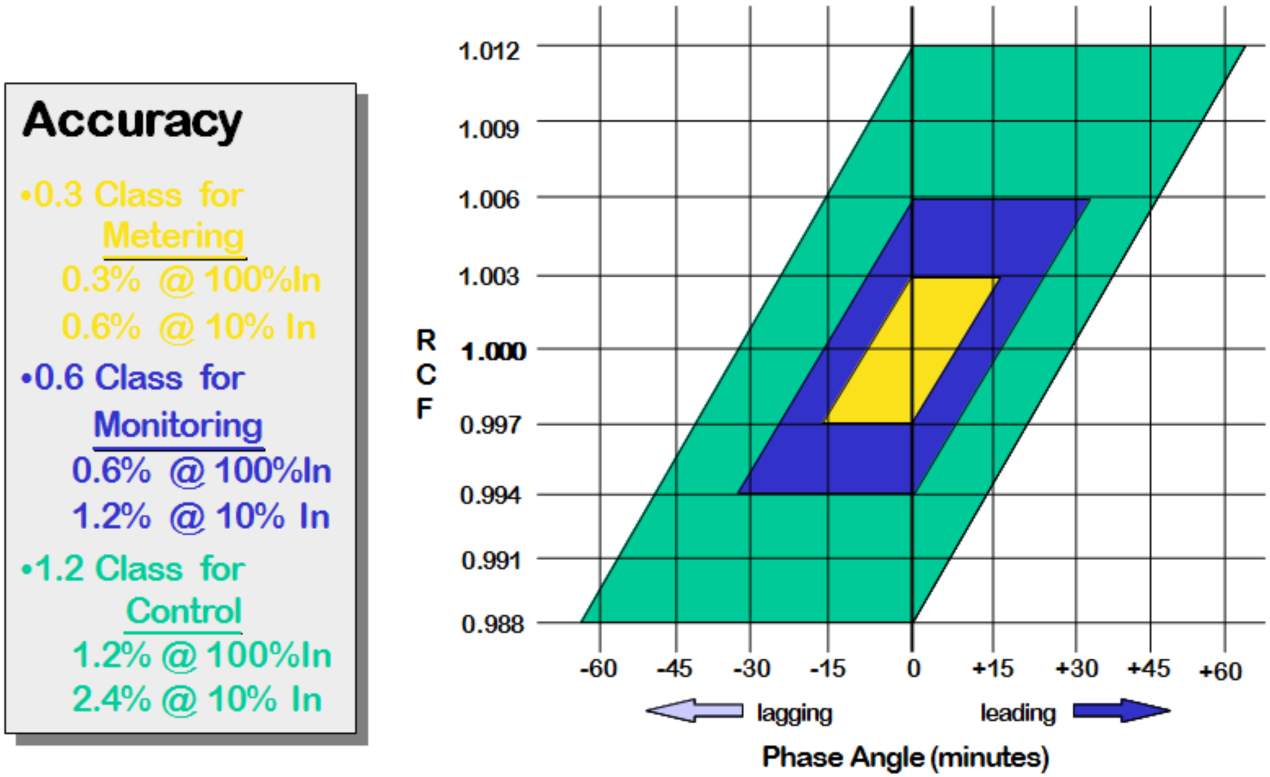
- An accuracy classification for an instrument transformer includes the standard burden as well as the maximum percent error limits for ratio and phase angle error.
- The standard burdens for which a transformer's accuracy rating applies will be designated along with the accuracy rating.



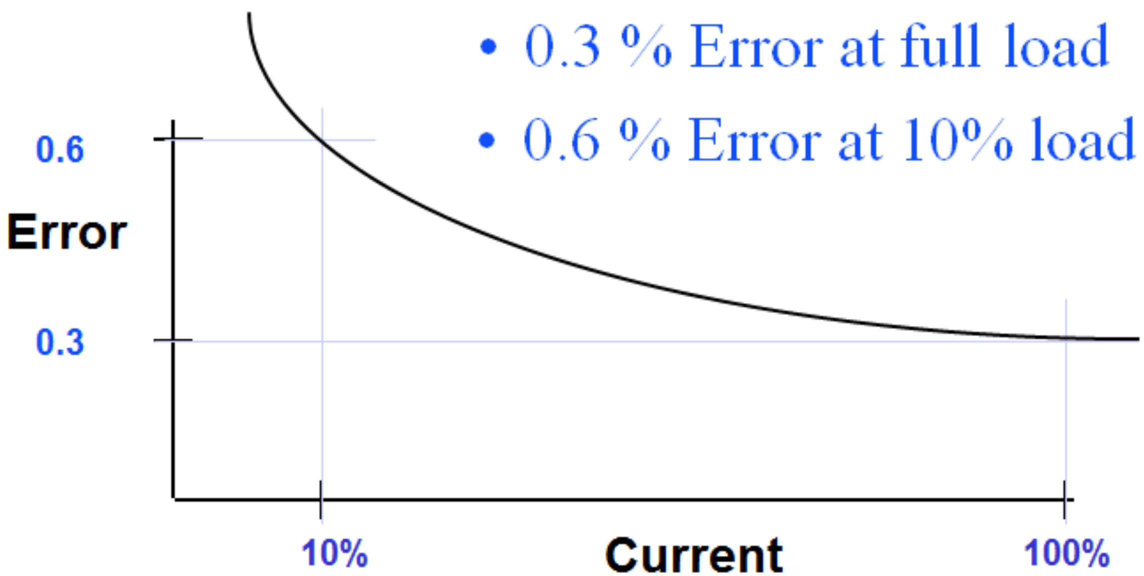
# CURRENT TRANSFORMER ACCURACY

- The corresponding ratio correction factor and phase angle for any point inside the 0.3 class parallelogram for 100% rated current will always give a transformer correction factor between .997 and 1.003.



