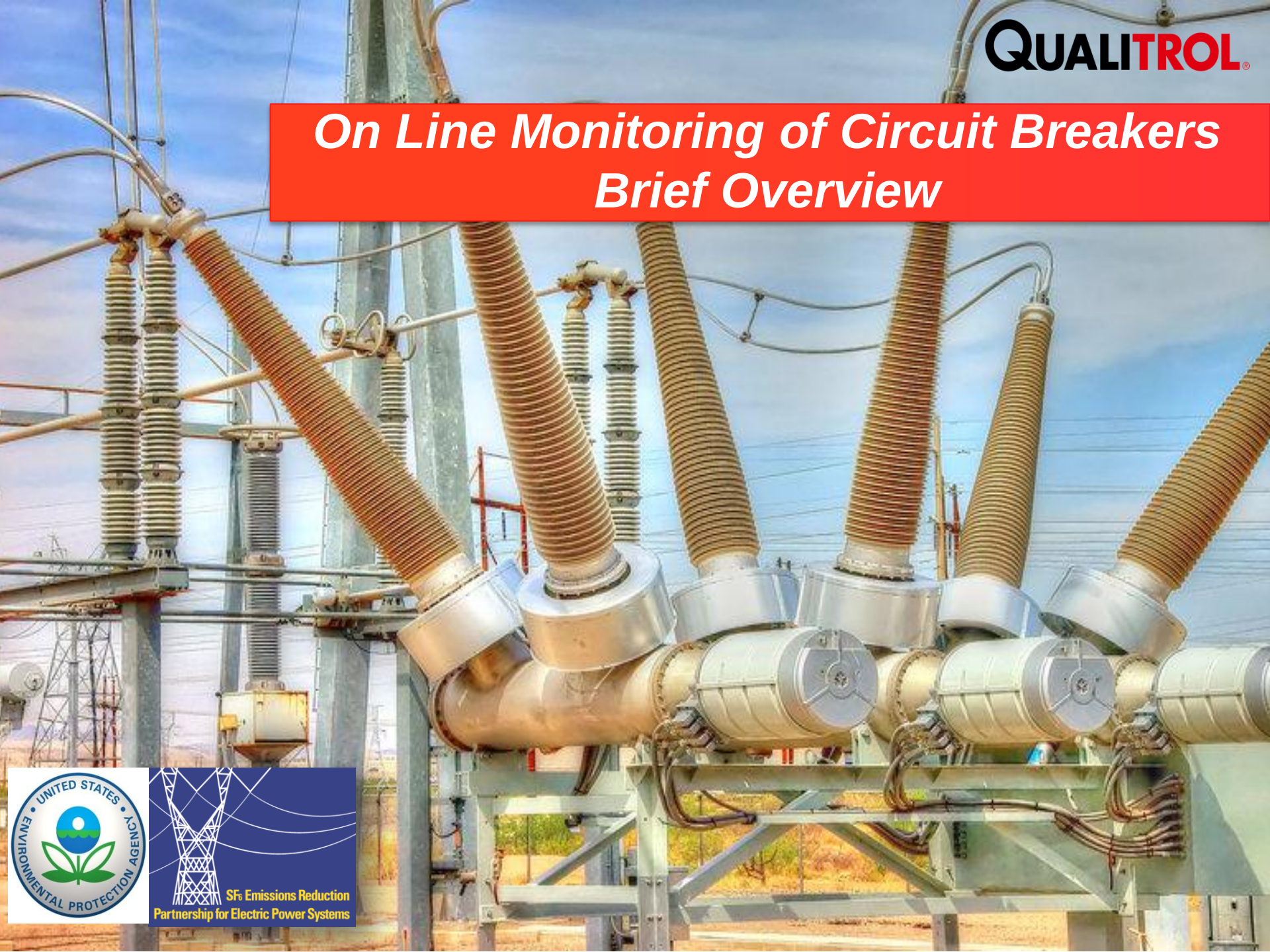

QUALITROL
On Line Monitoring of Circuit Breakers
Brief Overview
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
SF6 Emissions Reduction
Partnership for Electric Power Systems

HV Circuit Breaker

David Cole - Technical Application Specialist

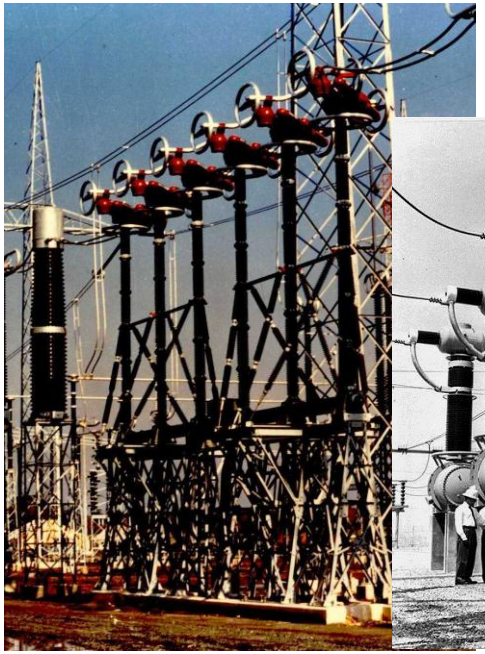
June , 2014

- *Types of Circuit Breaker*
- *Time Base Maintenance*
- *Condition Base Maintenance techniques*

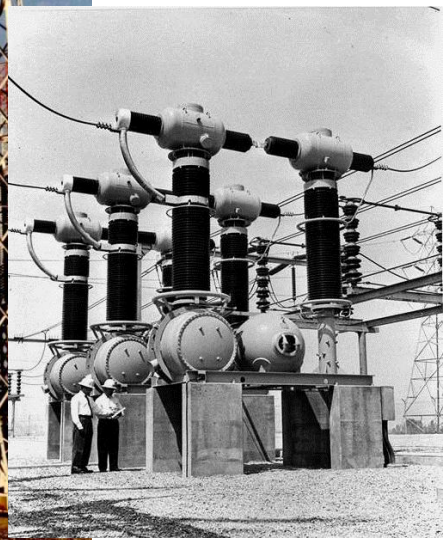
Condition Base Maintenance Solutions

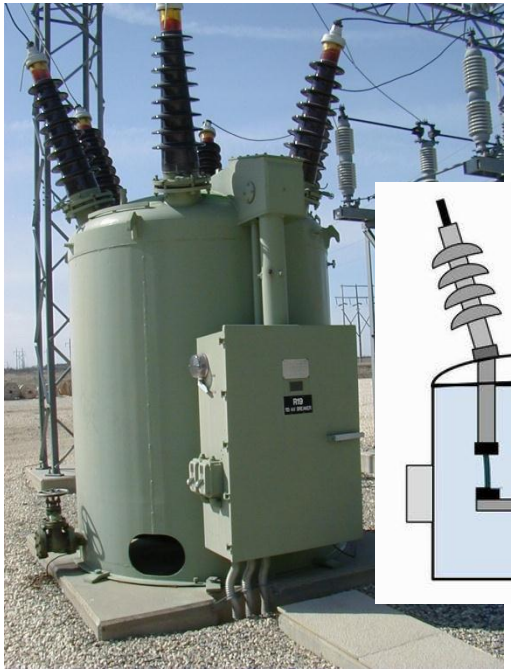
Circuit Breaker Development over the years – Arc Quenching Media

- **Air blast** were the dominant circuit breaker technology in the 1960's.
- **Oil as interrupting and insulating medium** 1970's to early 1980's.
- **The first circuit breakers using SF_6 gas** as an interrupting and insulating medium were developed in the late 1960's. Commercially available in the late 1970's, SF_6 gas circuit breakers became the dominant circuit breaker technology in the 1980's and **still remain until today.**
- **Vacuum circuit breaker** technology was first introduced in the1960's

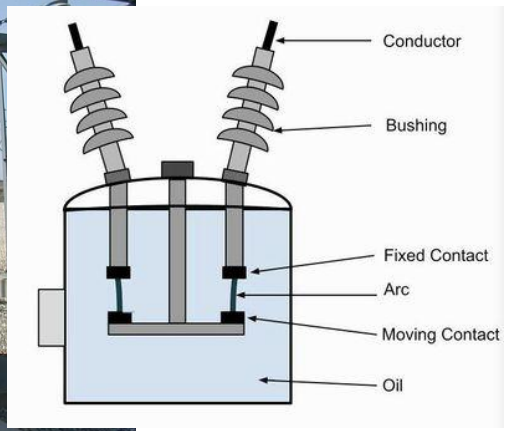


Air Blast





Oil isolated



Types of Circuit Breaker

According to their services the circuit breaker can be divided as:

1) Outdoor circuit breaker

2) Indoor breaker

Outdoor type air insulated circuit breakers are classified as:

