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HIGH ACCURACY CURRENT TRANSFORMERS

TESCO's Meter School

TESCOOL ▶▶

July 10, 2023

11:15 AM – 12:00 PM

Tom Lawton



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WHERE WOULD YOU USE HIGH ACCURACY CT'S?

*Inside
of...*



Generator



Transformers



Transformers



Switchgear



Metering Panels
LV Switchgear, MCC's



Generation

High Voltage Transmission

Medium Voltage

Low Voltage

*Installed
at...*



HV Poles

HV Poles

Substation



MV/LV Poles

Substation

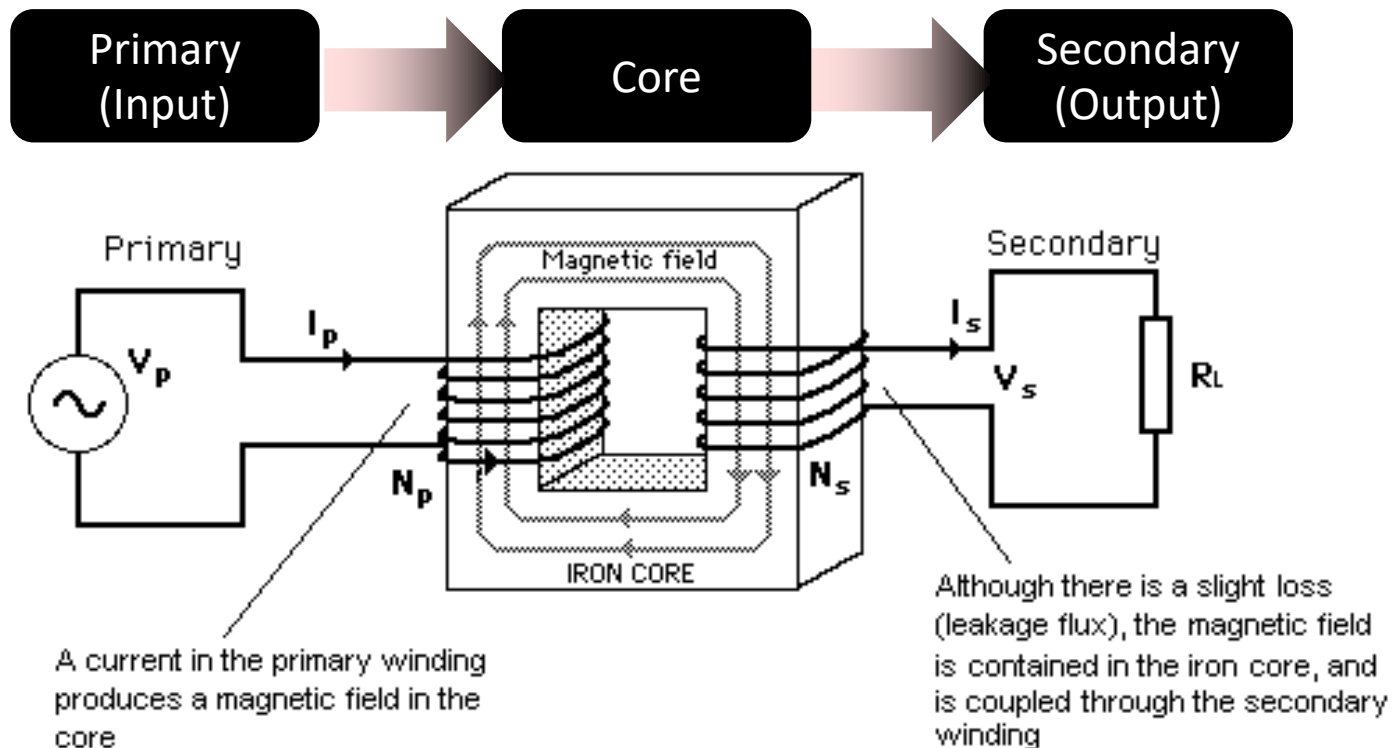


Commercial & Residential

Large Industrial



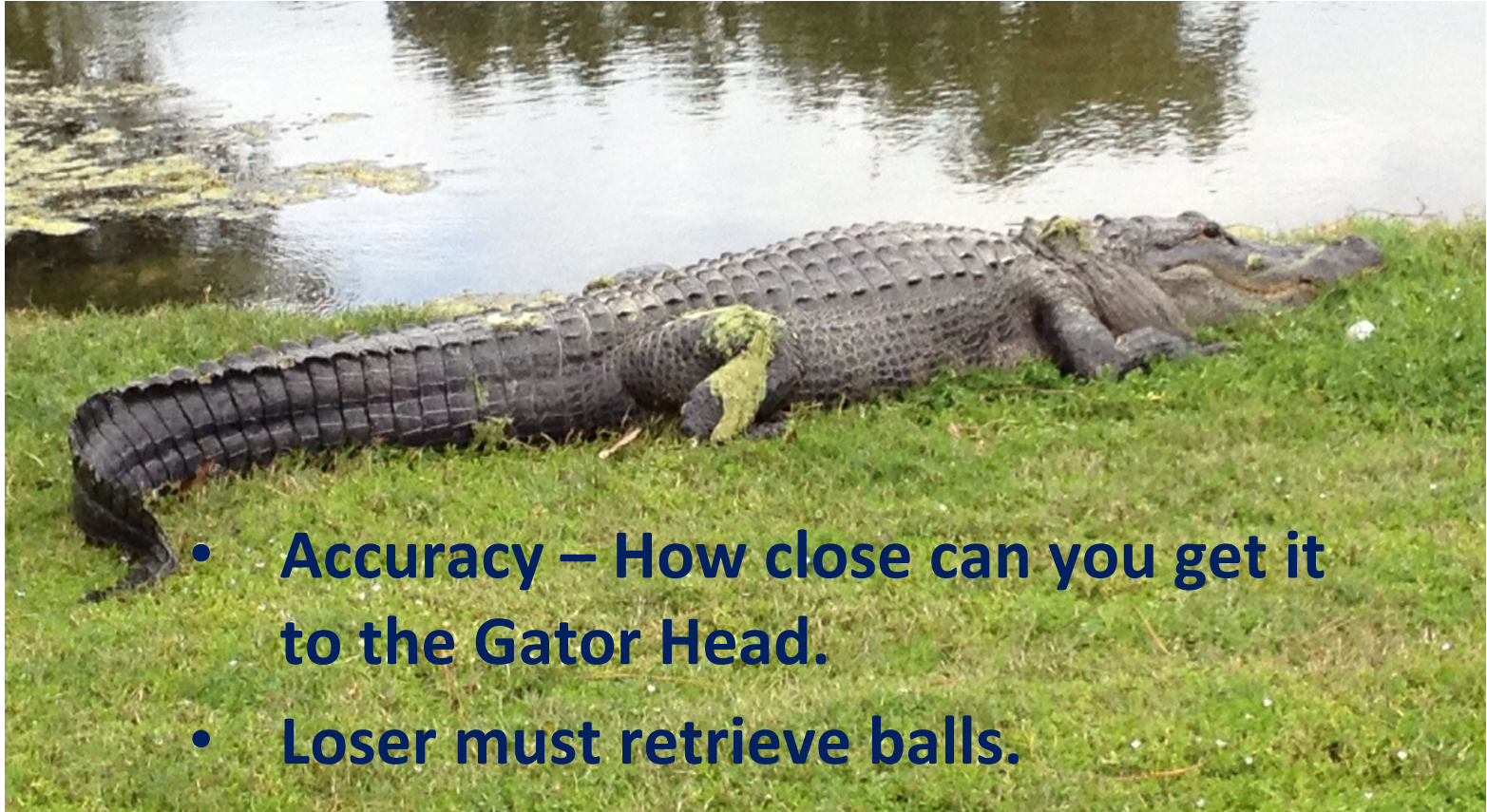
CURRENT TRANSFORMERS



Transform the voltage or current input into a standard 5 or 1 amp output



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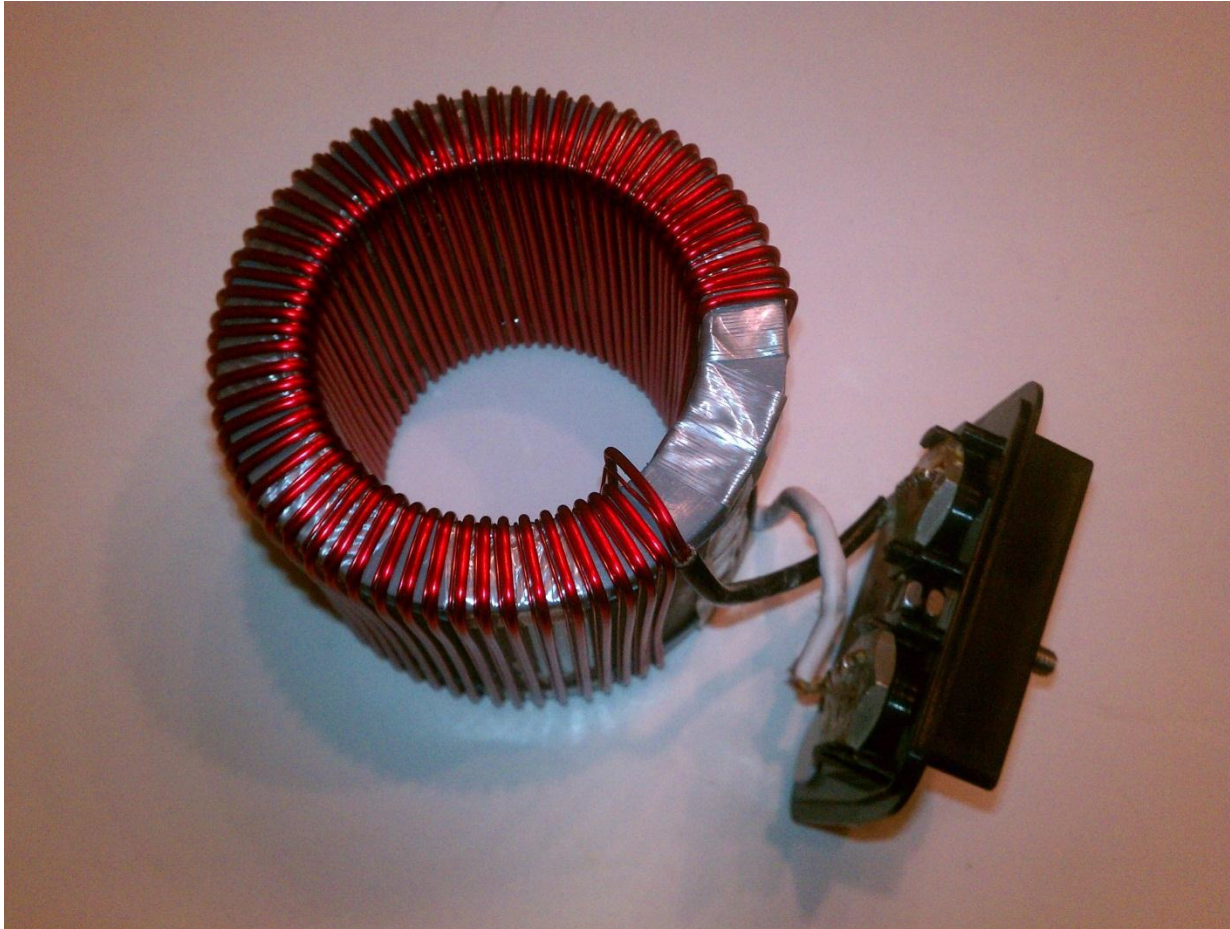


- Accuracy – How close can you get it to the Gator Head.
- Loser must retrieve balls.



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WHAT IMPACTS ACCURACY?



- Number of Secondary Turns
- Core material and/or cross section
- Secondary Burden

ENERGY REQUIRED TO ENERGIZE THE CORE

$$\text{mmf} = \phi \mathfrak{R} = k_1 \left[\frac{Z_s I_s}{N_s f} \right] k_2 \left[\frac{\text{mmp}}{A_c \mu_c} \right] = k_1 k_2 \left[\frac{Z_s I_s \text{mmp}}{N_s f A_c \mu_c} \right]$$