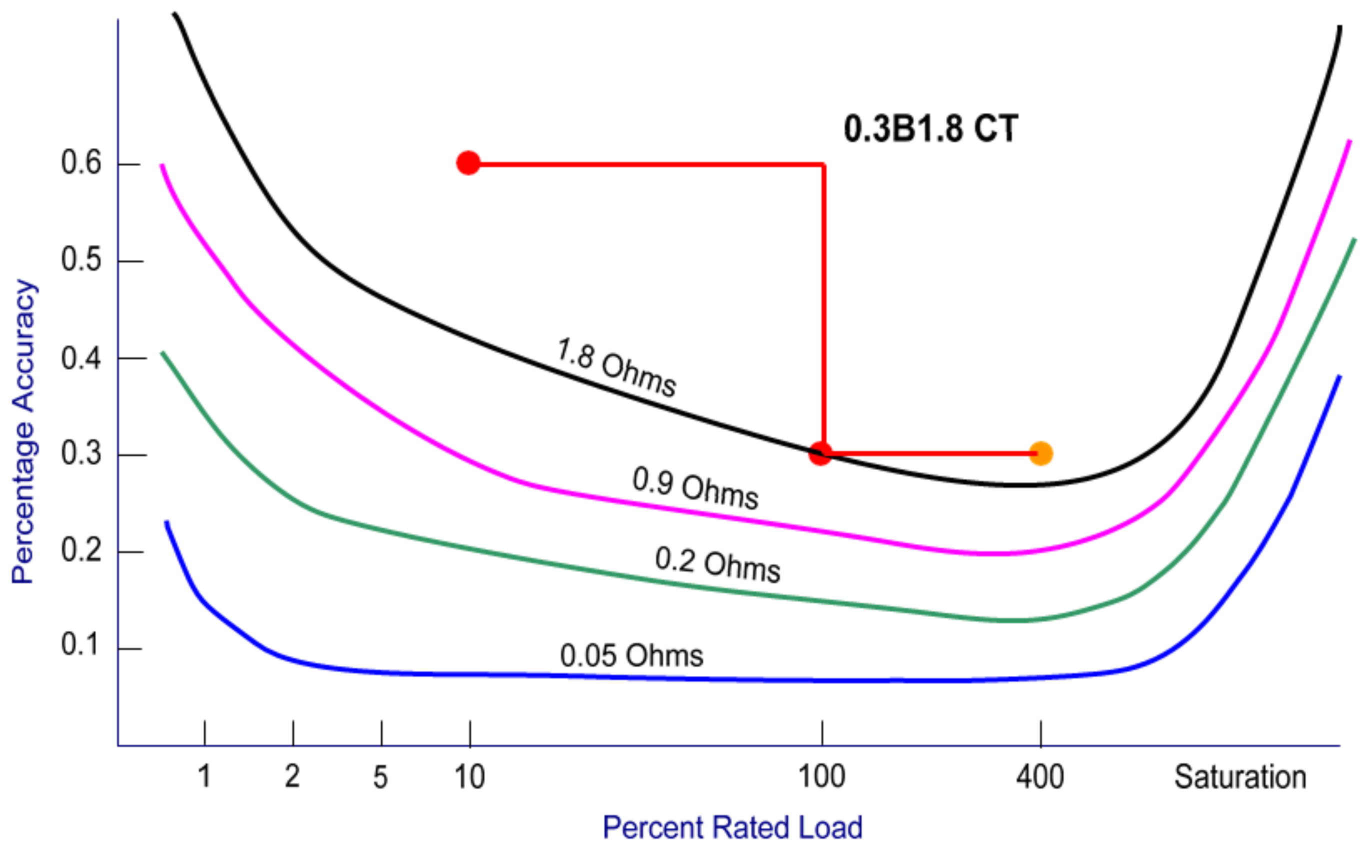
# CURRENT TRANSFORMER ACCURACY

- In addition to burden (secondary load), a CT's accuracy is affected by the Metered Load (primary current).
- The limit of permissible error in a current transformer for a given accuracy class has one value at 100% rated current and twice that amount of error at 10% rated current.
- Below 10% rated current, error may be as much as 5 – 10%.



# CURRENT TRANSFORMER ACCURACY

- Example of a CT with a rating factor of 4 and a rated burden of 1.8



# CT ACCURACY SUMMARY

- A CT's accuracy is best between 100% rated load and it's maximum rated load with rating factor applied.
- Below 10% rated load, a CT's accuracy is unknown and errors can be significant.
- Above maximum rated load (with rating factor applied), a CT's core can become saturated and errors can be significant.
- A CT's accuracy improves as secondary burden decreases.
- Errors in Current Transformer accuracy from any of the above conditions <u>always</u> result in a <u>loss</u> for the utility.