1) Dead tank type circuit breaker
2) Live tank type circuit breaker

Types of Circuit Breaker - DTB

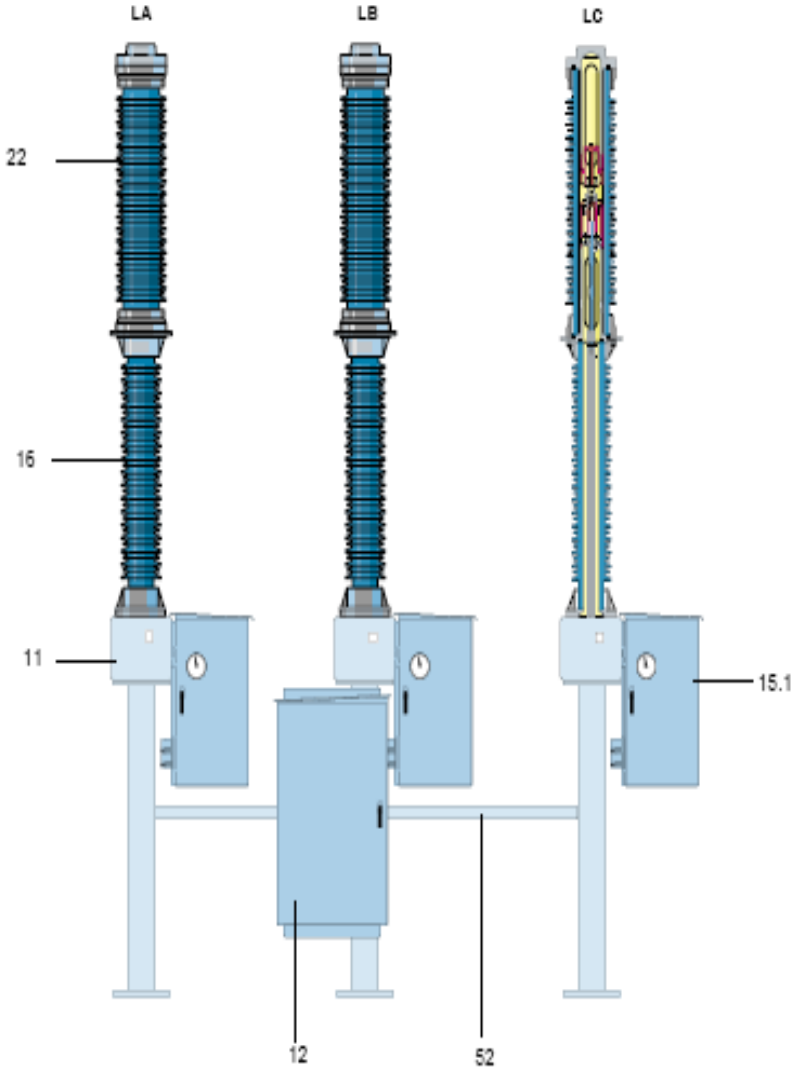
1) Dead tank type circuit breaker

In dead tank type CB, the switching device is located, with suitable insulator supports inside a metallic vessel(s) at ground potential filled with insulating medium.

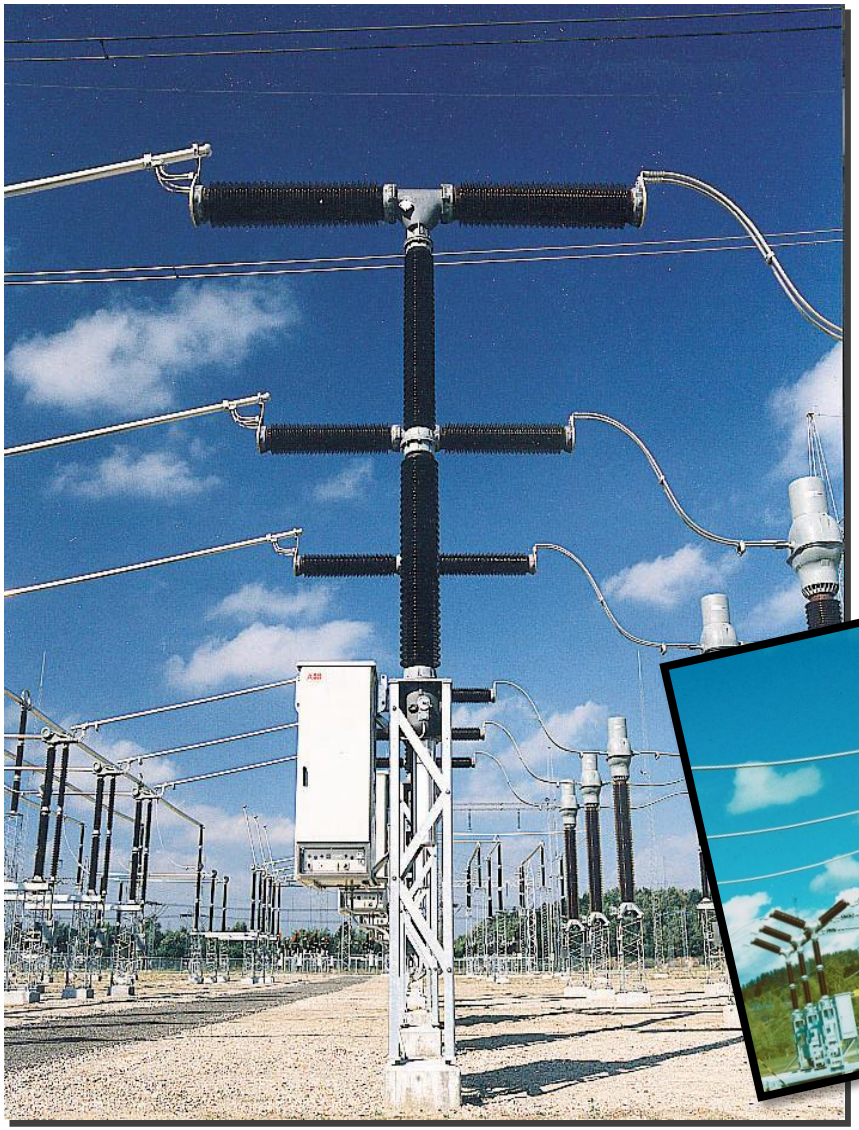
DTB has current transformer build in and tend to use larger control cabinet when compared with Live Tank Breakers.

2) Live tank type circuit breaker

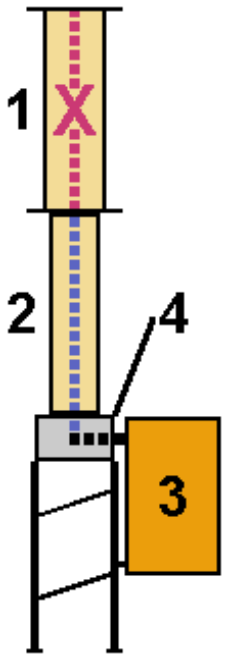
In live tank circuit breaker, the interrupts are located in an insulated busing, at the system potential. The live tank circuit breakers are cheaper and required less mounting space.

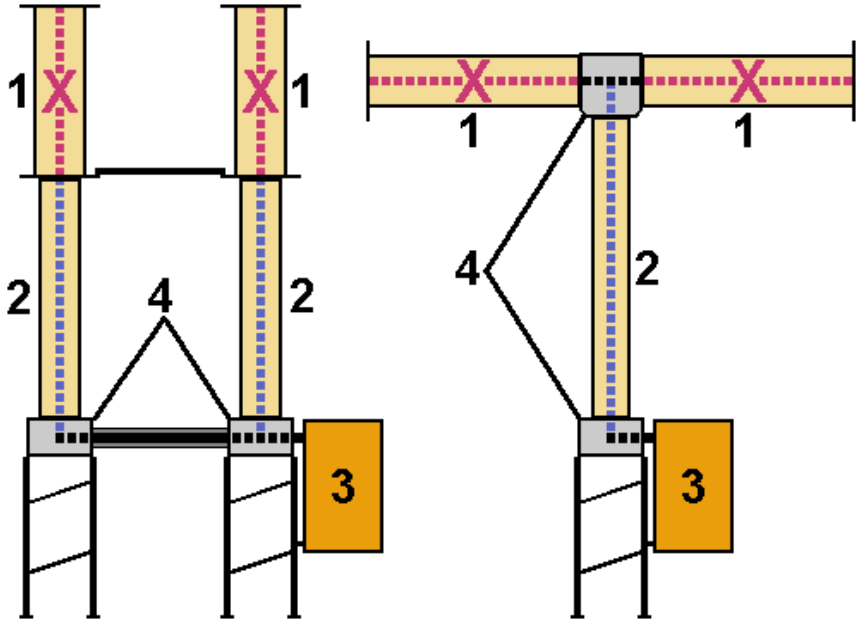


Types of Circuit Breaker – Live Tank Breaker



One or two Interrupter per phase





- One breaking element
  - 1 interrupter
  - 1 support insulator
  - 1 mechanism housing

