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The Fire of Autotransformer as Result of 400 kV Bushing Explosion

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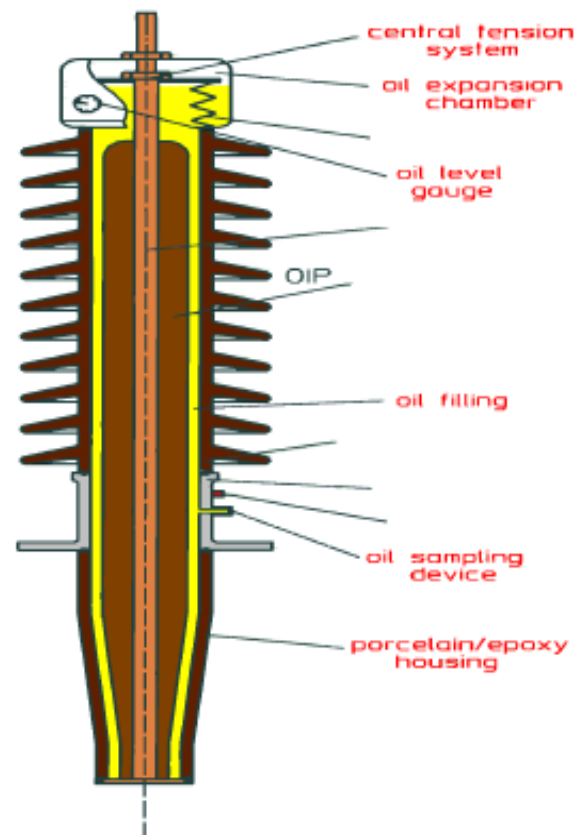
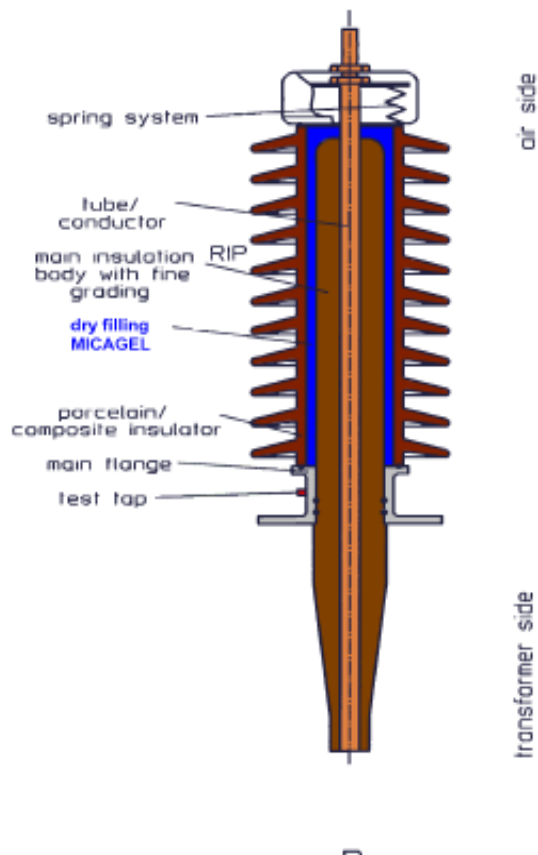