# Sources of Burden on CTs

**1. Size & Length of metering control cable**

- Resistance for #12 copper wire is approximately .0018 Ohms per foot.
- 50 feet of control cable = .09 Ohms burden.

**2. Connections**

- How many connections are in a CT's secondary circuit?
- Quality of connections: Are they tight? Is there oxidation or corrosion?

**3. Meter**

- The current coils in the meter are considered equivalent to a short circuit and the burden imposed on the circuit is insignificant.

# CT RATING FACTOR

- Rating factor (RF) is a term which applies only to current transformers.
- Also known as “thermal rating factor” or “continuous thermal rating factor.”
- It is the number by which the primary load current may be increased over its nameplate rating without exceeding the allowable temperature rise and accuracy requirements.
- The rating factor is temperature dependent.
  - The ambient temperature at which the rating factor applies will be stated.
- The standard ambient reference levels are at 30 and 55 degrees centigrade. (86 and 131 degrees Fahrenheit)
- Usually, the manufacturer will only list the rating factor at 30 degrees ambient.
- It is very important that the ambient temperature be considered when applying CT’s above the nameplate rating.

# CT Rating Factor

- If a current transformer has a rating factor of 4 at 30 degrees centigrade, it will safely carry, on a continuous basis, 4 times the nameplate rating.

- In other words, a 200:5 CT with a RF of 4 will safely carry 800 amps at 30 degrees centigrade ambient temperature.

- We can use the formula below to determine what the CT's rating factor would be at 55 degrees centigrade or at any other temperature:

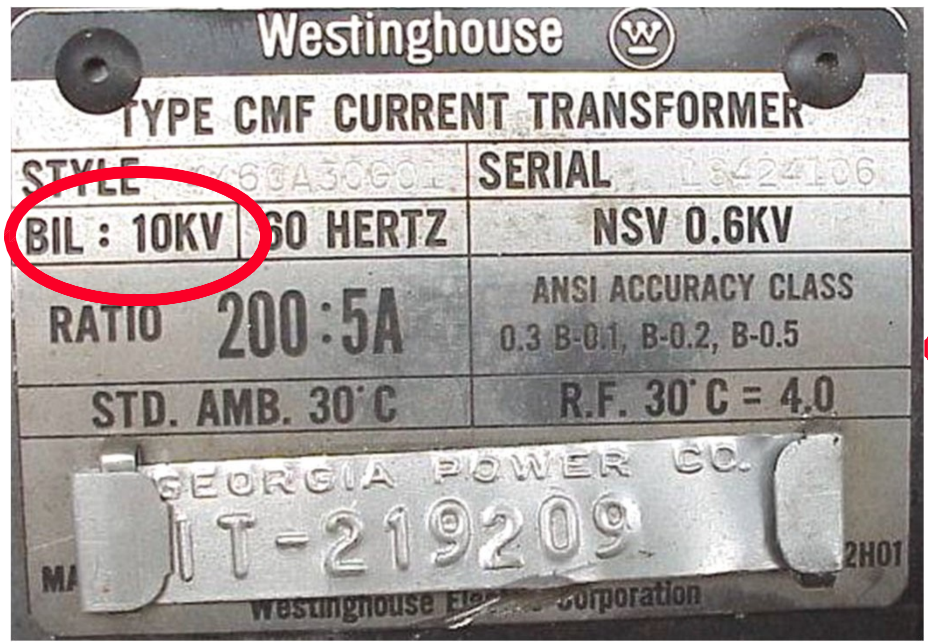
$$New\ \ RF = \sqrt{\frac{(stated\ \ RF)^2\ (85 - new\ \ Amb\ {}^{O}C)}{55^{O}C}}$$

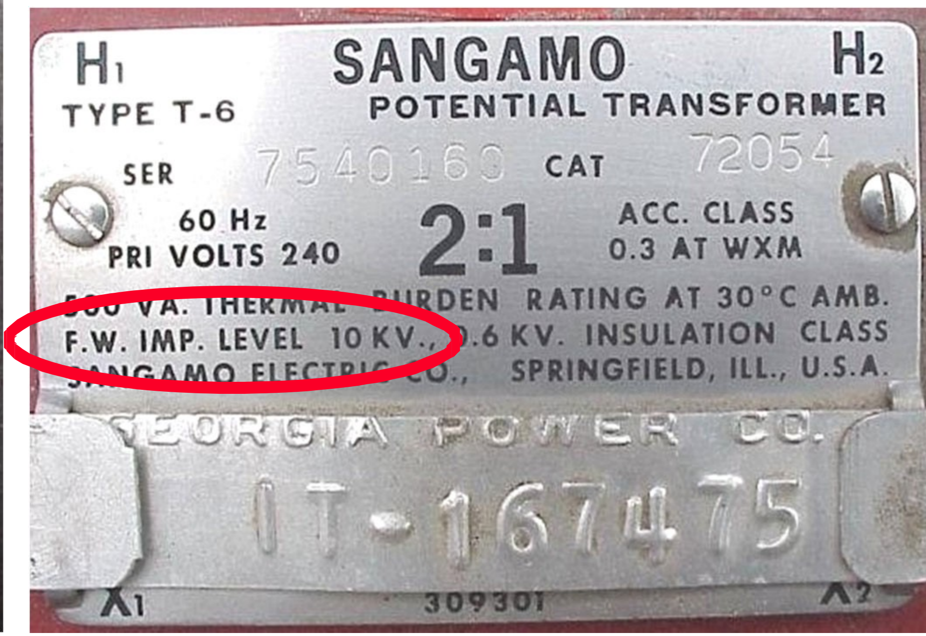
- The rating factor of this CT at 55 degrees centigrade would be:

$$New\ RF = \sqrt{\frac{4^2\,(85-55)}{55}} = 2.95$$

# Basic Impulse Level

- The BIL rating on instrument transformers are test ratings and never apply to actual in-service voltage.
- These test values are for factory dielectric tests that are designed to check the insulation and workmanship of instrument transformers.

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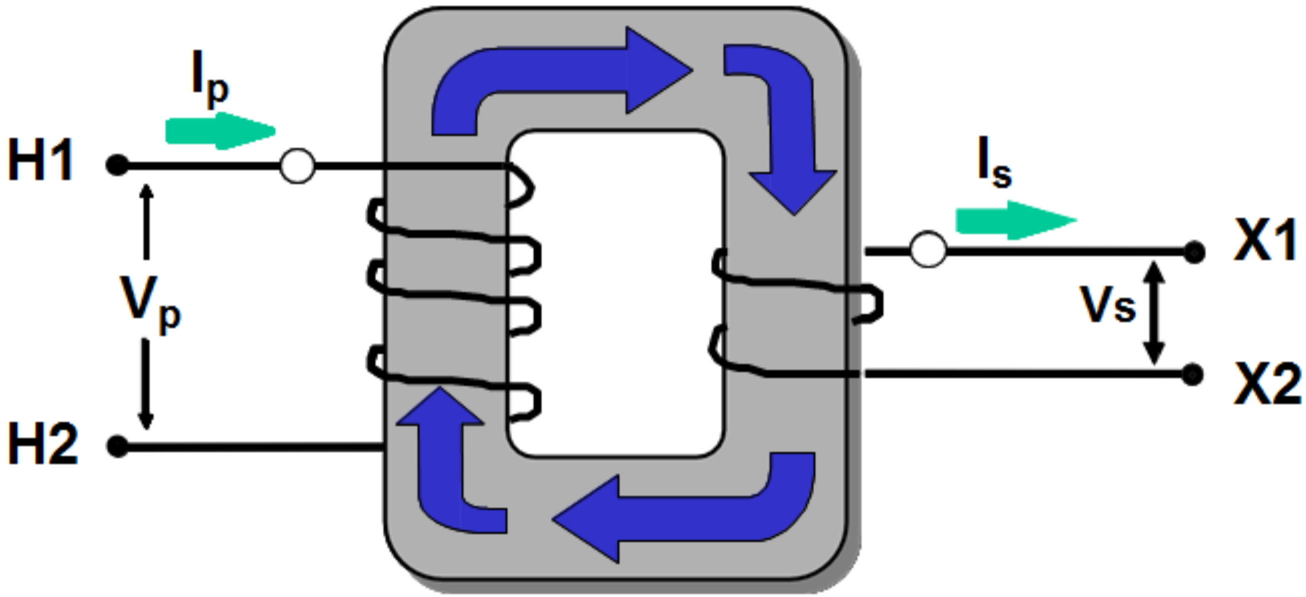
# POLARITY

- Primary and secondary terminals of instrument transformers are said to have the same polarity when, at a given instant, the current enters the identified or marked primary terminal and leaves the identified or marked secondary terminal in the same direction as though the two terminals formed a continuous circuit.
- In the application of instrument transformers it is necessary to understand and observe polarity markings when connecting watthour meters to them.
- All instrument transformers, whether current or potential, will have polarity marks associated with at least one primary terminal and one secondary terminal.
- The polarity markings are often white dots.
- The polarity markings are sometimes a letter and number combination. H1 for the primary marking and X1 for the secondary mark.

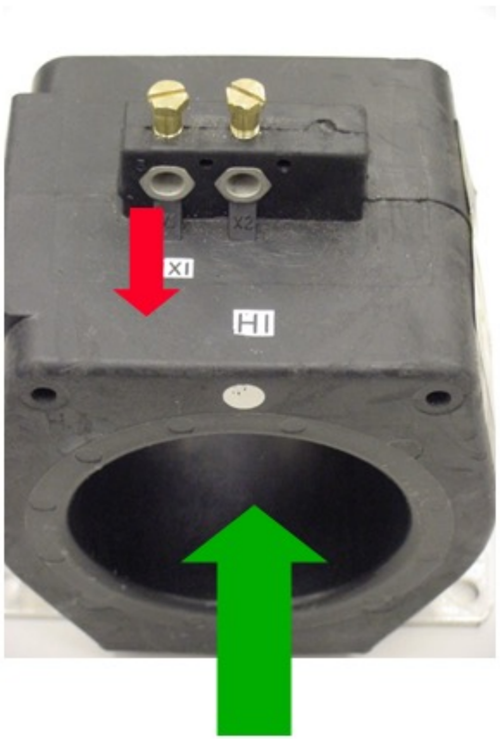
# POLARITY

When primary current enters H1, secondary current leaves X1.