ϕ = flux in the core

$\mathfrak{R}$ = magnetic reluctance

k_1 = constant of proportionality

k_2 = constant of proportionality

Z_s = secondary impedance

mmp = core mean magnetic path

I_s = secondary current

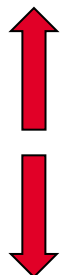
A_c = core cross-sectional area

N_s = number of secondary turns

μ_c = permeability of core material

f = frequency, Hz

If



Secondary turns or core cross section

secondary impedance

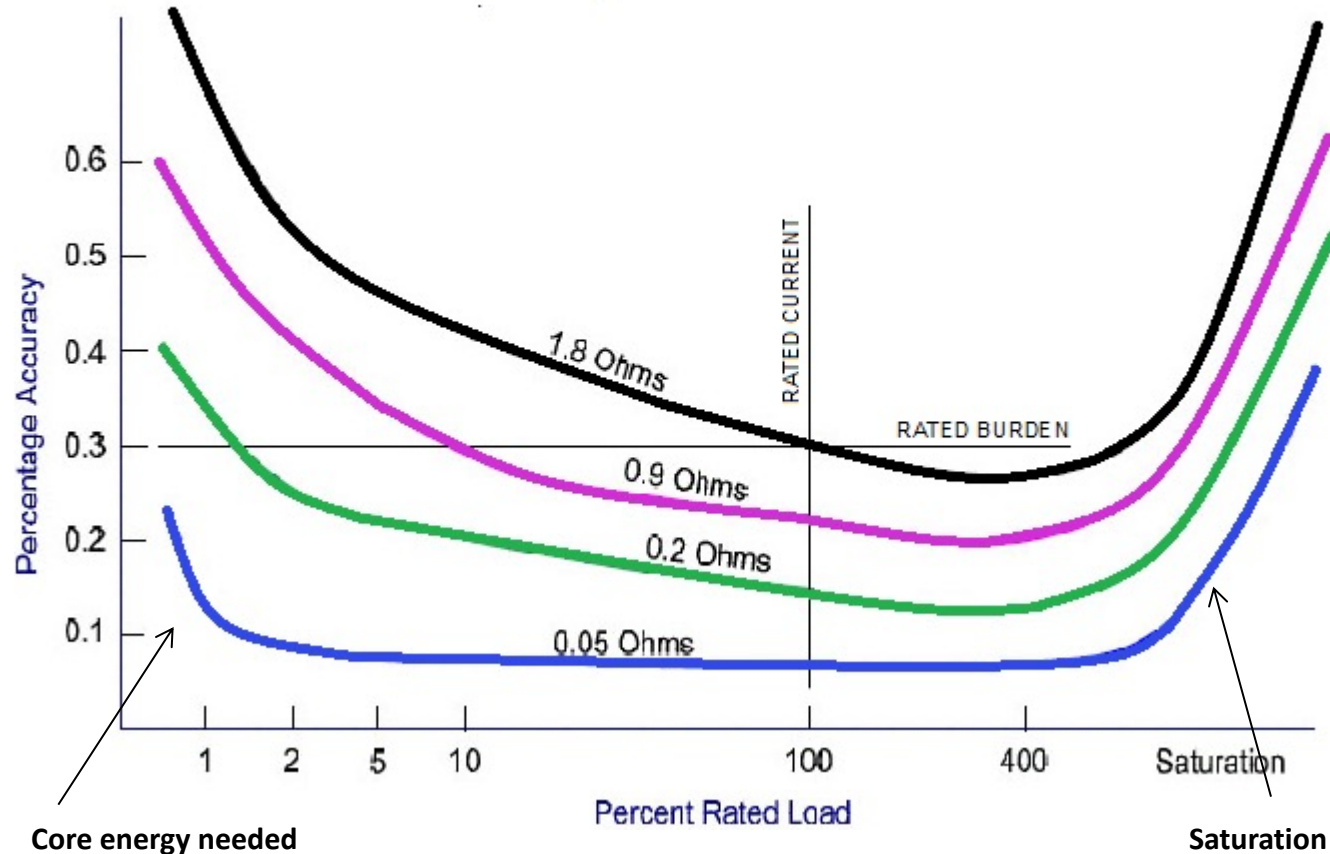
Then



energy required to energize core

Courtesy of Electric Power Transformer Handbook

CT – Accuracy – Burden - Load



CT METERING ACCURACY

Actual secondary
current



Rated secondary
current

Difference in % is known as the
“Accuracy”
of the CT

Definition: There are two sources of error in instrument transformers, namely ratio error and phase angle error. In a given transformer, the metering error is the combination of the two separate errors. This combination is called Transformer Correction Factor (TCF), IEEE has established accuracy classes for both current and potential transformers. The limit of permissible error in a potential transformer for a given accuracy class remains constant over a range of voltage from 10% below to 10% above rated voltage

RATIO CORRECTION FACTOR (RCF)

IEEE C57.13 Terminology

$$\text{RCF} = \text{True Ratio} / \text{Marked Ratio}$$

Example: 500:5 CT

By test, CT Ratio = 100.1

$$\text{RCF} = 100.1 / 100 = 1.0010$$

What does this mean? How many amps is the meter seeing?

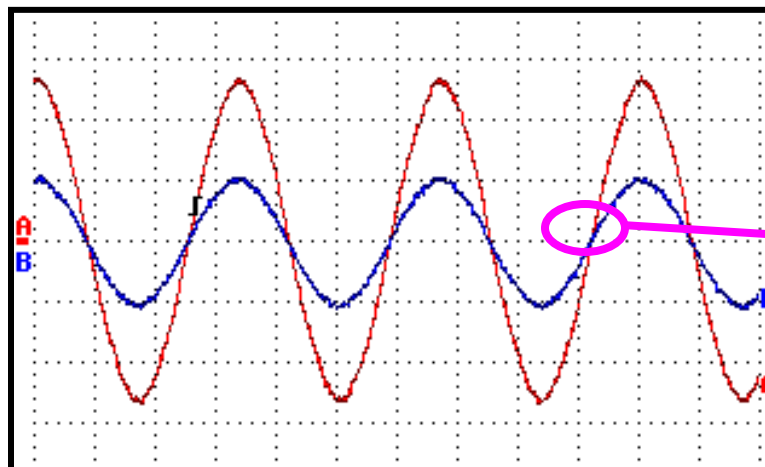
A. – With 500A through primary, only 4.995A is flowing on the secondary $4.995 \times 1.001 = 5\text{A}$. (Negative current error due to losses)

RATIO CORRECTION FACTOR (RCF)

RCF on Knopp Comparator

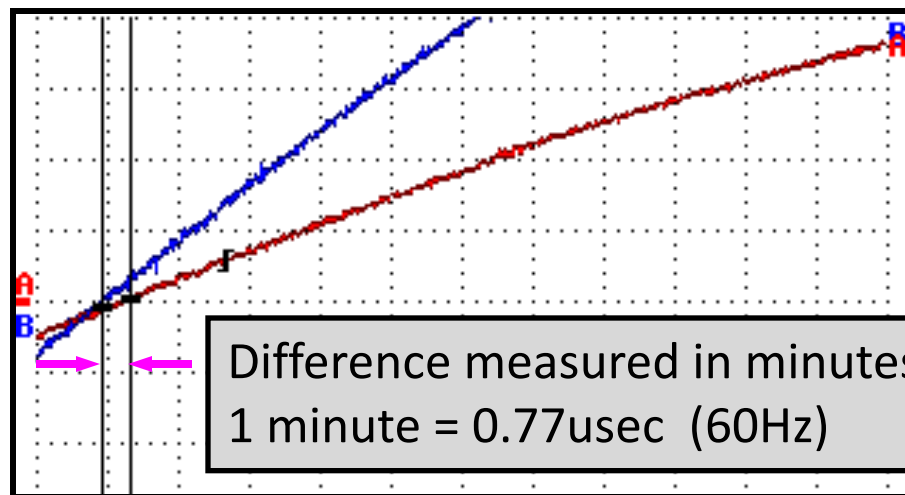


PHASE ERROR



Red = Primary Current
Blue = Secondary Current

When Secondary Current (blue) **leads** the Primary Current (red), Phase Error (°) is defined as **Positive**.