RIP

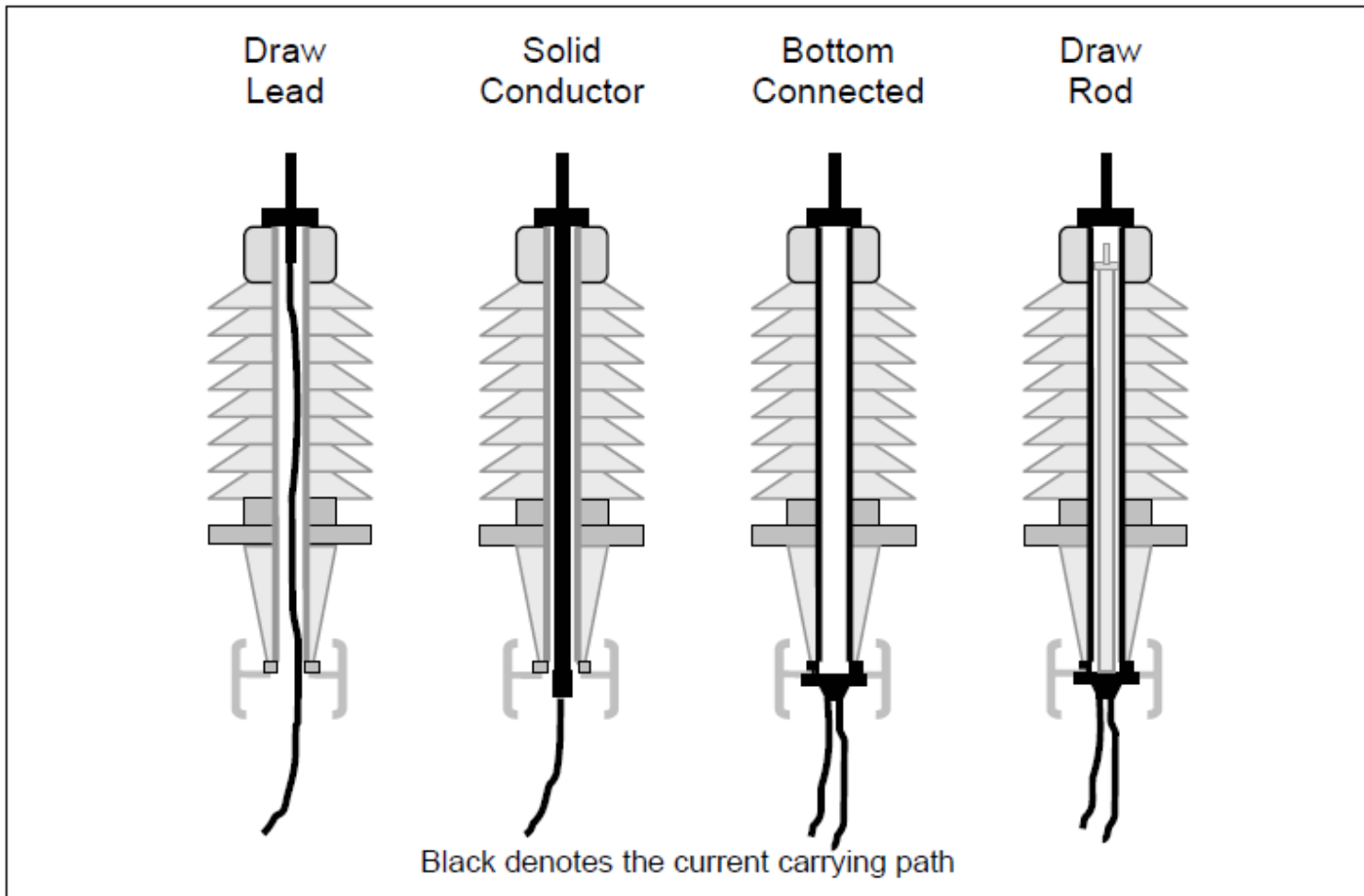
vs.

OIP

Technology



Principal Types of Bushing Connections





Periodic checks and measurements

It is imperative to monitor the condition of the oil and the insulation.

- Monitoring of the capacitance current.
- Measurement of Dielectric Dissipation Factor (DDF) or $\text{tg}\delta_1$ and capacitance C_1
- Measurement of partial discharges (PD)
- Dissolved Gas Analysis (DGA) of oil.
- $\text{tg}\delta_2$ and capacitance C_2