**All IT's are subtractive polarity!**

# POLARITY



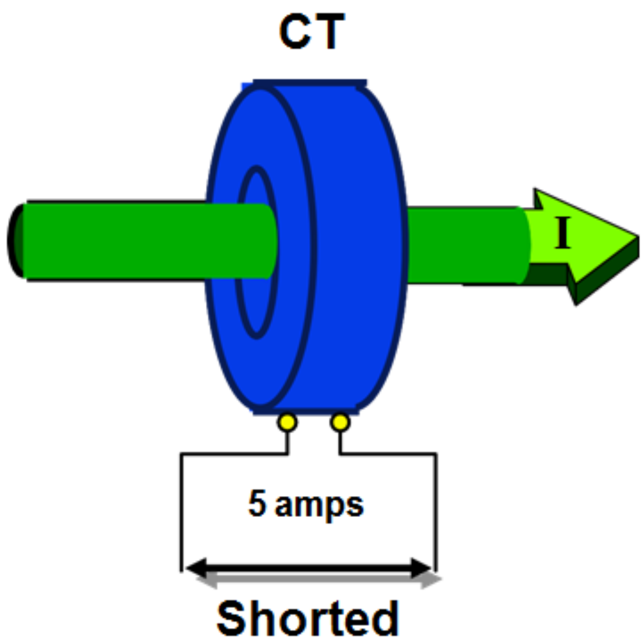

Primary Current In

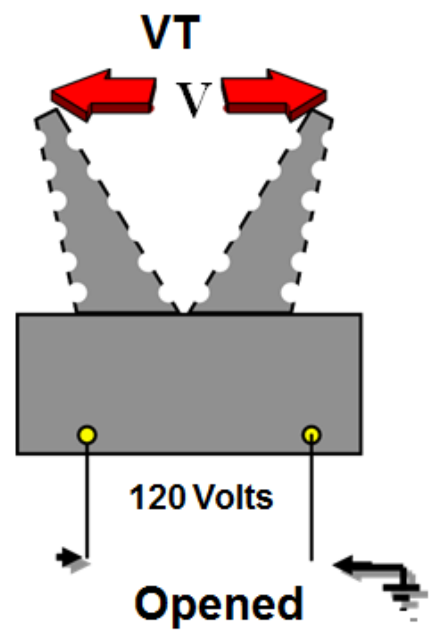
Secondary Current Out

# Secondary Currents: Rules to Remember

While in service:

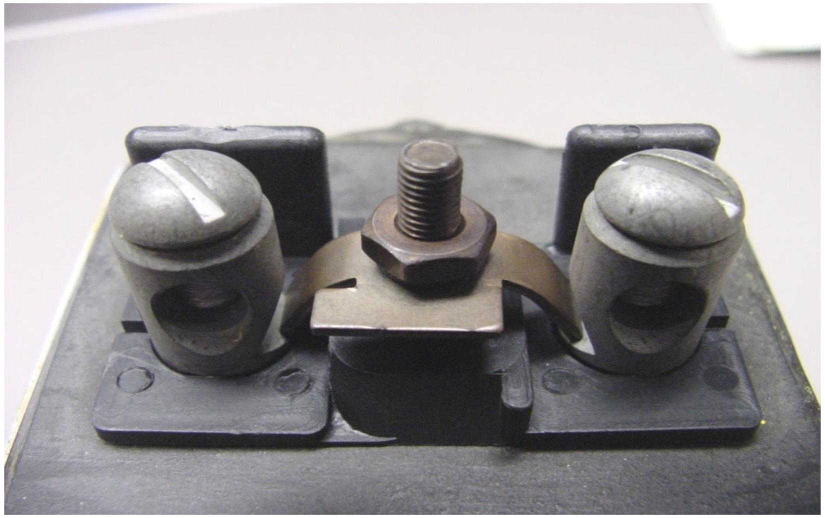
1. Never open circuit a CT secondary.
2. Never short circuit a PT secondary.



# CT SECONDARY CIRCUITS

- The current transformer has a low voltage secondary as long as the secondary connection is a continuous connection. This continuous connection normally exists through the metering control cable and the current coils in the meter. The meter may be by-passed by closing the shunting device on the CT or by opening the current switches on the test-switch block.



# CT SECONDARY CIRCUITS

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- If at any time, the secondary connection is opened and there is current flowing in the primary, the CT becomes a step-up voltage transformer and the secondary voltage can rise to very high voltages.

- This can be understood by some basic Ohm's Law calculations.
  - E = I R

- With a continuous secondary connection, the resistance is very low and the voltage remains very low. But, as the secondary circuit is opened, the resistance rises very rapidly and the secondary voltage can quickly rise to thousands of volts. The actual formula is:

$$E = \sqrt{3.5 \bullet Z_b \bullet I_s}$$

- The high voltage that is present on the open secondary of an energized CT poses two hazards. The first is an electrical shock hazard to personnel. The second hazard is the breakdown of the current transformer's insulation, resulting in damage or destruction of the transformer.