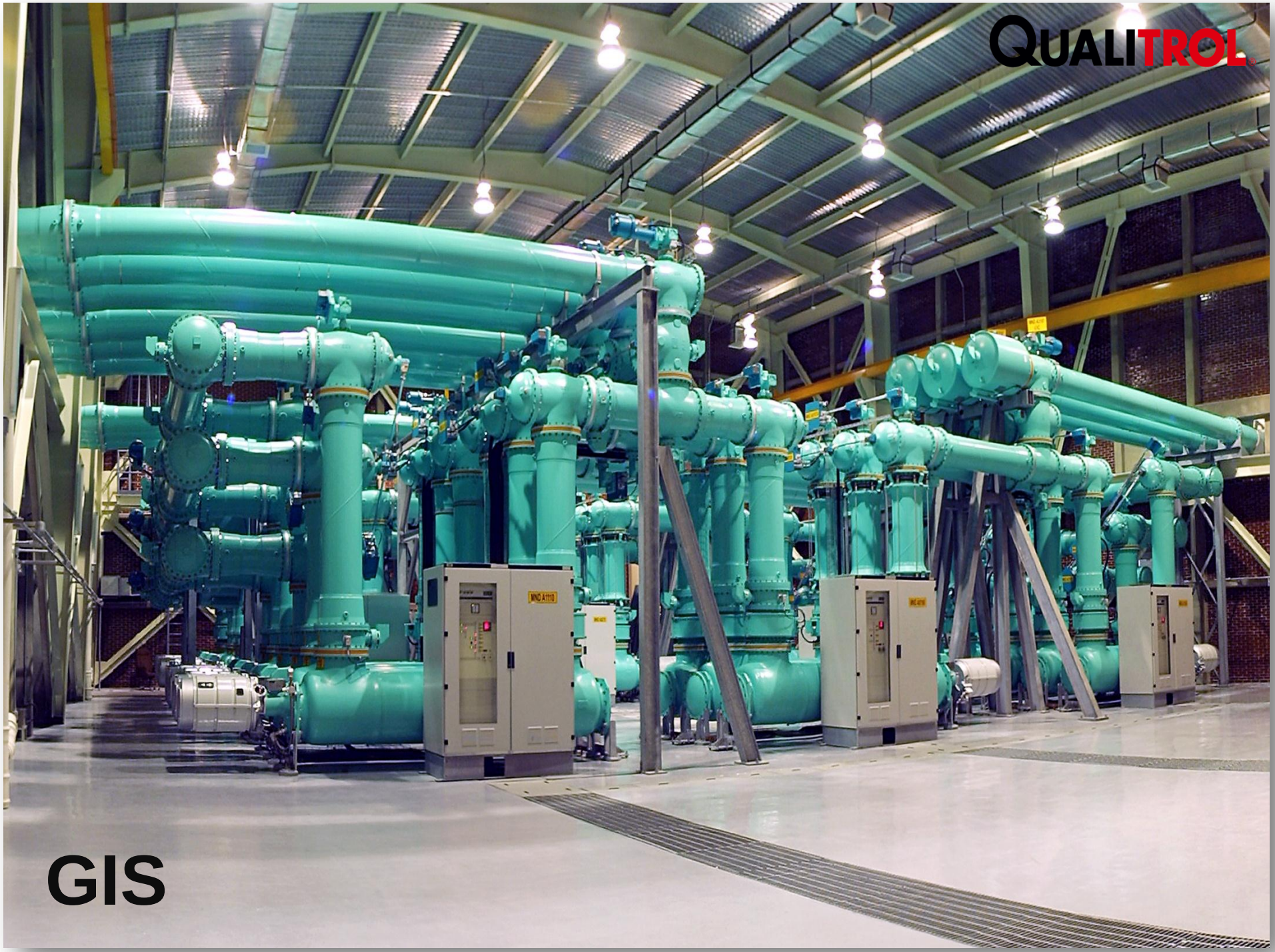
  One Interrupter: up to 300kV

- Two breaking elements
  - 2 interrupters
  - 1 or 2 support insulator(s)
  - 2 mechanism housings

  Two Interrupters : from 362 to 550kV

QUALITROL® Defining Reliability

NOW 550kV is available with “ONE” interrupter unit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GIS

Types of Operating Mechanism

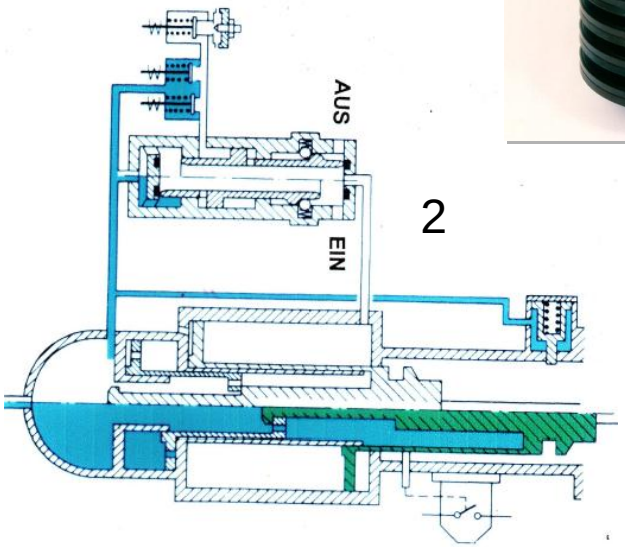
According to the operating mechanism of circuit breaker they can be divided as:

1) Spring operated circuit breaker

2) Pneumatic circuit breaker

3) Hydraulic circuit breaker

1



2

3

Spring mechanism leading the market

CIGRE Final Report 2004-2007
Part 2 – Reliability of High Voltage SF6 Circuit Breakers

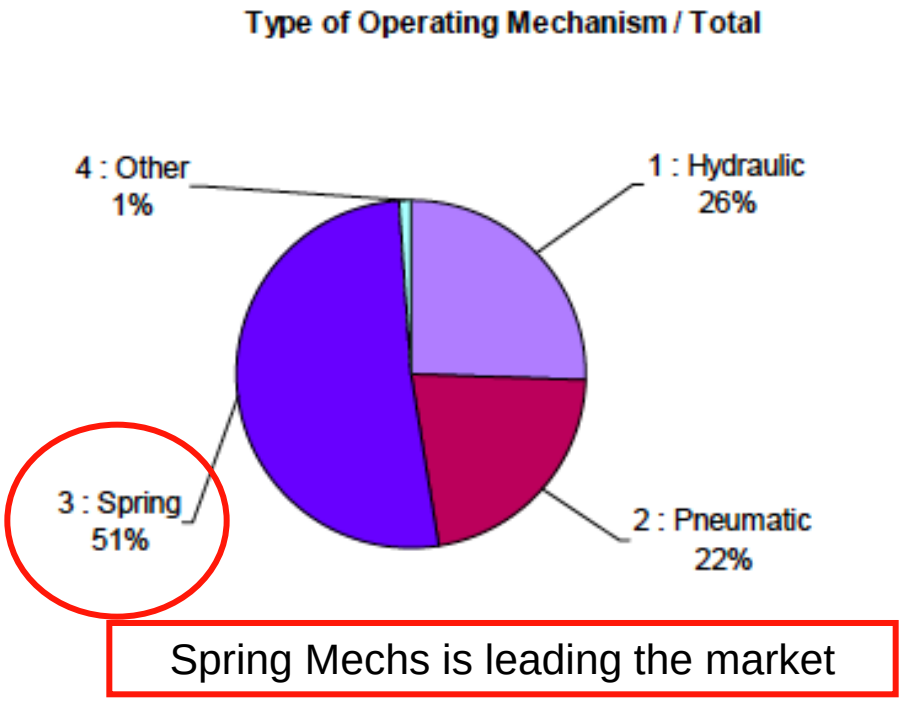
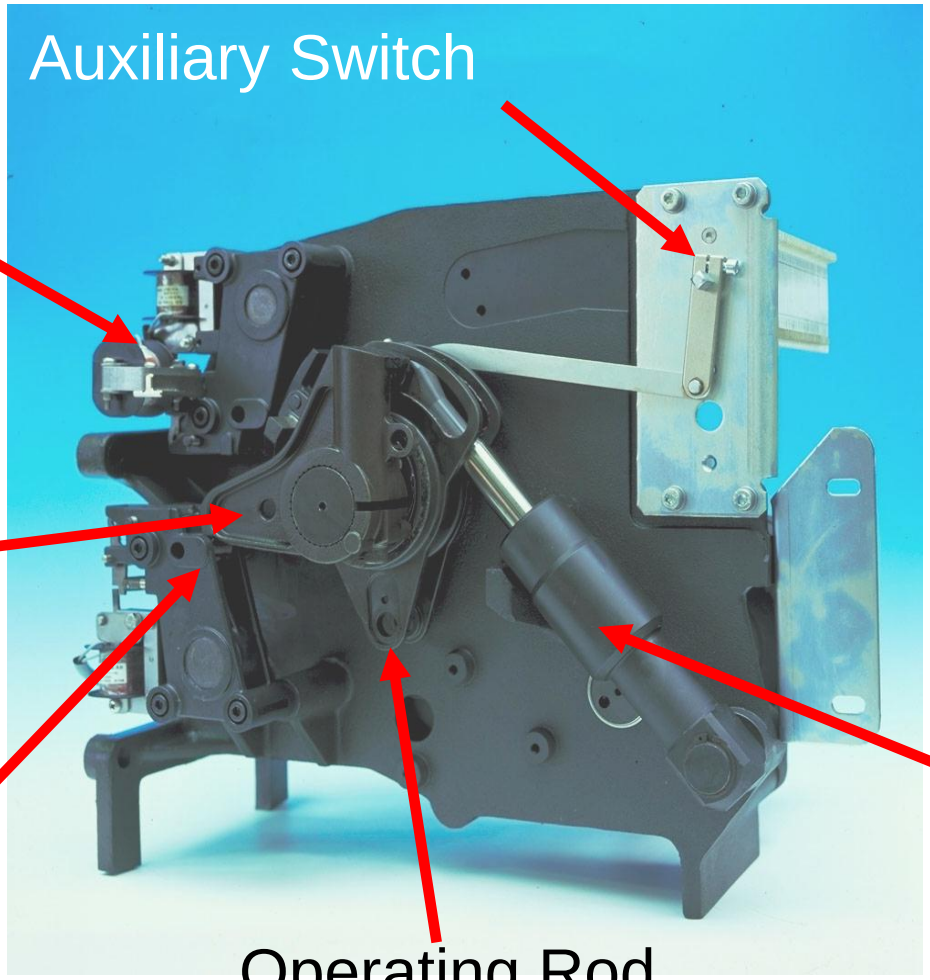