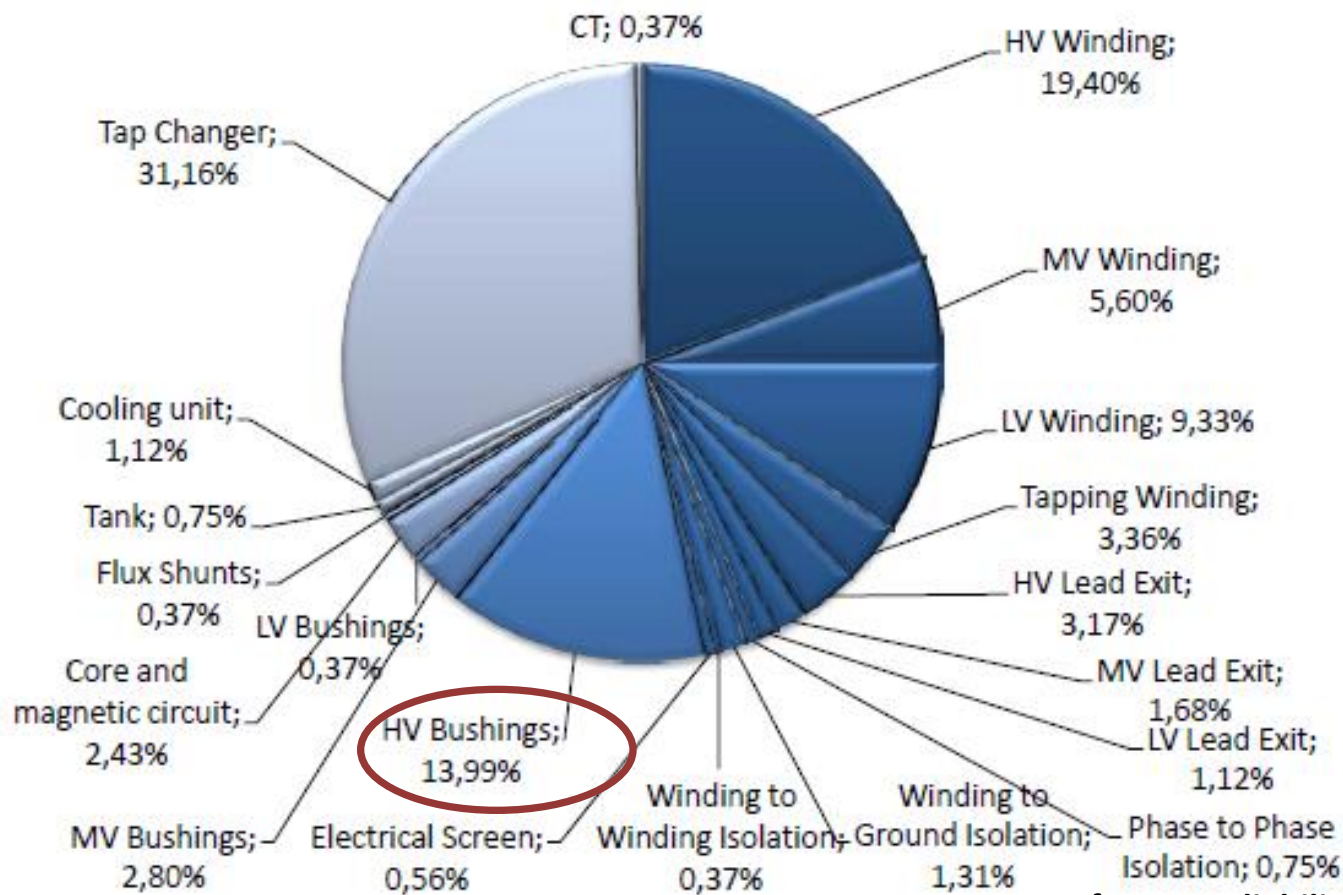
Problem Statement

- There is a large population of transformers with **oil-impregnated, porcelain casing bushings** that are older than 10 years.
- The life of these bushings is determined by the condition of the insulation and the oil.
- Failure in the bushing insulation leads to catastrophic failure of the entire transformer due to fire/explosion.



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14% of substation transformers failures are due to HV Bushings