# OSHA Standard 1910.269(w)(2)

*"Current transformer secondaries." The secondary of a current transformer may not be opened while the transformer is energized. If the primary of the current transformer cannot be de-energized before work is performed on an instrument, a relay, or other section of a current transformer secondary circuit, the circuit shall be bridged so that the current transformer secondary will not be opened."*

tescometering.com

# Site Verification & Safety

MEUA

*3/12/24*

2:15 – 3:00 PM

Perry Lawton, TESCO

# SITE VERIFICATION: 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.***

# Potential list of tasks to be completed during a Site Verification of a Transformer Rated Metering Site

- Double check you are at the correct location by verifying the site and the meter serial number against your records

- 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.

# SITE VERIFICATION CHECKLIST (CONT)

- 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 issue.
- Burden test CTs and voltage check PTs.
- 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.

# Site Verification Checklist (cont)

- 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.

# Site Verification Checklist (cont)

- 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

# 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

# Admittance Testing

- What is Admittance?
- Admittance testing measures the overall “health” of the secondary loop of the CT.
- Measured in units of MiliSiemens (mS)
- Admittance is the inverse of impedance.
- Impedance is the opposition to current.
- Therefore, admittance testing measures the overall “health” of the secondary loop of the CT.

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# ADMITTANCE TESTING

- Admittance testing devices inject an audio sine wave signal into the secondary loop of the CT.
- The resulting current is measured.
- The voltage of the initial signal is known.
- From these two parameters, the impedance, and thus the admittance can be calculated.

# Admittance Testing

- Admittance test results are not immediately intuitive.
- Some analysis and interpretation is need.
- What do all these mS values mean?

# ADMITTANCE TESTING

Three phase process is recommended.

1. Test each CT individually
2. Test the matched sets
3. Test over time

# De-magnetization

CT's can become magnetized, due to a number of reasons, including leaving the shorting clip open, near lightning strikes, and harmonic content.

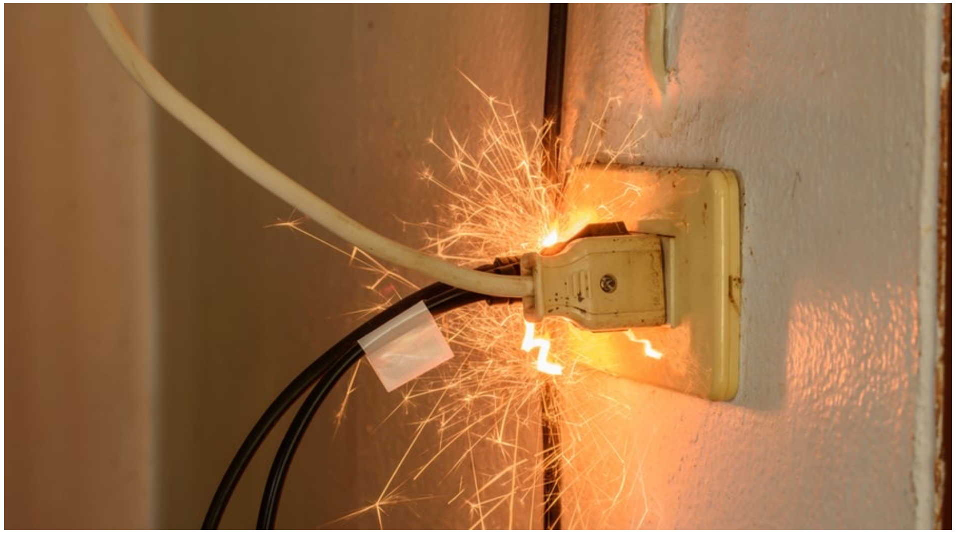
CT's can be demagnitized by slowly and smoothly increasing the secondary resistance until saturation occurs, and then slowly and smoothly decreasing the secondary resistance.

A resistance that will cause a secondary current reduction of 65% to 75% will typically put the CT into saturation.

*Some information has been taken from Radian Research's Application Note 1109A: Admittance Testing Verifies CT Testing Integrity

## Fatal Electrical Injuries

- The highest rate of fatal electrical injury in 2019 occurred in the Construction industry (0.7/100,000), followed closely by the Utility industry (0.4/100,000).
- In 2019, there was one electrical fatality for every 33 fatalities from all causes. The long-term trend has declined from one electrical fatality for each 23 fatalities from all causes in 2003 to the 2019 level of one in 33.



# Does Age Matter – Or Experience?

## Fatal Electrical Injuries

- In 2019, 8% of all electrical injuries were fatal.
- By age group Fatalities tend to go down with age and experience (and perhaps a healthier respect for electricity).
    - 16 to 17 – 5.4 times as likely as the average worker to experience an electrical injury on the job site.
    - 18 to 19 years age group – 2.4 times
    - 20 to 24 years age group - 1.8 times
    - 25 to 34 years age group - 1.5 times
    - 35 to 44 years age group – 1.1 times, and;
    - those 45 years and up are at or below the average frequency of electrical injury.