Figure 2-7: CB service experience per kind of operating mechanism / present survey

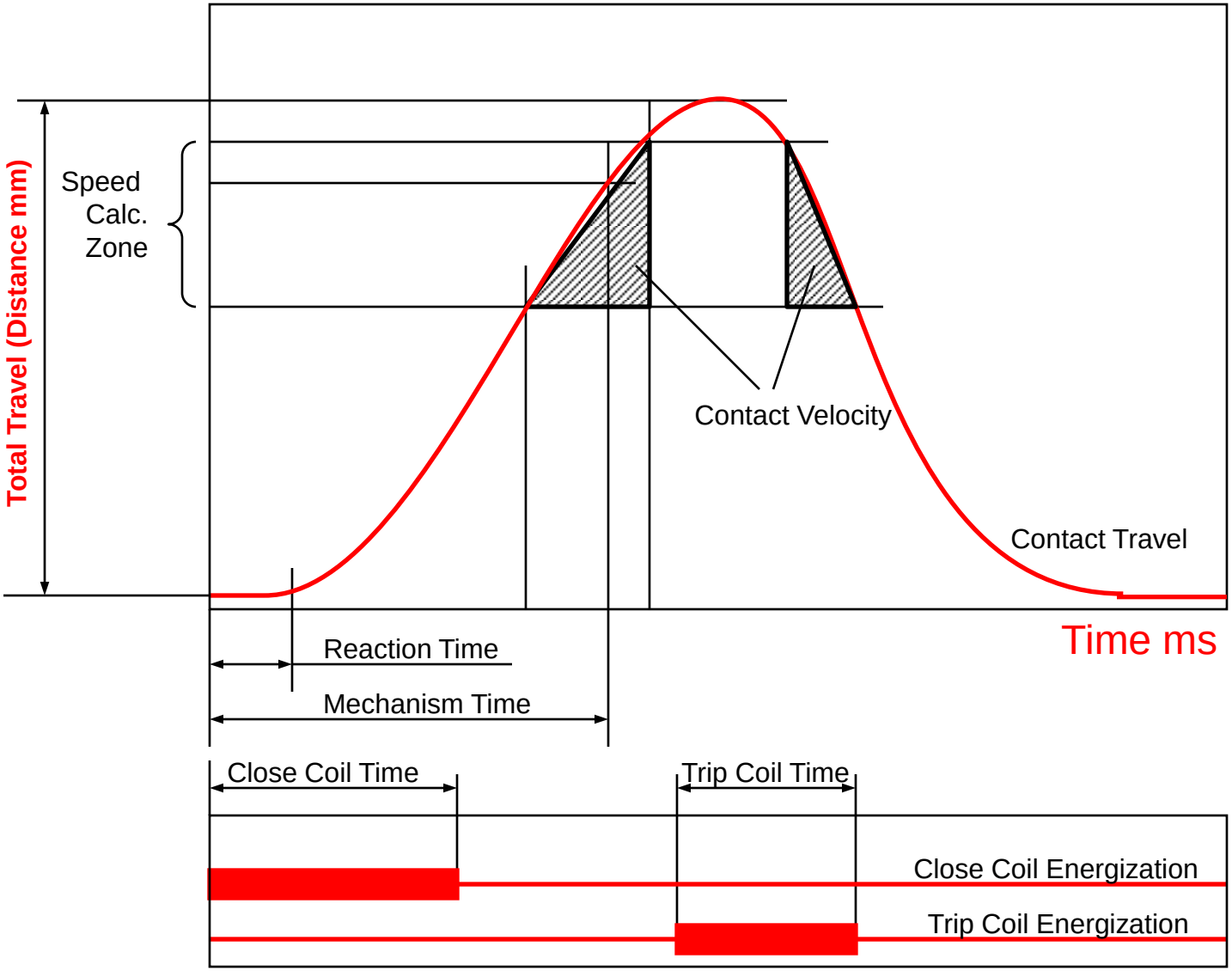
Mechanism Type – Spring Mech



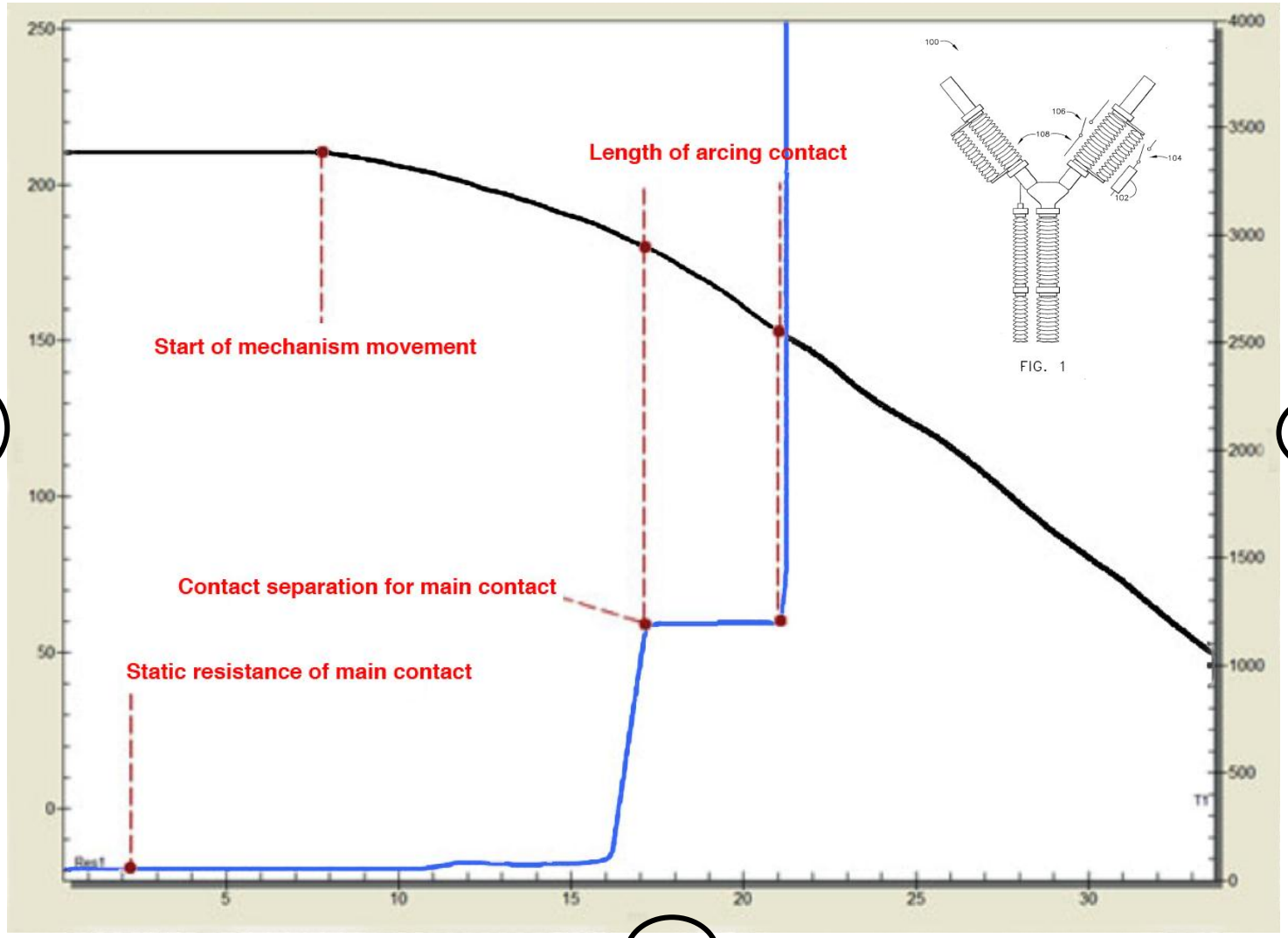
- **Visual Inspection:**
  - Inspection intervals – every 1 / 2 years
  - External Cleaning
  - Verify heating element
  - SF_6 pressure
  - Fittings / valve verification
  - Structure Torque confirmation

- **Maintenance:**
  - 5, 10, 15 years maintenance
  - Limit of operations or 10/15 years – Overhauling
  - Adjustment's in M/S – Velocity and MS – Timing
  - Contact Resistance
  - Dynamic resistance
  - Density Monitor Calibration inspection
  - DewPoint of the SF_6 and Purity of the SF6
  - SO2 Levels – Contamination
  - Search for SF_6 Leakage
  - Protection re-commissioning