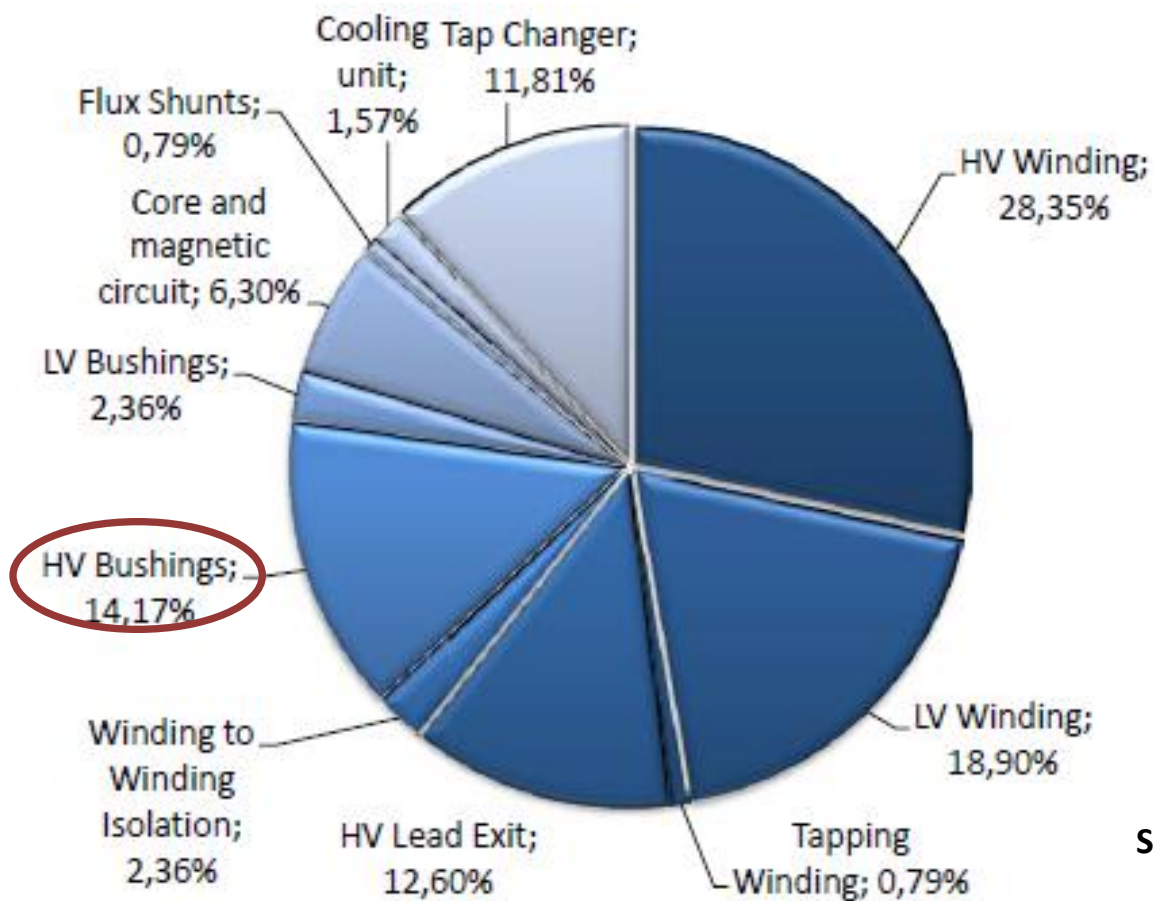
**Failure Location
Analysis,
Substation
Transformers,
U ≥ 100KV, 536
Failures**

Source: Transformer Reliability Survey WG A2.37 2015



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14% of Generator Step-Up Transformers failures are due to HV Bushings