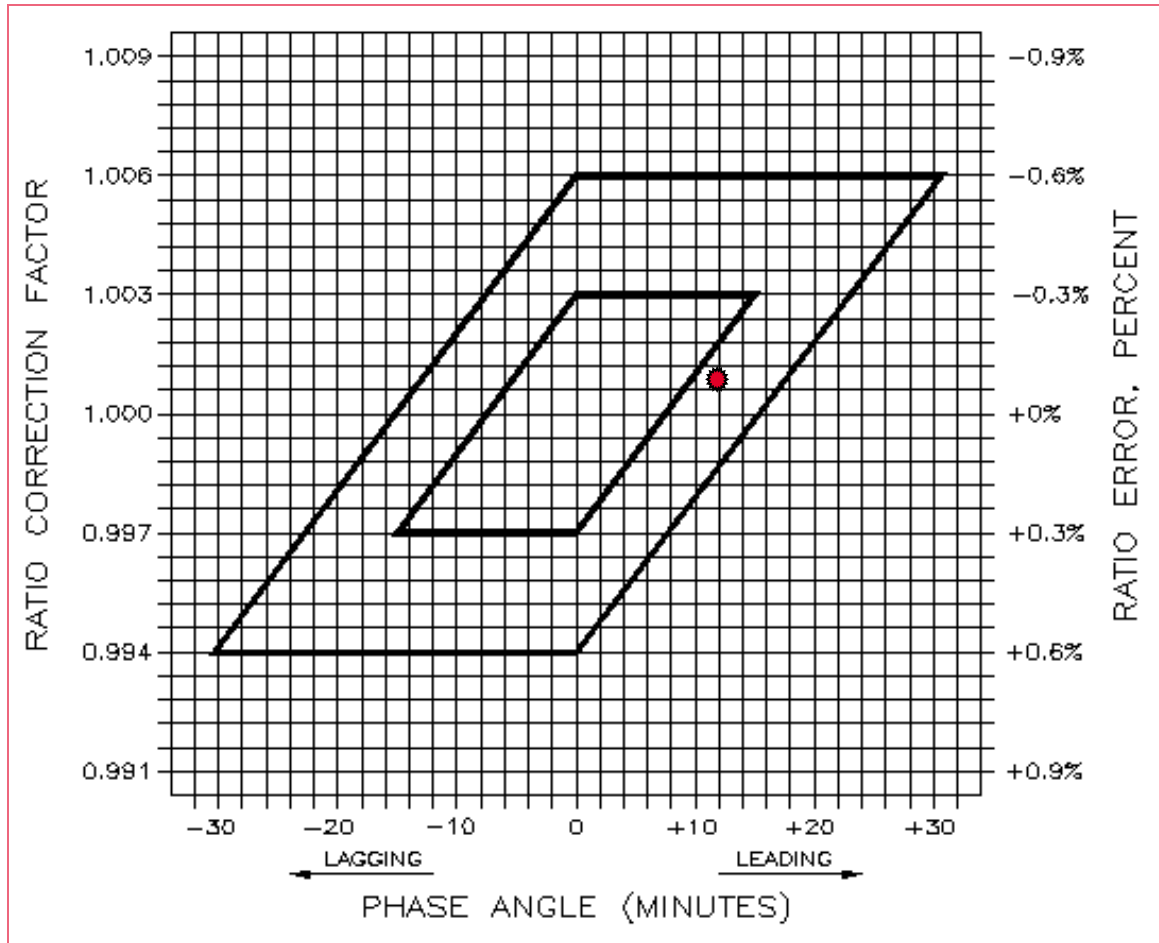


Difference measured in minutes
1 minute = 0.77usec (60Hz)

Phase Error on Knopp Comparator



CT PARALLELOGRAM



**IEEE STD. C57.13 LIMITS OF
ACCURACY CLASS FOR CURRENT
TRANSFORMERS
FOR METERING
0.3 ACCURACY CLASS**

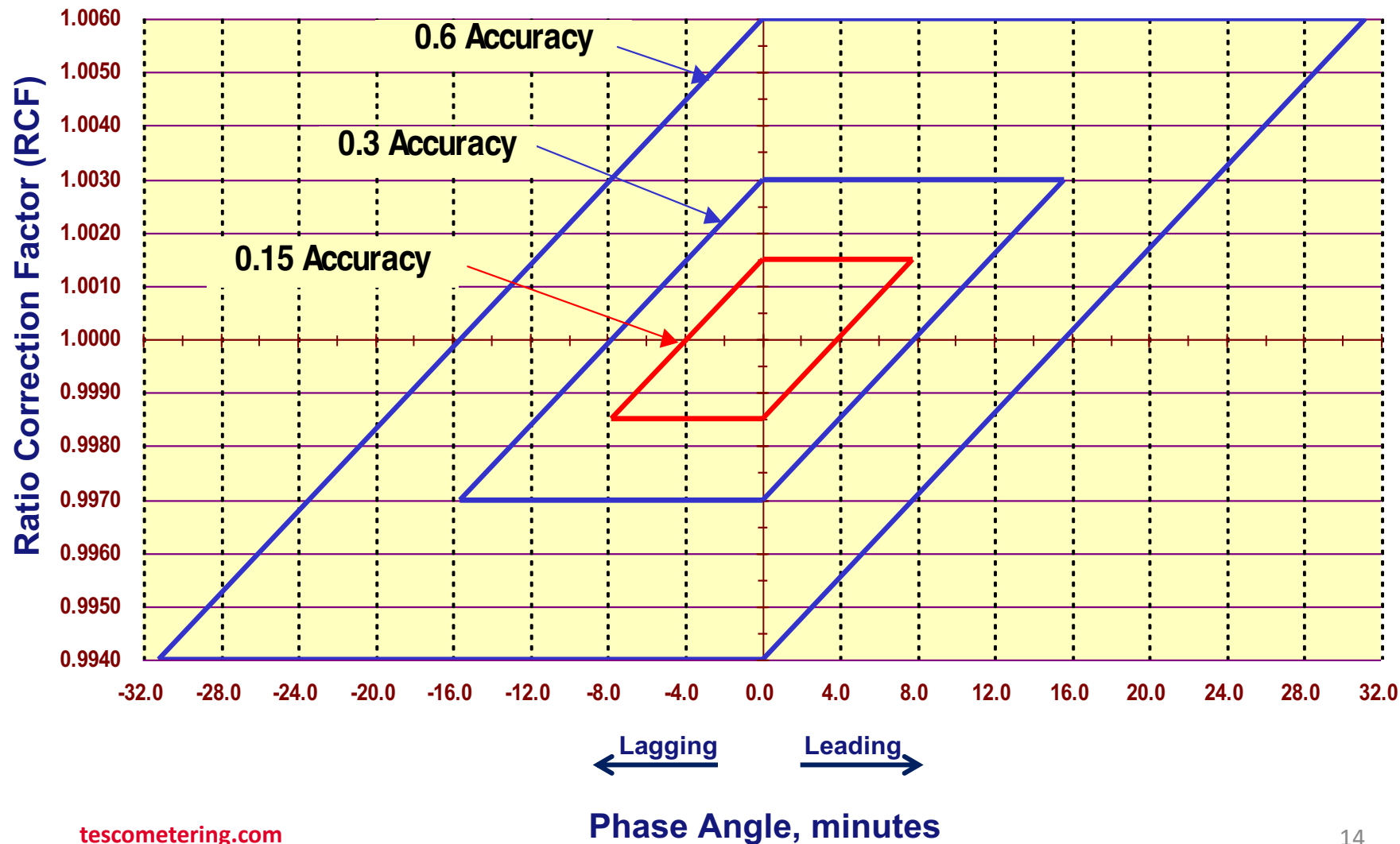
Recall the Knopp
Comparator

The values were:

- Ratio Error = 1.00278
- Φ Angle Error = 5.2

CT PARALLELOGRAM

IEEE C57.13 – ACCURACY LIMITS

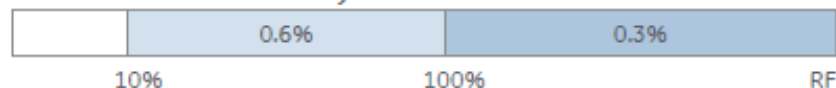




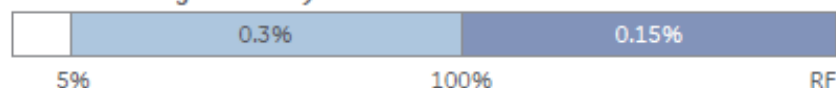
IEEE Metering Class

There are three revenue grade metering classes defined by IEEE C57.13-2008 and C57.13.6-2004. These are illustrated below, with limits shown as a percent of rated CT current:

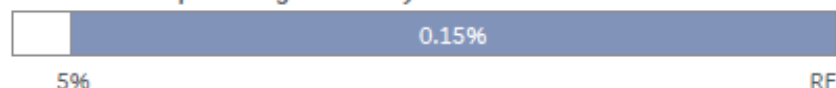
0.3 Class - Standard Accuracy



0.15 Class - High Accuracy



0.15S Class - Special High Accuracy



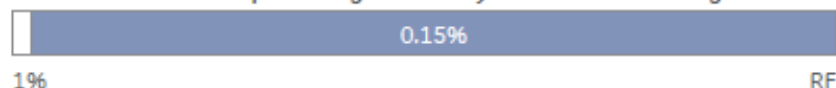
Encompass & RevenueSense Exceed IEEE Standards

Encompass and RevenueSense redefine CT performance by exceeding the operating range within their respective IEEE accuracy classes, offering utilities additional flexibility to reduce inventory, part numbers, and billing multipliers. RevenueSense also allows for a further reduction of metering losses by extending high accuracy performance down to 1% of rated current.

GE Encompass - Standard Accuracy with Extended Range



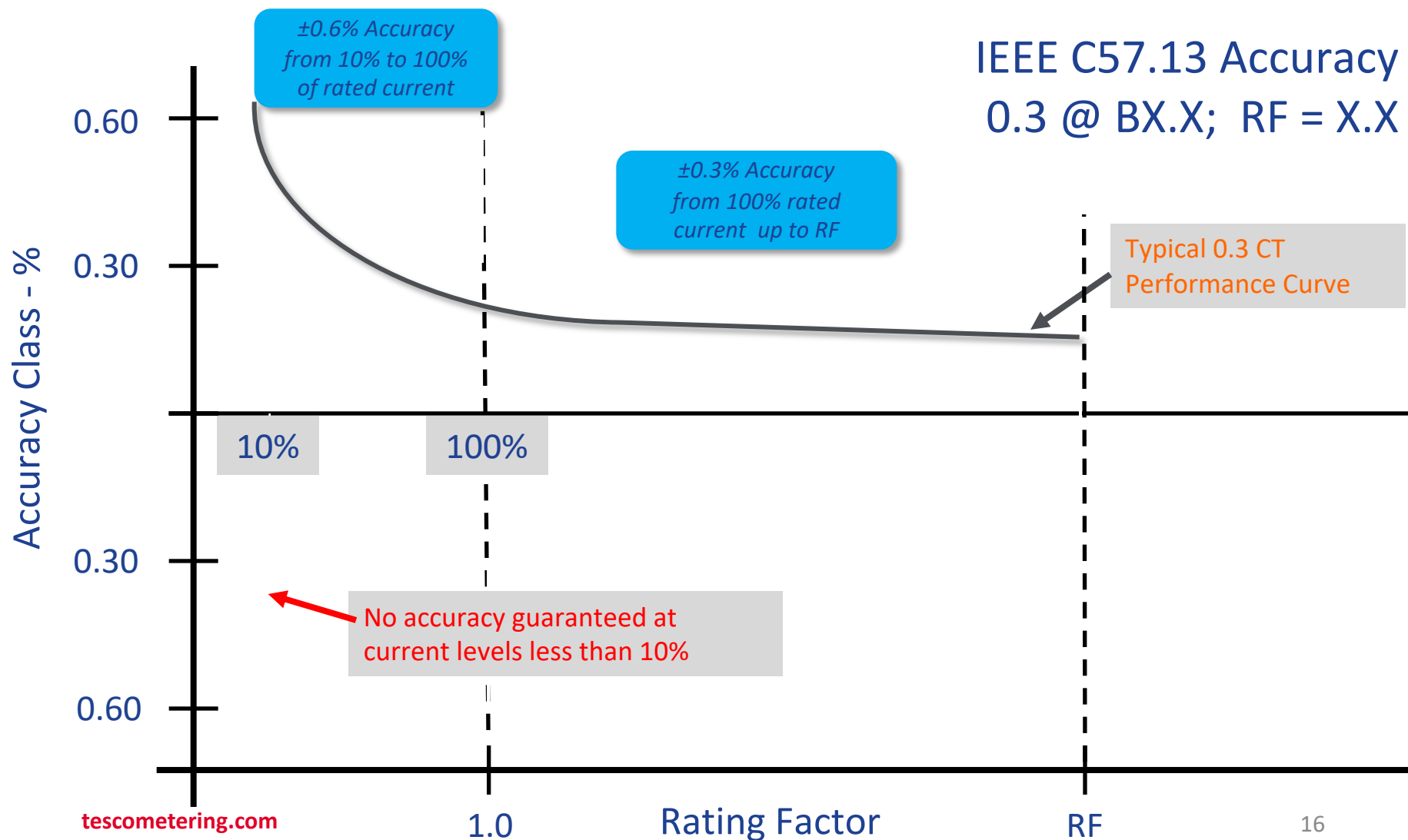
GE RevenueSense - Special High Accuracy with Extended Range





