KUHLMAN ELECTRIC
CORPORATION

A MEMBER OF THE ABB GROUP

Asset Management Measurement and Control Solutions

FIELD ENGINEERING SERVICES

Substation Test Information

FES In-service and On-Site Accuracy Testing

Substation Test Information

FES In-service and On-Site Accuracy Testing

1. In-Service Unit Testing

- On-Line Evaluation of BCT RCF/PA
  - CT Revenue Verification
  - CT Excitation Performance
  - CT & Load Problems Identified
- Generator CT Testing
  - CT Performance
  - Wiring Verification

2. On-Site Accuracy Testing

- RCF and PA Metering Certification
- NIST Trace-ability
- Off-Line Test

Substation Test Information
FES In-service and On-site Accuracy Testing

1. In-Service Unit Testing (BCTs and GCTs)

- Variable Resistance Type of Test
  - Existing BCT Burden Disconnected (2 minutes)
  - CT Voltage and Current Values at Different Resistances
  - Wiring Verified

- RCF and PA Data is Derived from Excitation Data
  - Core Cross-Section Information is Assumed
  - Data not Traceable

- Must have access to shorting terminal to replace burden

ON-LINE TESTING OF CURRENT TRANSFORMERS

THEORY OF OPERATION

The proposed method uses the well known equation:

$$I_{sec} = \frac{I_{pri}}{N} - I_{exc}$$ where

I_{sec} - secondary current
I_{pri} - primary current
I_{exc} - secondary exciting current
N - number of turns

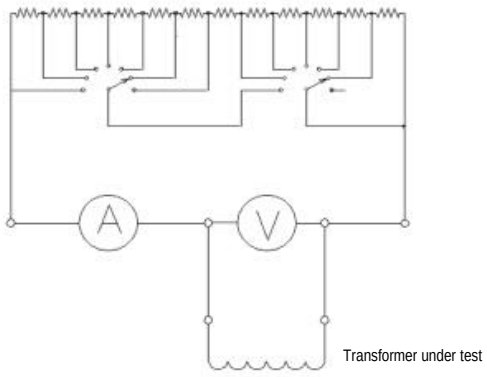
and is based upon inserting additional burdens in steps into the secondary loop while the transformer is energized with a stable primary current.

In order to circulate transformer secondary current through the burden resistance (R_{br}) an induced secondary voltage (terminal voltage) is required:

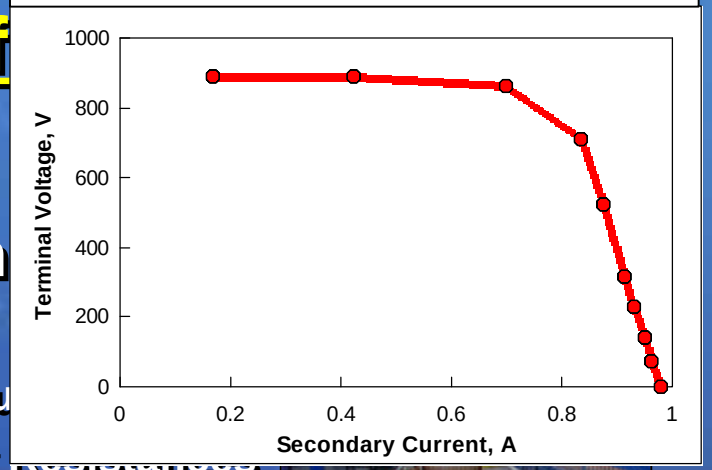
$$V_{term} = I_{sec} \times R_{br}$$

This voltage is produced by the flux **Ö** in the magnetic circuit of the transformer (Faraday's Law) Hence, the higher the resistence, the greater flux **Ö** will become, and an increased secondary exciting current is necessitated . As a result, the secondary current will decrease with the increasir of the burden resistance.

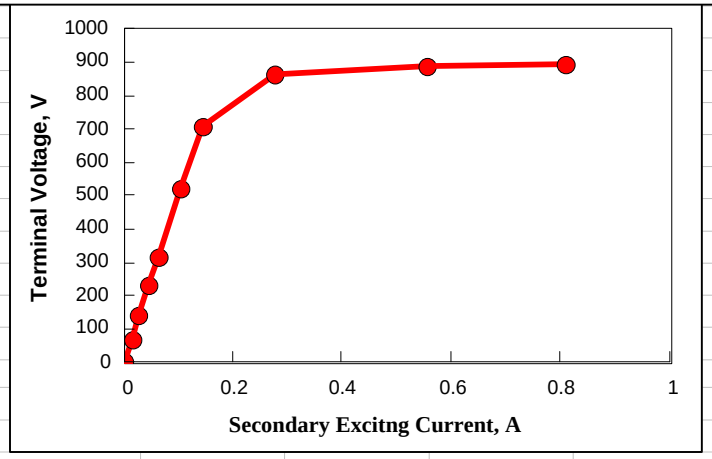
The measuring circuit for this method is shown in figure 1.



At each burden the terminal voltage and corresponding secondary current are recorded



Each measured secondary current value is then subtracted from the current value obtained at zero burden. Using these derived current differences, secondary excitation curve is plotted.