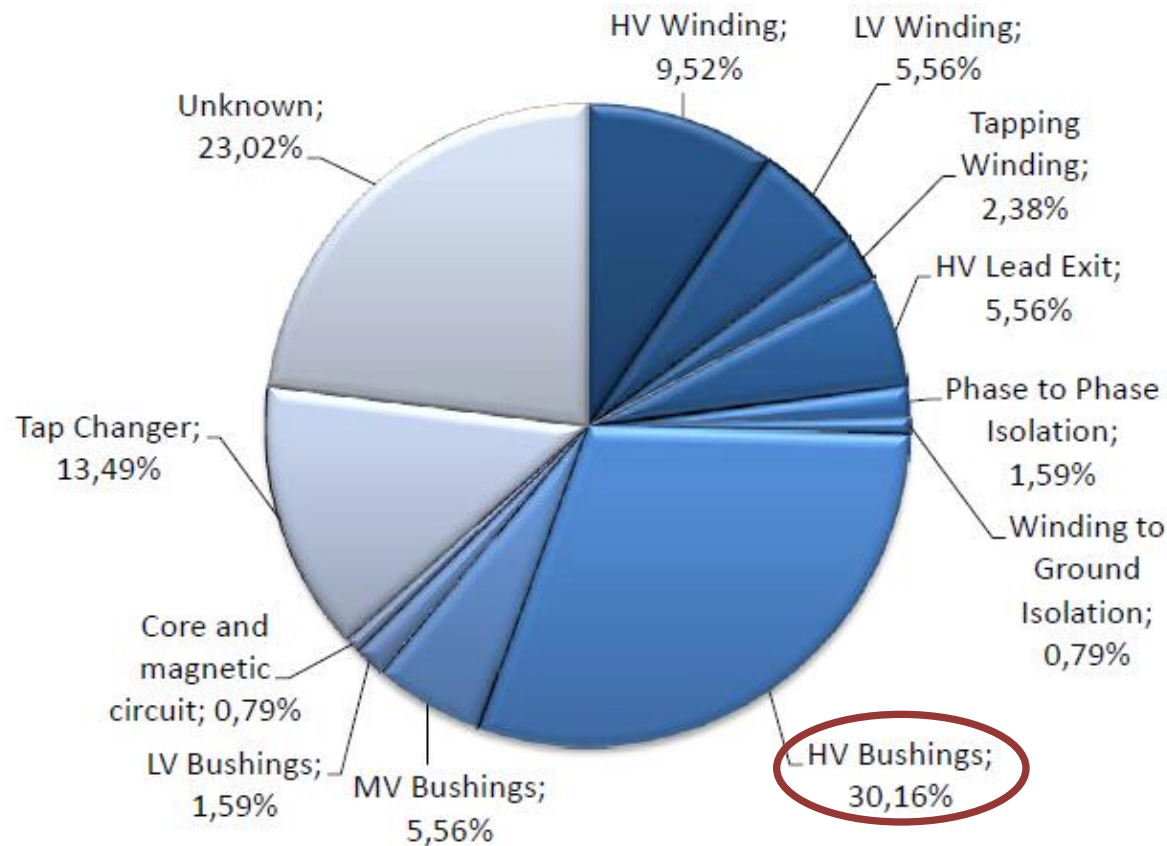


**Failure Location Analysis,
Generator Step-up Transformers,
 $U \geq 100\text{KV}$, 127 Failures**

Source: Transformer Reliability Survey WG A2.37 2015



30% of Failures where fire or explosion occurred are due to HV Bushings



**Failure Location
Where Fire or
Explosion
Occurred, 126
Major Failures**

**Source: Transformer Reliability
Survey WG A2.37 2015**



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Explosion of the 400 kV Bushing in a Single-Phase 167 MVA Autotransformer





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The active part of the autotransformer after fire