Close / Open Operation Analysis



Dynamic Contact Resistance Test



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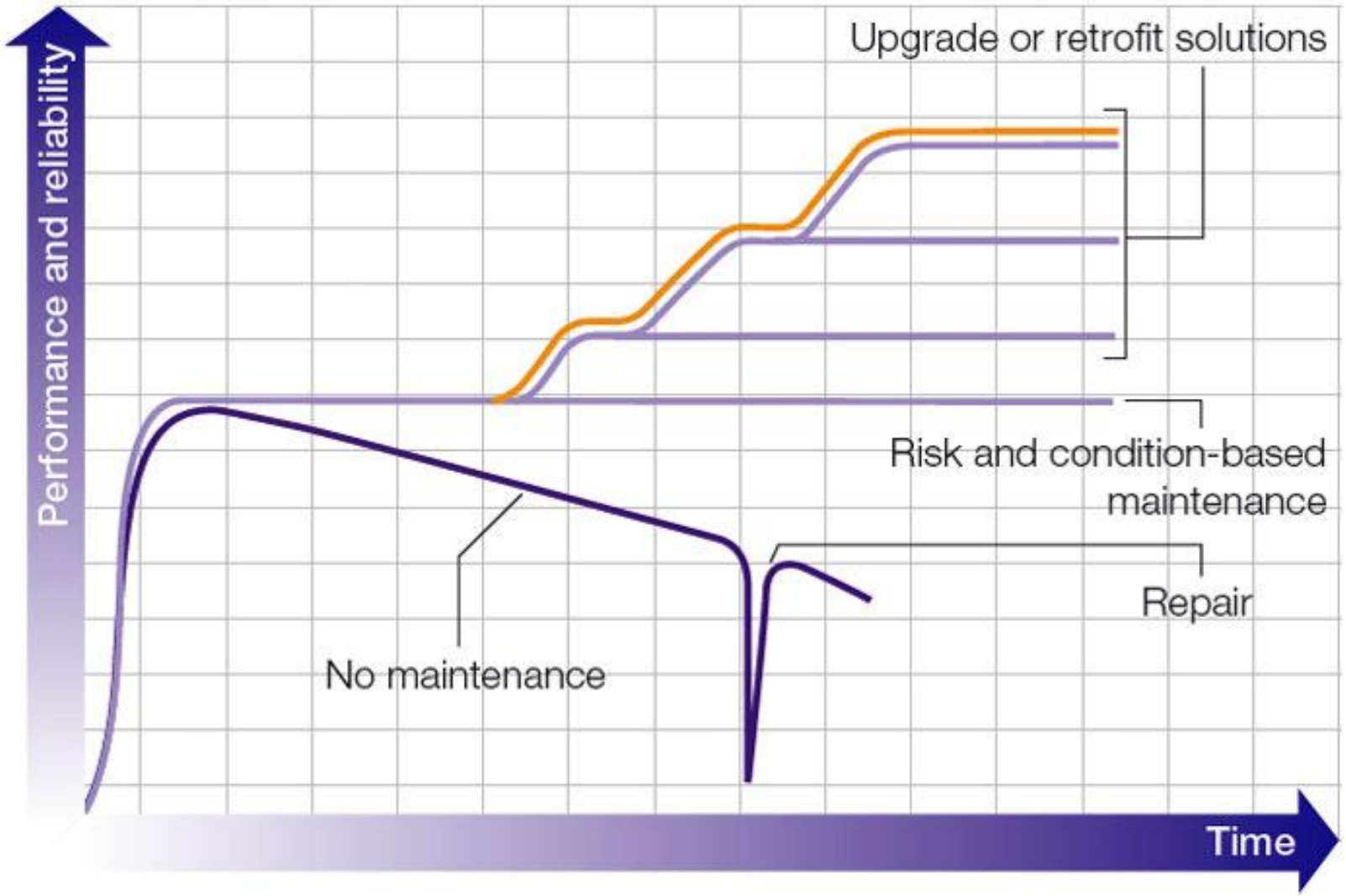
Defining Reliability

Issues with Time Based Maintenance

- Difficult to keep up with maintenance schedules consequently maintenance intervals are increasing
- Maintenance on a breaker is not always necessary and sometimes can do more harm than good!
- Record keeping is sometimes an issue. This is important to monitor long term trends on specific breaker types
- Good to have an on line system to look in between the extended maintenance periods and emulate where possible the off line tests
- Good to have software to automatically analyse results and look for trends
- Eventually on line condition monitoring will replace time based maintenance

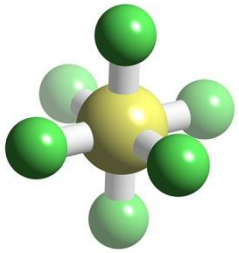
CBM Strategy



Breaker Online Monitoring

Interrupter Wear

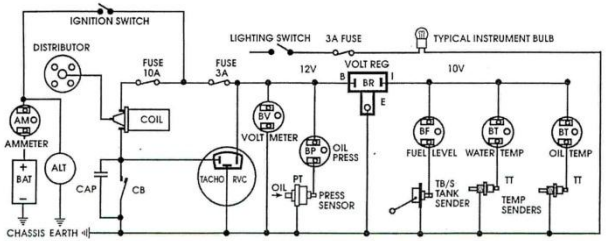
SF_6 Gas System



SF6 MONITORING

Mechanical System

Electrical Controls & Auxiliaries

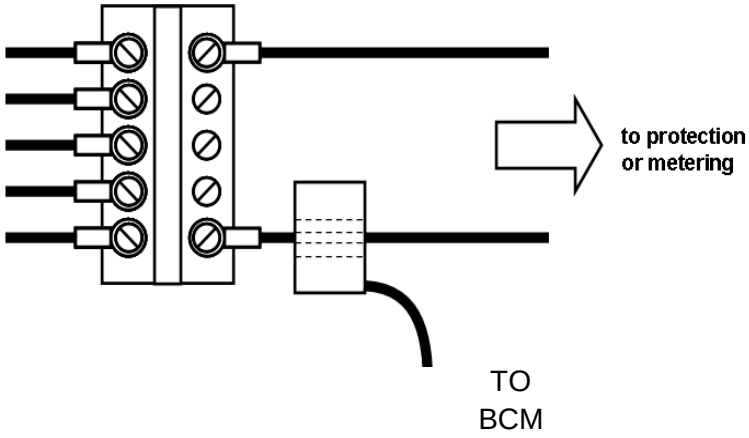


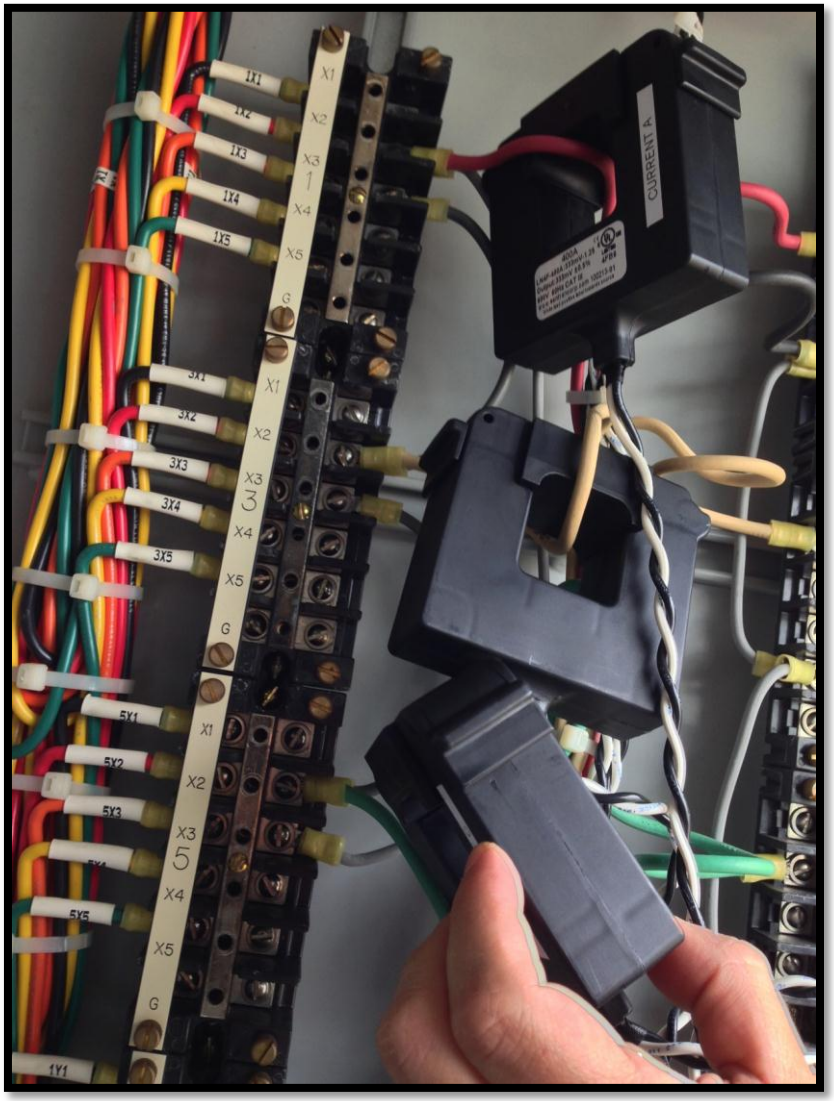
List of Monitoring

- Coil Continuity (Integrity)
- Total Travel (Stroke)
- Contact Velocity (Meters/s)
- Reaction Time (ms)
- Coil Energization Time (ms)
- Contact Wear (I^2T)
- Trip Count (Oper. Counter)
- Auxiliary contacts (ms)
- Motor Current Signature
- Motor – Charging time
- Pump start counts
- Tank/Gas Temperature
- Mech./Cab. Temperature
- Heater 1 (On all the time)
- Heater 2 On (heater w/o thermostat)
- RMS Current
- Voltage (Fault Recording)
- Re-strike detection
- Smart SF6 sensors
- Leak Rate (%)