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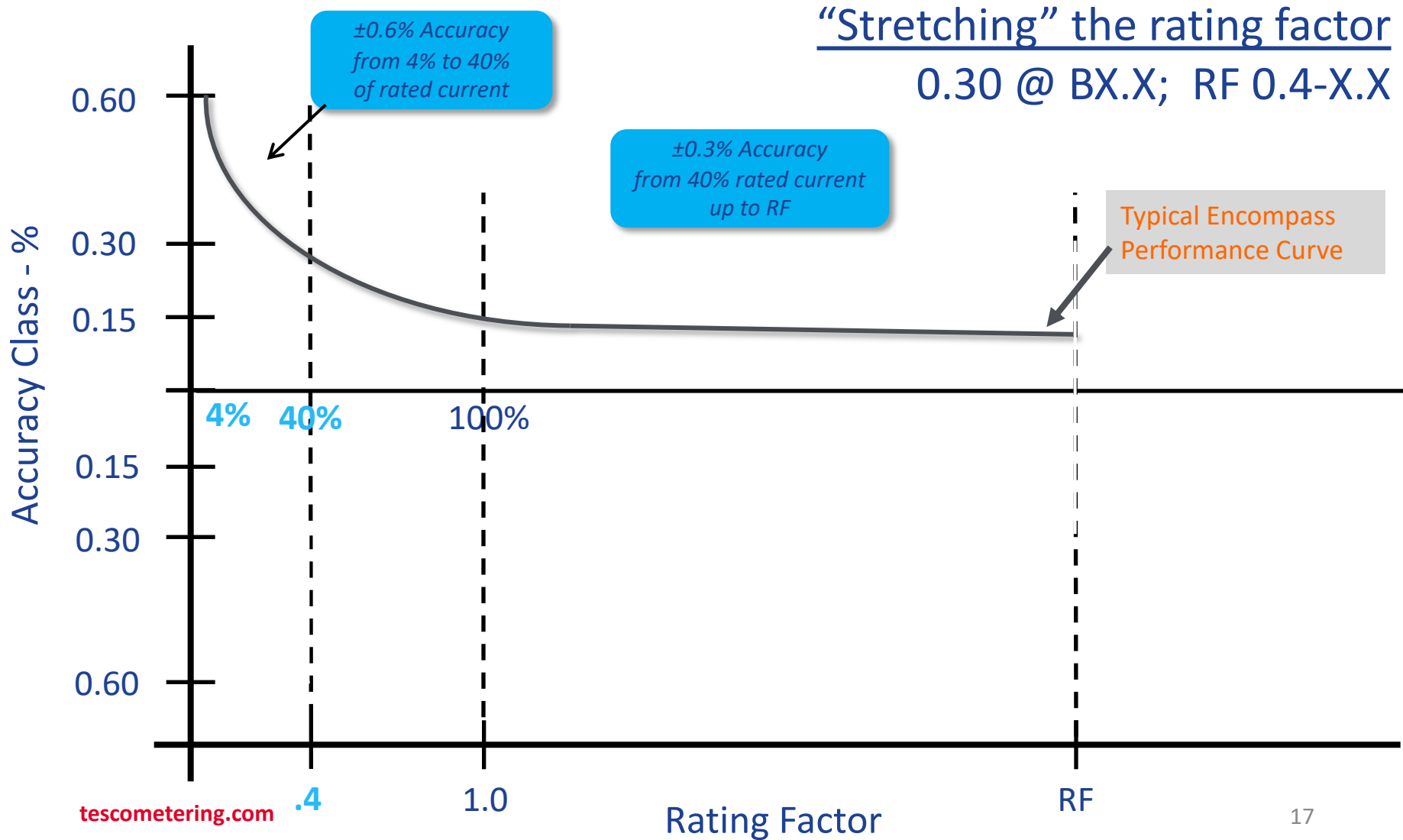
STANDARD 0.3 ACCURACY CLASS