Substation Test Information
FES In-service and On-Site Accuracy Testing

2. On-Site Accuracy Testing

a) Secondary access only-Open primary

– RCF and PA Metering Certification

$Io = (Ipri / N)-Isec$

$Ratio\ Error = Io \times Sin (M + 2) / Isec$

$PA = Io \times Cos (M + 2) / Isec$

– NIST Trace-ability

Instrumentation traceable to NIST
Data calculated from actual readings

– Off-Line Test

Short Outage for Testing

Substation Test Information
FES In-service and On-Site Accuracy Testing

2a. On-Site Accuracy Testing

– Theory of Operation

$I_{sec} = (I_{pri} / N) - I_o$

where: I_{sec} = secondary current

I_{pri} = primary current

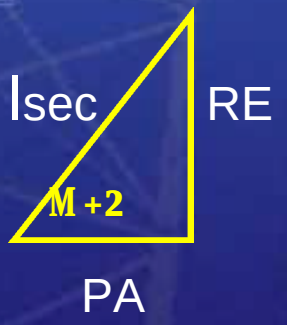
I_o = secondary exciting current

(where Iex is made up of Im magnetizing and Iw core loss currents)

N = number of turns

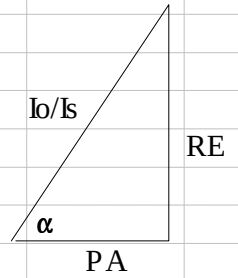
Ratio Error (RE) = Io x Sin (M +2) / Isec *(RE is proportional to core loss current.)*

PA = Io x Cos (M +2) / Isec *(PA is proportional to the magnetizing current.)*



where: 2 = the angle between VA and Watts at corresponding voltage.

M = the angle between impedance Z and resistance R of the load.



The proposed method used well known equation:

$$I_{sec} = \frac{I_{pri}}{N} - I_o$$

where

N - number of turns
Io - secondary exciting current

Ratio error RE = Io x sin **(Φ +2)** / Isec

Phase angle PA = Io x cos **(Φ +2)** / Isec

Isec	Vo	Io	Io/Isec	W	VA	Burden	Rb	Xb	Rw	M	2	α	RE	PA
5	9.45	0.0068	0.00136	0.04100	0.0643	1.8	1.62	0.785	0.1	0.428	0.879	1.307	0.00131	1.2
0.5	0.95	0.001	0.0019	0.00065	0.0009	1.8	1.62	0.785	0.1	0.428	0.813	1.241	0.00180	2.1
5	4.95	0.0055	0.0011	0.01700	0.0273	0.9	0.81	0.392	0.1	0.407	0.897	1.304	0.00106	1.0
0.5	0.50	0.0008	0.0016	0.00028	0.0004	0.9	0.81	0.392	0.1	0.407	0.786	1.193	0.00149	2.0
5	2.96	0.005	0.001	0.00900	0.0148	0.5	0.45	0.218	0.1	0.377	0.917	1.294	0.00096	0.9
0.5	0.30	0.0006	0.0012	0.00013	0.0002	0.5	0.45	0.218	0.1	0.377	0.749	1.126	0.00108	1.8

Substation Test Information
FES In-service and On-Site Accuracy Testing

2. On-Site Accuracy Testing

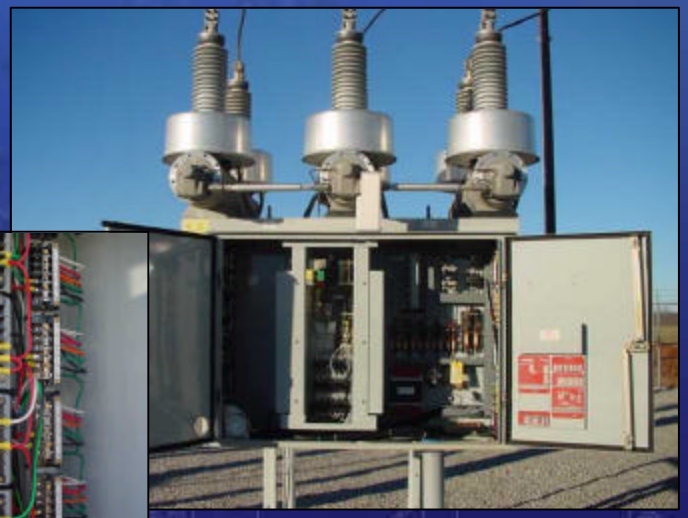
b) Primary and secondary access

– RCF/PA Certification- Comparator method

Highly accuracy comparator & standard transformer
Driver transformer
Accurate burdens

– NIST Trace-ability

Comparator traceable to NIST
Actual readings on RCF and PA taken



– Off-Line Test

Outage for Testing
Isolated from primary circuit

Transformer Test Information
Factory Services and Accuracy Testing

Special Services

- Metering IT Certification Testing
  - At factory
  - RCF/PA & Dielectric Testing
- Metrological Certification
  - Customer Test Facility
  - Testing Range Improvement to Lower and Higher Currents
  - Direct NIST Trace-ability
- Transformer Refurbishment
  - Transformer Upgrades