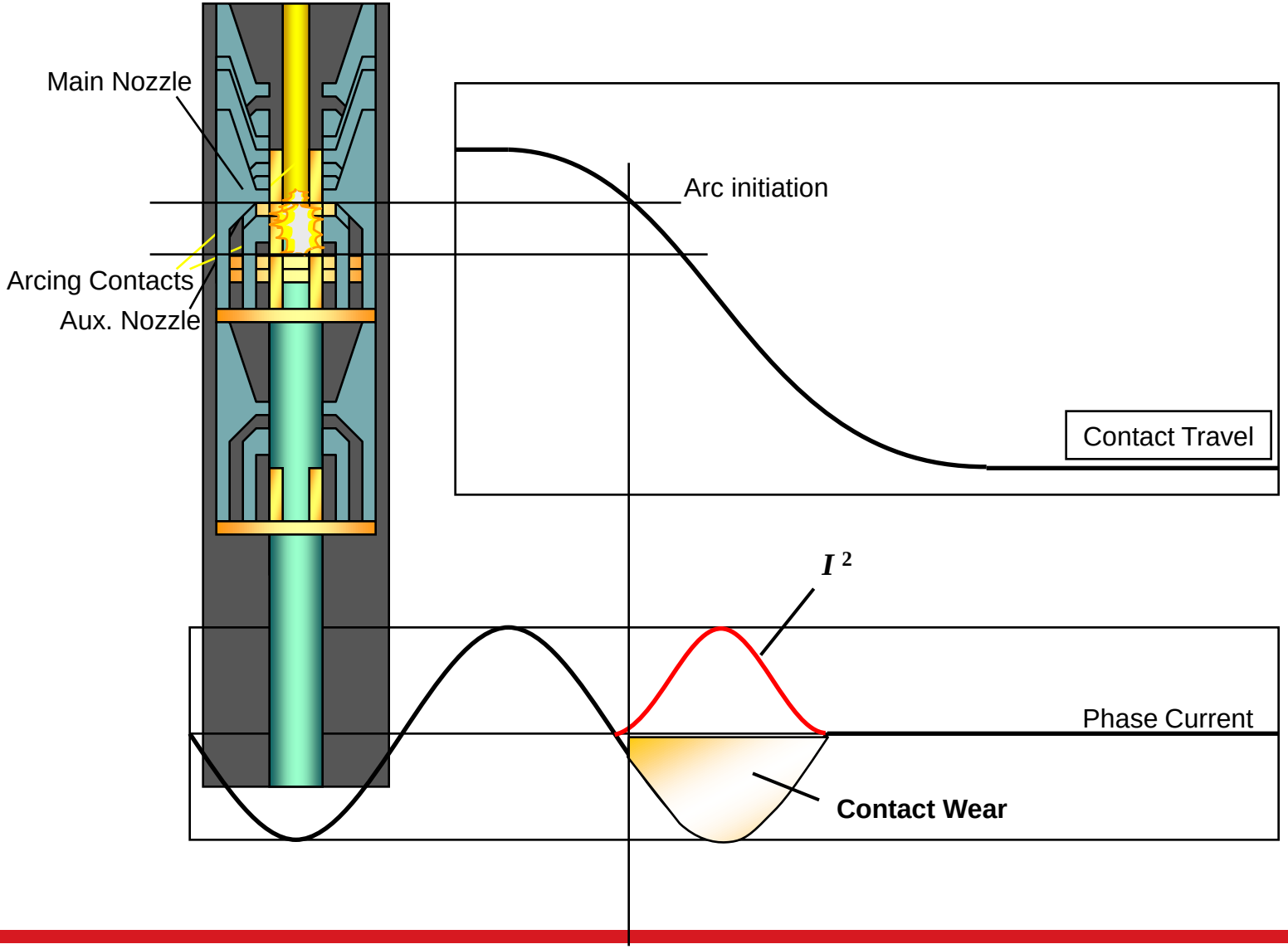
Phase Current

- Ring or Split Core CT's
- Ratio = 5000:1
- Nominal Values:
  - 1.0 A
  - 2.0 A
  - 5.0 A





Interrupter Wear Calculations



SF_6 Monitoring – Density, Pressure, Temperature & Dewpoint

Sensors RS-485 / 4-20mA
Modbus / DNP 3.0

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Defining Reliability

SF_6 Monitoring – Density, Pressure, Temperature & Dewpoint

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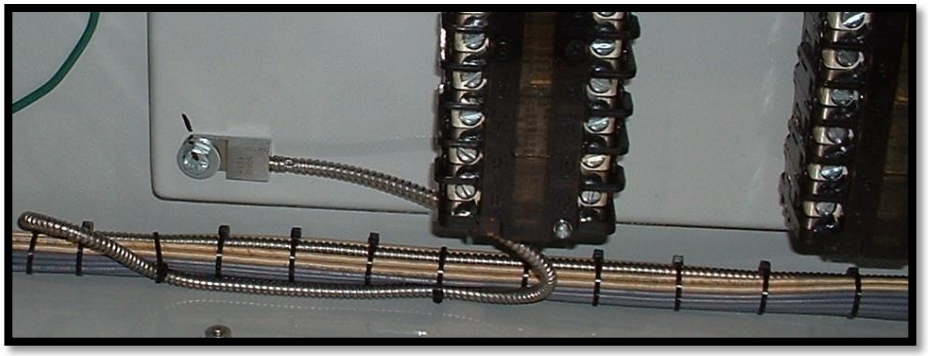
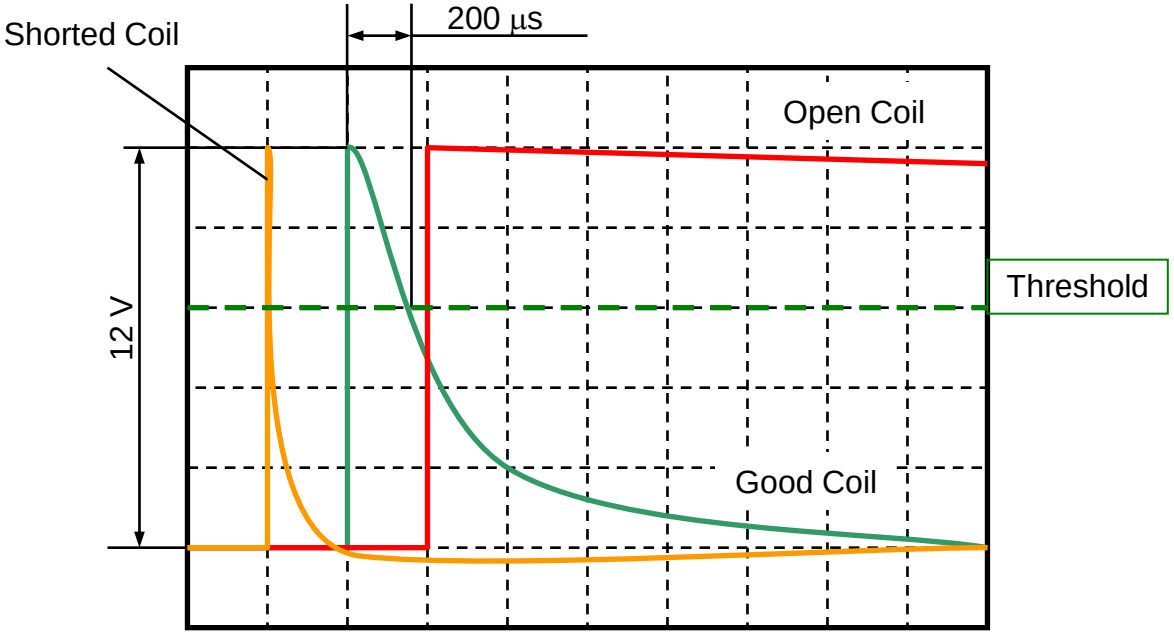
- Measure Heater Current
- Determine on/off condition
- Assemblies of 2 and 4 CT's Optional
- Ratio = 1000:1
- Ring or Split-Core