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ITI ENCOMPASS

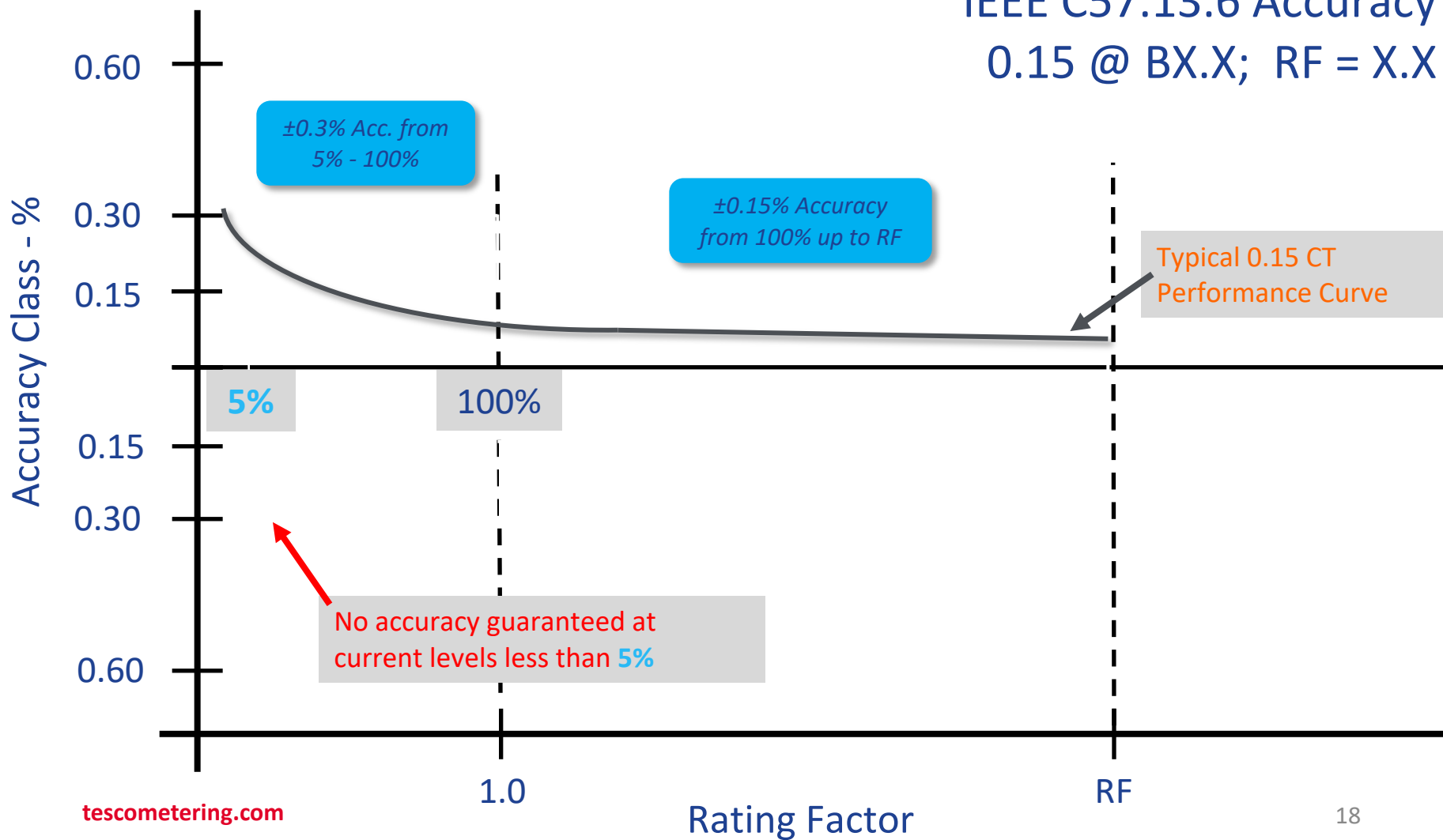




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0.15 HIGH ACCURACY CLASS

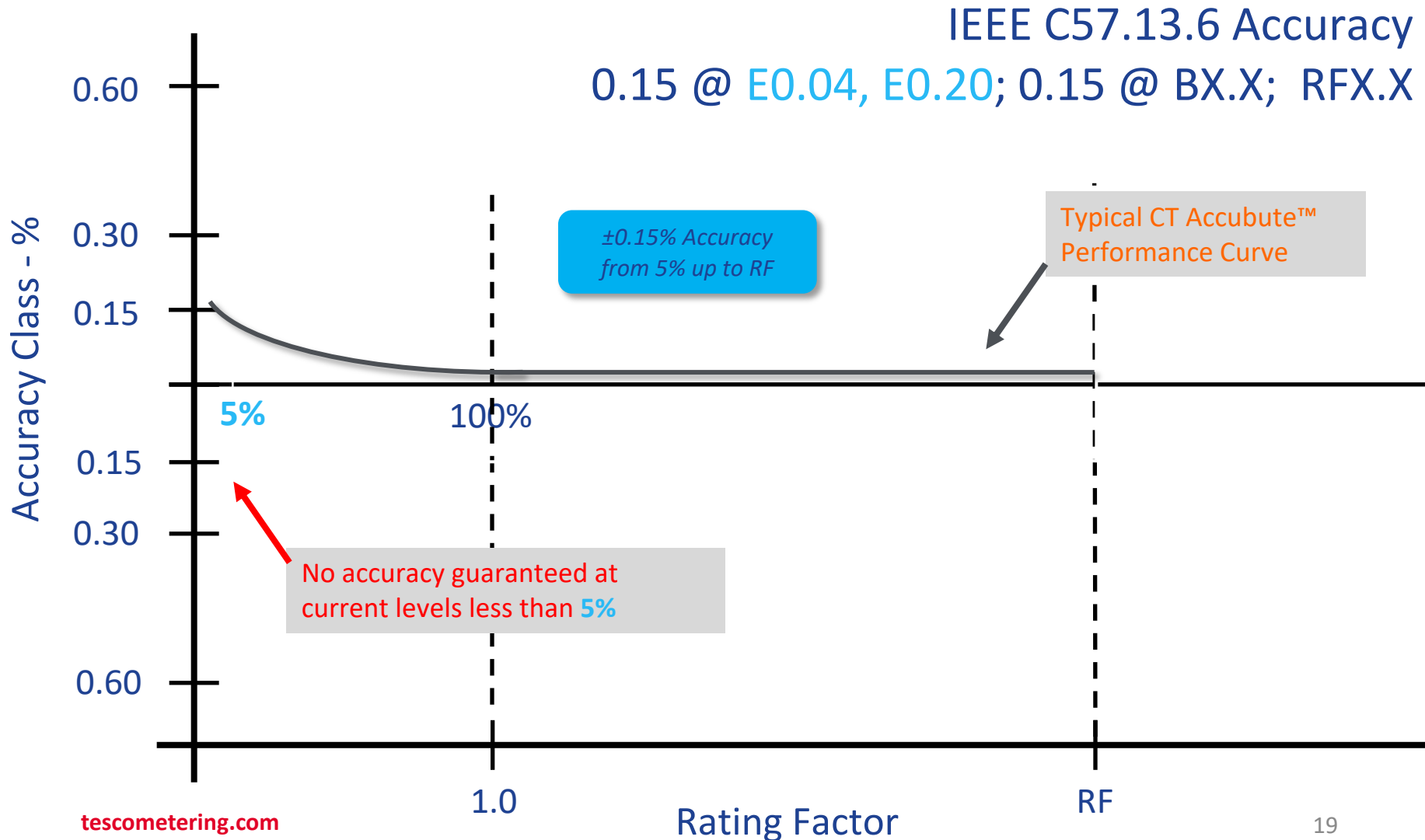
IEEE C57.13.6 Accuracy
0.15 @ BX.X; RF = X.X





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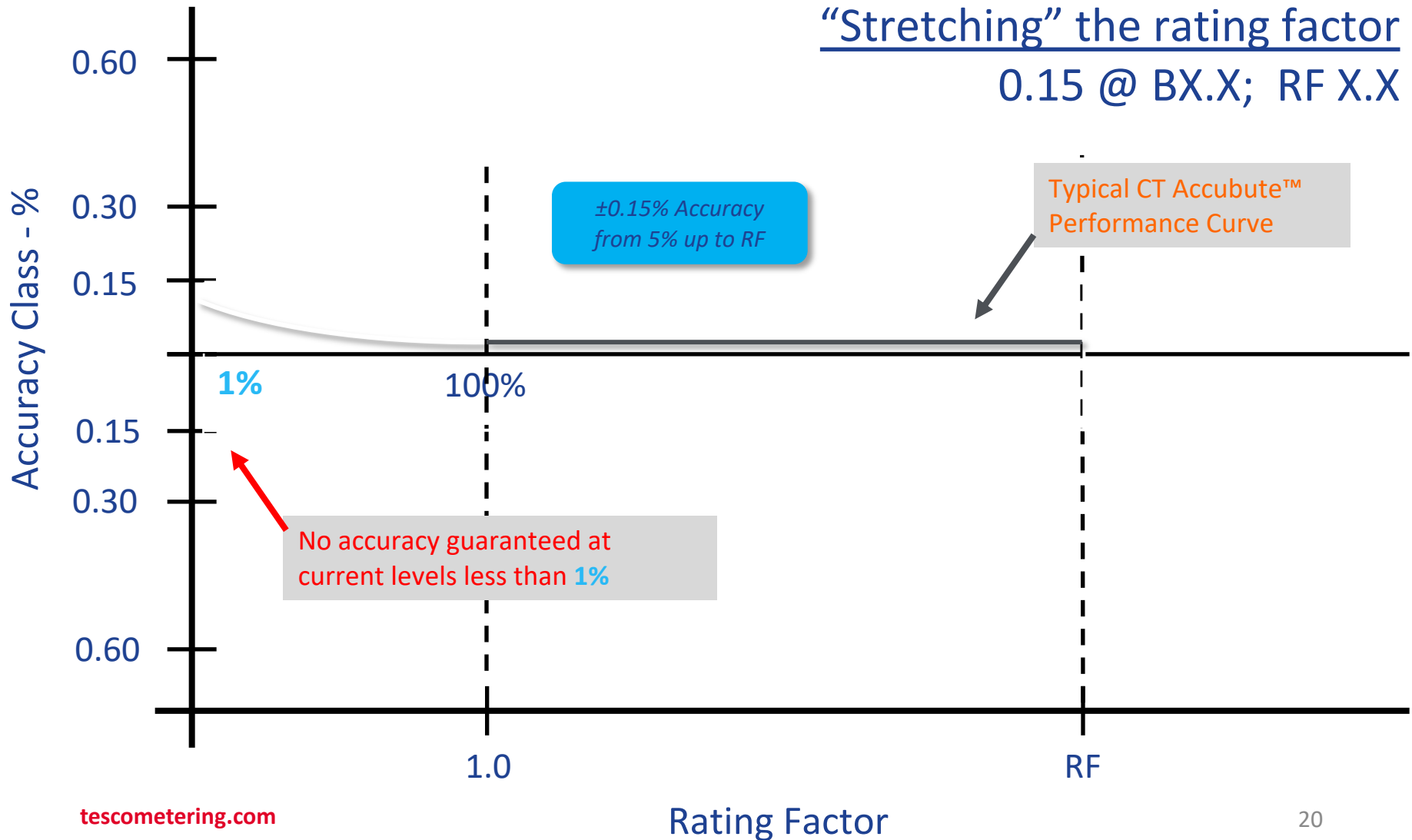
0.15S SPECIAL HIGH ACCURACY (ACCUBUTE)





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0.15S HIGH ACCURACY EXTENDED RANGE



- Standard Revenue Metering Accuracy (IEEE 0.3 Accuracy Class)

- $\pm 0.3\%$ accurate from 100% Nameplate Rating, up to Rating Factor
- $\pm 0.6\%$ accurate below 100% Nameplate Rating, down to 10% of Nameplate Rating

- GE ITI Encompass CT's

- $\pm 0.3\%$ accurate from 40% of Nameplate Rating, up to Rating Factor
- $\pm 0.6\%$ accurate below 40% Nameplate Rating down to 4% of Nameplate Rating

- High Accuracy (IEEE 0.15 Accuracy Class)

- $\pm 0.15\%$ accurate from 100% Nameplate Rating, up to Rating Factor
- $\pm 0.3\%$ accurate below 100% Nameplate Rating, down to 5% of Nameplate Rating

- GE Somersworth Accubute™ (IEEE 0.15S Accuracy Class)

- $\pm 0.15\%$ accurate from down to 5% of Nameplate Rating, up to Rating Factor

- GE RevenueSense High Accuracy Extended Range (IEEE 0.15S Accuracy Class)

- $\pm 0.15\%$ accurate from down to 1% of Nameplate Rating, up to Rating Factor

What do I need to know?