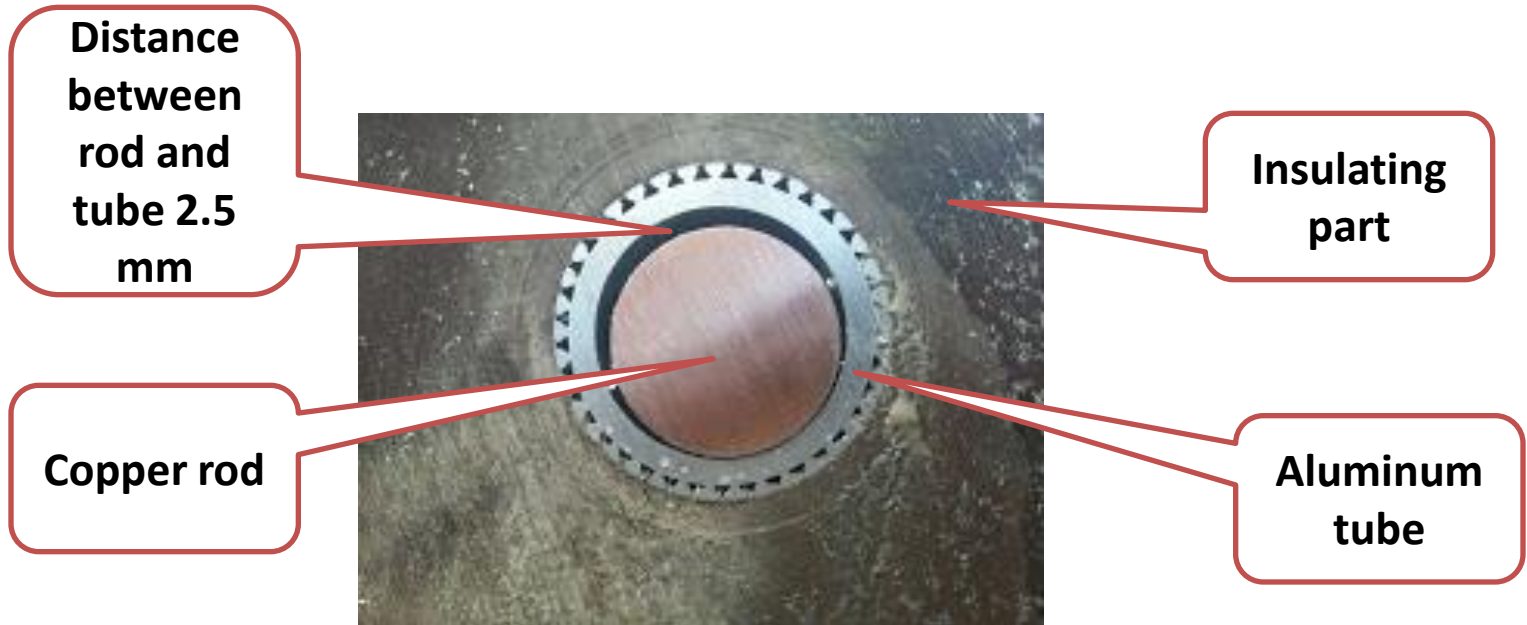


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Tracks on bottom part of copper rod and on inner surface of the aluminum tube



Cross-section of bushing's core





Analysis Results

- Due to network and substation overvoltage, micro arcs arise between the rod and the tube.
- The magnitude and location of these micro arcs are random and depend on many factors:
 - The amplitude of the wave (transient overvoltage).
 - Its time characteristics.
 - The electrical parameters of the autotransformer.
 - The electrical devices (arrester, cable or air lines, switchgears and disconnectors, etc.) attached to it.



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Solutions: Fire Protection by Automatic Shutoff valve



Automatic Shutoff valve



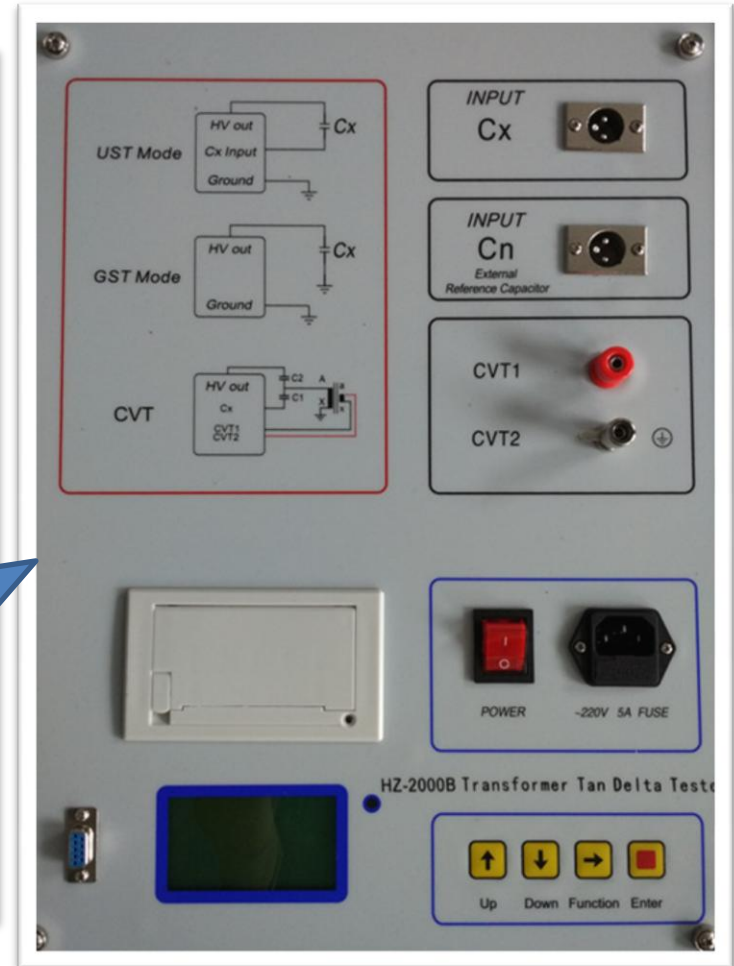
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Solutions: Regular DGA and Insulation tests