Temperature Sensor



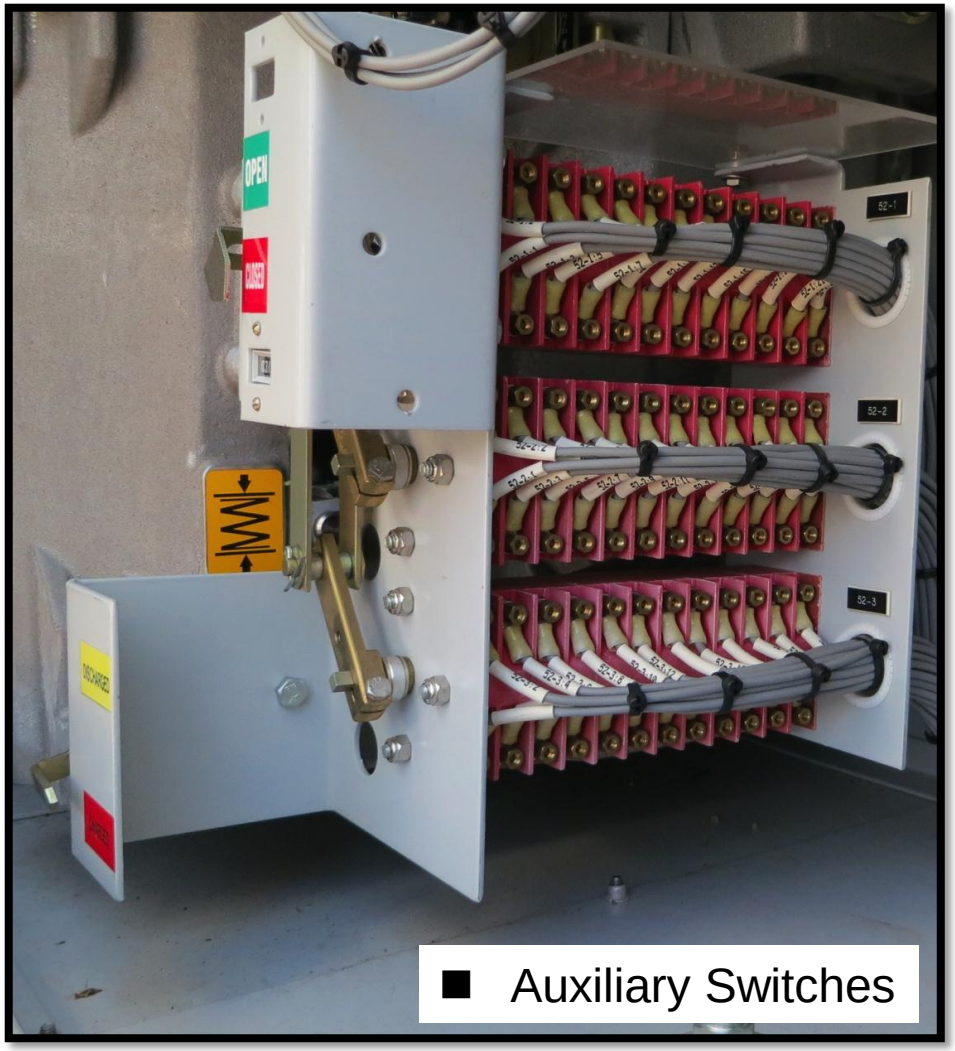
- Resistive temperature devices (RTD)
- Resistance change: 38.5 Ω/ 100 ° C
- Mounting locations: tank, mechanism or cabinet

Coil Continuity (Integrity)

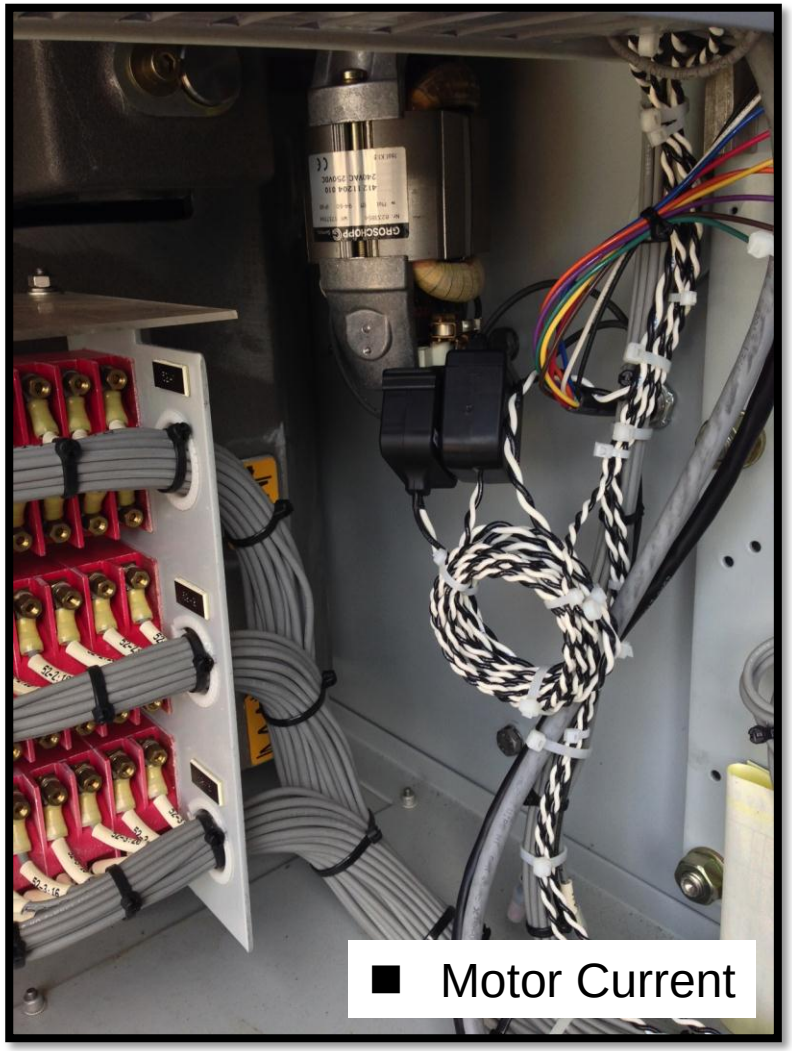


- Does not trip breaker
- Tolerates additional coil monitoring measures
- Works with variety of coils
- Coil Current
- Reaction time, coil finger print