B - Burden

R - Ratio

A - Accuracy

V – voltage class

E – Etc (window size, special requirements)

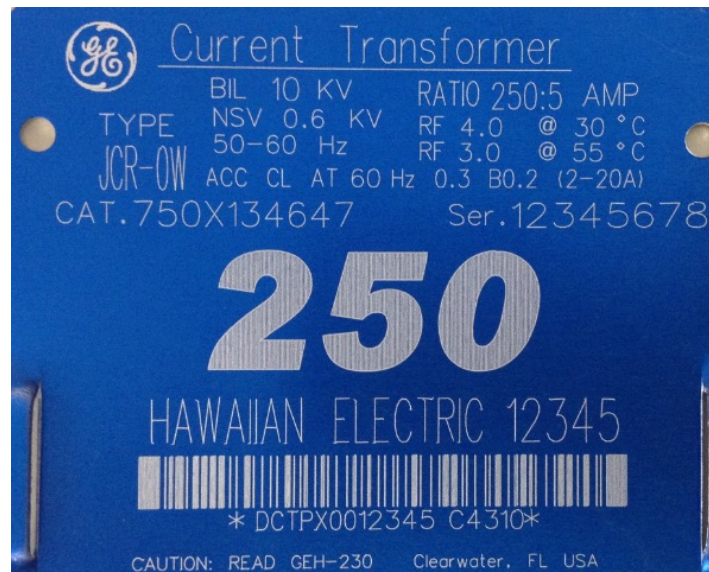
R – Rating Factor

Revenue metering application

NAME PLATE INFORMATION: BURDEN

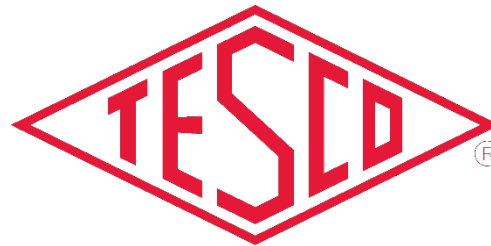
Definition: Load connected to CT secondary

- Includes devices & connecting leads
- Expressed in ohms
- Standard values = B0.1, B0.2, B0.5, B0.9, B1.8
E0.04, E0.2



Standard IEEE CT Burdens (5 Amp) (Per IEEE Std. C57.13-1993 & C57.13.6)

Application	Burden Designation	Impedance (Ohms)	VA @ 5 amps	Power Factor
Metering	B0.1	0.1	2.5	0.9
	B0.2	0.2	5	0.9
	B0.5	0.5	12.5	0.9
	B0.9	0.9	22.5	0.9
	B1.8	1.8	45	0.9
	E0.2	0.2	5	1.0
	E0.04	0.04	1	1.0



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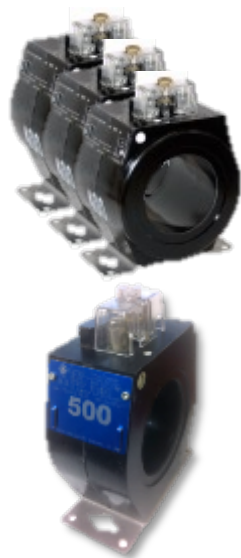
STANDARD ACCURACY EXTENDED RANGE

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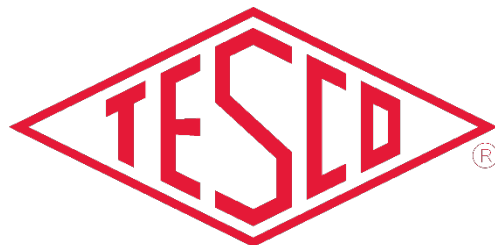
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LOW VOLTAGE ENCOMPASS™ SERIES



System Current	20A	40A	60A	80A	100A	200A	400A	600A	800A	1000A	1200A	1400A	1600A	1800A	2000A
200:5 JAK-0C (Rating Factor 4.0)	±0.6% Accuracy					±0.3% Accuracy									
400:5 JAK-0C (Rating Factor 4.0)						±0.3% Accuracy									
1000:5 JAK-0C (Rating Factor 2.0)						±0.6% Accuracy					±0.3% Accuracy				
500:5 JAK-0W Encompass™ (4% to 400%)	±0.6% Accuracy					±0.3% Accuracy									

One Encompass CT offers equal to, or better accuracy class over the range of multiple legacy CT's



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HIGH ACCURACY EXTENDED RANGE

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LOW VOLTAGE REVENUESense™ SERIES



System Current	6A	20A	40A	60A	80A	100A	200A	400A	600A	800A	1000A	1200A	1400A	1600A	1800A	2000A
200:5 JAK-OC (Rating Factor 4.0)			±0.6% Accuracy				±0.3% Accuracy									
400:5 JAK-OC (Rating Factor 4.0)			±0.6% Accuracy				±0.3% Accuracy									
1200:5 JAK-OC (Rating Factor 1.5)						±0.6% Accuracy						±0.3% Accuracy				
600:5 JAK-OS High Revenue Sense (1% to 300%)	±0.15% Accuracy															

- One RevenueSense™ CT improves accuracy over the range of multiple legacy CT's, with significant improvement at low currents



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PRODUCT LINE SUMMARY

Encompass



Size	Mini	Intermediate	Padmount*	Large
Model	JCR-0W	JAK-0W	JAB-0W	JAD-0W
Ratio	250:5 or 500:5	500:5	500:5 or 1500:5	1000:5 or 1500:5

**Hi Temp available*

RevenueSense



Size	Mini	Intermediate	Padmount*	Large
Model	JCT-0S	JAK-0S	JAB-0S	JAD-0S
Ratio	600:5	600:5 or 1000:5	600:5, 1000:5 or 2000:5	1200:5 or 3000:5

**Hi Temp available*

Current Ratio

“Low ratio” and “high accuracy” are not friends!!

Burden

“High burden” and “High Accuracy” are not friends!!

Physical Size

“Large windows, small cross-section”
and “High accuracy” are not friends!!

SIZING CTs FOR METERING

- Use as low of a ratio as possible with the RF covering the maximum current level
- CT error is **almost** always negative
- Using a more accurate metering class will almost always result in higher revenue levels
- Burden adversely affects accuracy, the lower the applied burden, the better the accuracy performance

QUESTIONS AND DISCUSSION

Tom Lawton

President



TESCO – The Eastern Specialty Company

Bristol, PA

215.228.0500

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

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ISO 17025:2017 Accredited Laboratory