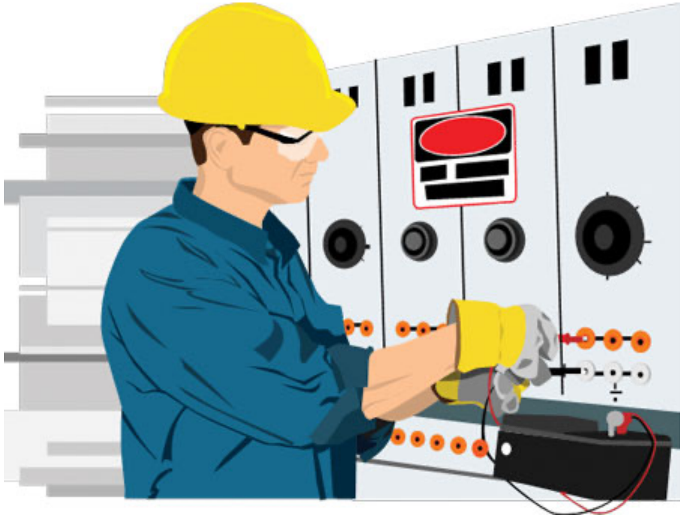
# Non-Fatal Electrical Injuries

- The median number of days away from work for nonfatal electrical injuries was 9 in 2019.
- Electrical injuries are typically classified as burn or shock. For non-fatal injuries, electrical shock injuries were nearly triple the electrical burn injuries in 2019.
- The Utility industry rate of nonfatal electrical injury involving days away from work (0.9/10,000) surpassed the Construction industry rate (0.7/10,000) in 2016.
- The Mining industry had rate of nonfatal electrical burn injury of 1.0/10,000 for 2016, followed by the Utility industry (0.9) followed by the construction industry (0.4). The rate for all of Private industry remained consistent at 0.1.

# How Dangerous is Metering?

**Electricity is Organized Lightning** – George Carlin

Any Voltage without current will not kill you, but any voltage with current can kill you.



# How Dangerous is Metering?

# SAFETY FIRST - PPE

## Personal Protective Equipment

- Leathers
- Rubber Gloves
- Face Shield
- FR Clothing
- Safety Shoes

## What is Arc Flash?

While an arc flash is sometimes used interchangeably with “arc fault”, an arc flash is more accurately defined as the light produced during an arc fault. An arc fault is a type of electrical fault that results from the breakdown of an insulating medium between two conductors where the energy is sufficient to sustain an arc across the insulator (often air) and can cause extreme amounts of light (arc flash), immense heat upwards of 19,000 degrees C, and a resulting explosive pressure wave (arc blast). These forces combine to create a hazardous condition that can vaporize metal, destroy equipment, and pose a significant hazard to anyone in the vicinity.