Other Connection Points

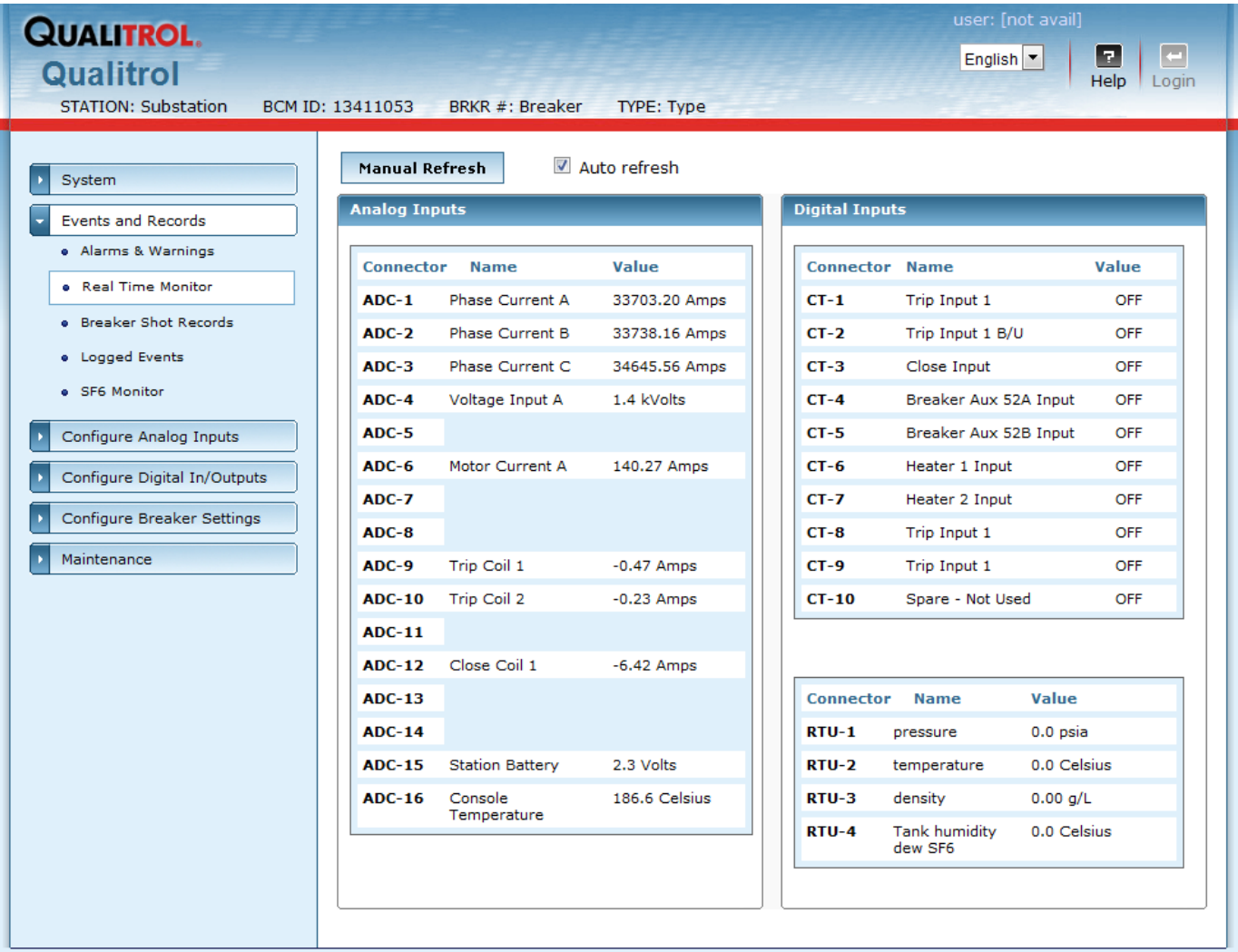


- Auxiliary Switches

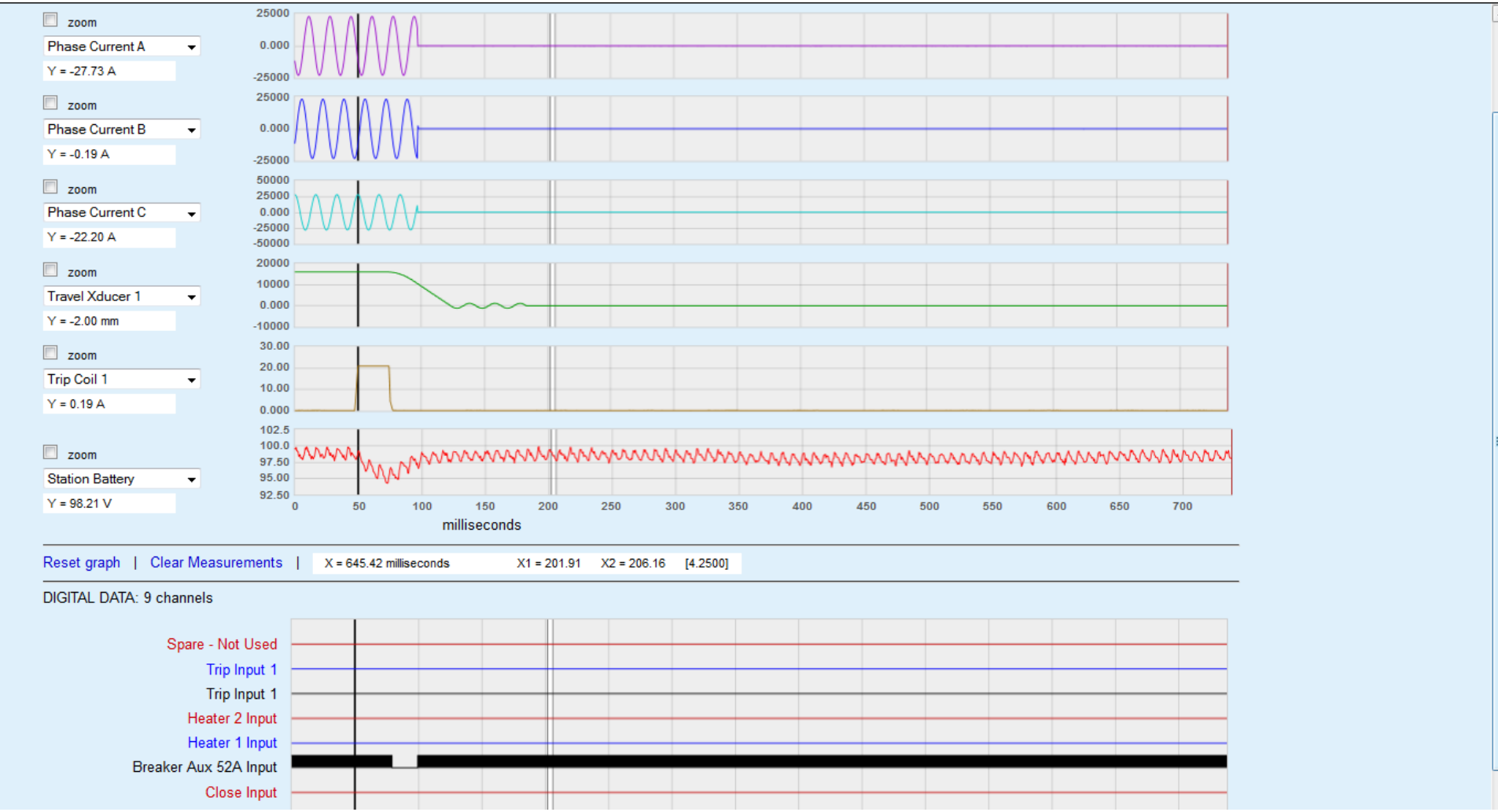


- Motor Current

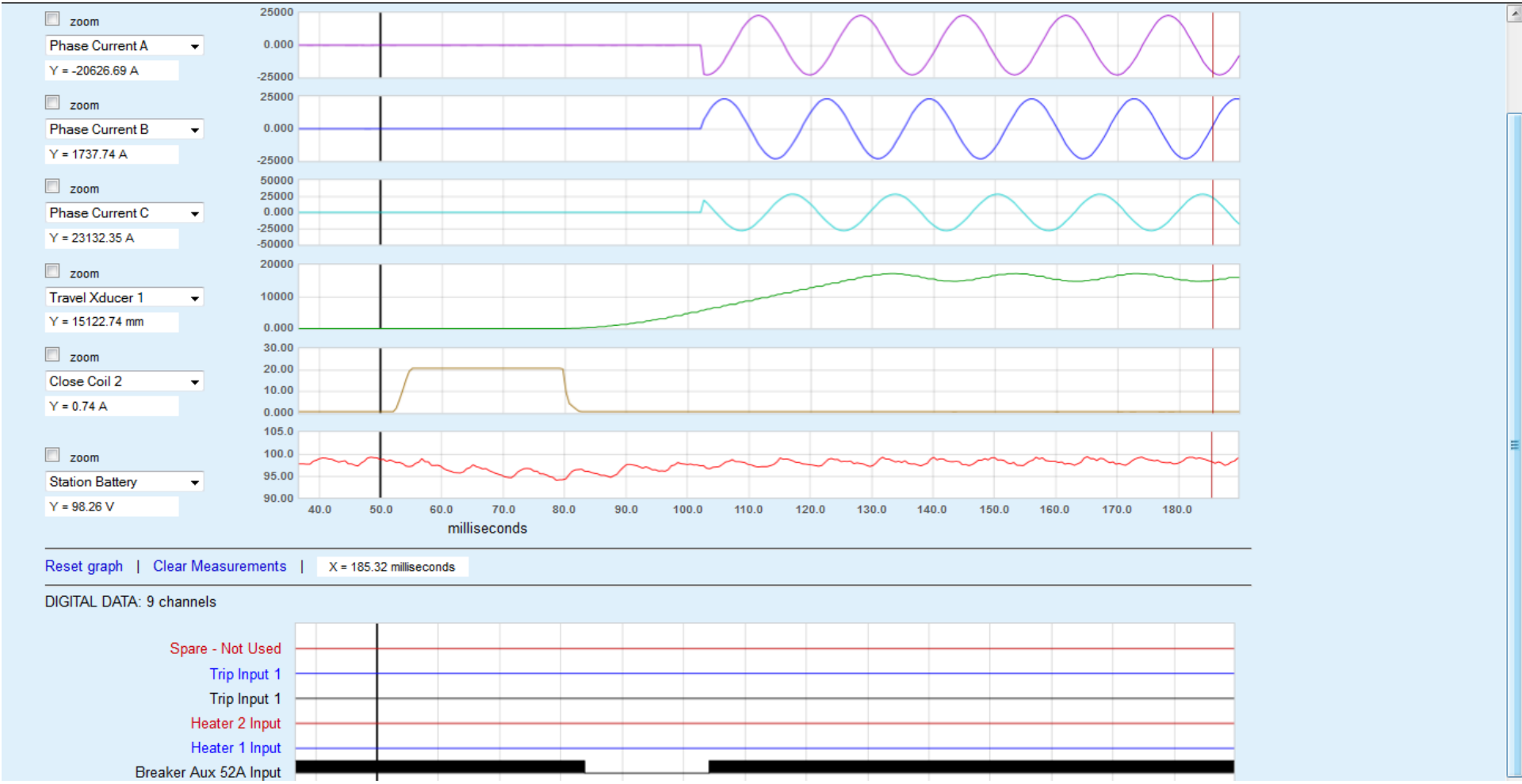
Real Time Monitoring – NEW FEATURE



Breaker Shot Record – Open Operation



Breaker Shot Record – Close Operation



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Concept of Fingerprint with Alarm

- A breaker trip or close operation is stored as a reference of a good operation
- If measured parameters deviate by programmed limits during subsequent operations then an alarm is raised to allow more detailed inspection of the results
- Off line software collects regular data and looks for trends, for example, the early identification of SF6 gas leaks or changes to motor run time indicating problems with spring charging

Example of on line Breaker Condition Monitor

Description Qualitrol's BCM is a continuous (24x7) on-line condition monitoring system for 11kv to 1200kV Circuit Breakers. Our solution can provide monitoring for single breaker to multi-site for thousands of breakers with centralized comprehensive monitoring and reporting.

Application The BCM system provides continuous monitoring for the overall health of circuit breakers:

- Allows corrective actions to be taken before any failure occurs
- Optimize maintenance visits based on actual condition
- Optimize or reduce replacement or repair expenditures
- Ensure compliance to EPA SF_6 monitoring

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Thank You