Dissolved Gas Analysis (DGA) can detect early signs of arcs/sparks in oil

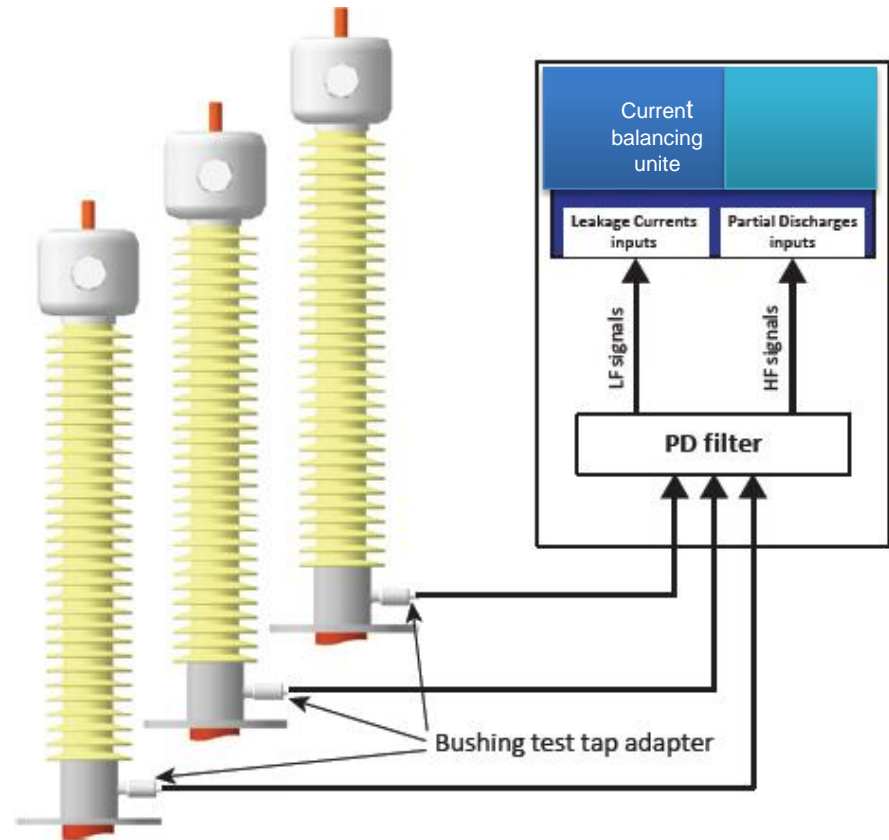
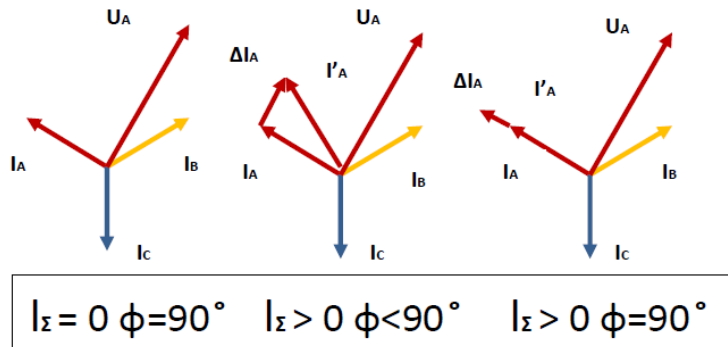
Tan-Delta and Capacitance testing can detect deteriorated bushing insulation



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Solutions: Universal On-line Bushing Monitoring System





Summary

- At Design time:
Take into account the possible effects of over-voltages which lead to partial breakdowns between the conductor rod and the inner tube.
- At Installation:
The presence of automatic oil shut off valve between the conservator and the tank can significantly reduce the consequences of explosion and fire of the transformer.
- At regular maintenance schedule:
Monitoring of Partial Discharges (PD), Leakage Current (Capacitance) and Dielectric Dissipation Factor ($\text{tg}\delta$ or PF); periodical measurement of transient over-voltages, $\text{tg}\delta/\text{C}$; DGA of oil and Thermovision can promptly detect serious problems inside the bushing before them become catastrophic.



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Thank You

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