# COVERING THE BASICS

# More of the Basics

# How Bad Can Things Get?

**Many thanks to Dominion Power**

**https://youtu.be/2Xoyb9M5-EA**

**Rubber Gloves and FR 4:10**

**Meter enclosure – shorted out 10:48**

**Thanks to Meter Grabber**

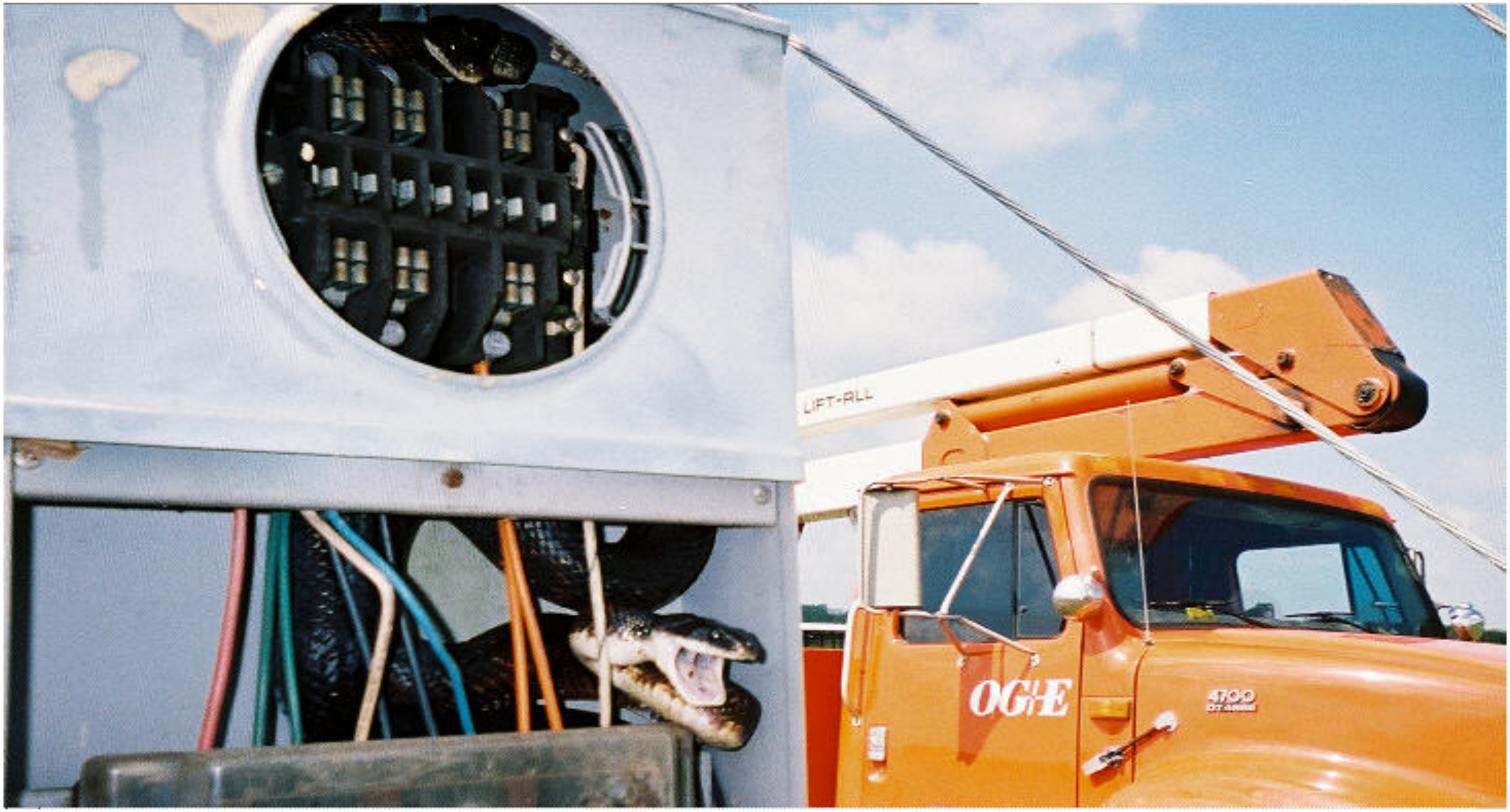
**https://youtu.be/Azuu8VnM36g**

# FIELD AUDITS, TROUBLE SHOOTING AND TESTING

- Always approach an electrical service with caution and while wearing your full PPE. Why?
- Never stand directly in front of the meter when removing the meter
- Before you even open the box or get the cover off….
    - Live box
    - Bees
    - Other live animals
- Broken Seal
- Cover dropping off

# Field Audits, Trouble Shooting and Testing 2

# Field Audits, Trouble Shooting and Testing 3



# ONCE THE BOX IS OPEN: ISSUES TO LOOK FOR

- Open line – open line side connection to the meter socket.
- Missing neutral – missing neutral connection to the center lug in the meter socket
- Cross phase condition – cross wiring between the test block and the meter socket.
- Hidden jumpers line to load – diversion on both legs.
- Dead Short - dead short phase to ground on the load side of one leg of the socket.
- Partial Short - partial short phase to ground on the load side of one leg of the socket

# Backfeed, Ground Fault and other Issues to Look For

- Back fed meter socket
- Ground fault
- Phase to phase fault
- Pulling a meter jaw with the meter

# Tools

- Socket Pullers
- Volt meters
- Specialized tools

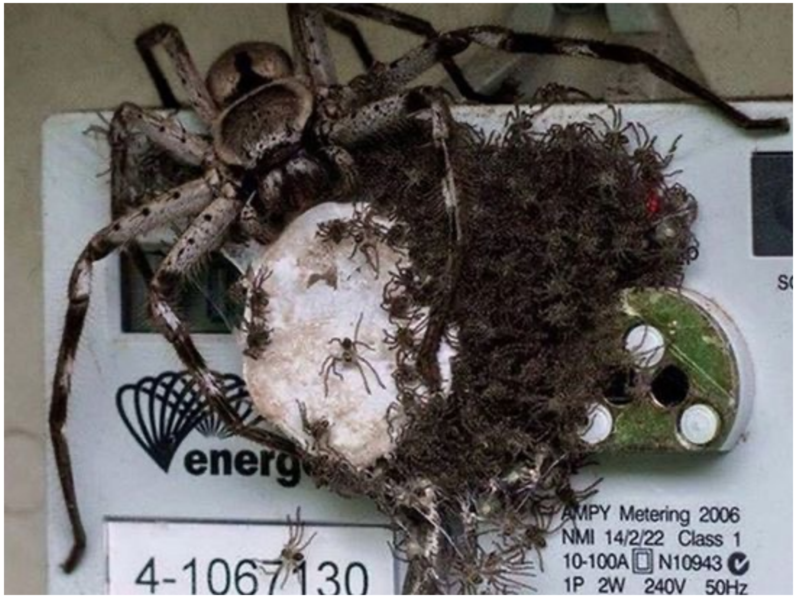


# SUMMARY

- Be Careful
- Assume the box is live
- Assume there is something live in the box
- Treat electricity with respect
- Treat all meter boxes with respect

# Around the Room

- Issues that you may have seen in your metering career already?
- Safety Issues not yet brought up?




## Closing

- Are you not only following the rules but actively making suggestions?

# Most Importantly…

We test and verify the sites to make sure we are not losing money and to make sure the sites are safe.

# QUESTIONS AND DISCUSSION

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