Quick Info

Buchholz relay was invented by Max Buchholz in 1921 and have been applied on oil-filled power transformers at least since the 1940s. Since then, it has been part of critical protective device sensitive to the dielectric failure in transformer.

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TAP CHANGER: DESIGN, OPERATION & MAINTENANCE AND MONITORING (PART 2)

Based on an international survey on substation transformer failure done by CIGRE, 41% of transformer failure is caused by On-Load Tap Changer (OLTC). It is therefore, paramount for the transformer operator to be able to assure the reliability of the OLTC. Typically, extensive maintenance are conducted on serviced aged OLTC to reduce the unexpected unavailability and failure rate of power transformer. However, a routine maintenance is a major expenditure, both in resources and time. Thus, a condition-based maintenance is a better option to determine the condition of OLTC and observe operation characteristics. In recent years, many diagnostic techniques are developed aiming at measuring the contact quality and the mechanical behaviour, or at identifying the presence of degradation mechanisms through their symptoms. Cigre Brochure 445 presents an overview of the different diagnostic techniques for different OLTC types and defects.

DIAGNOSTIC METHOD	OLTC TYPE
VIBRO-ACOUSTIC	Vacuum
	Reactor
	Resistor
MOTOR TORQUE	All
DISSOLVED GAS ANALYSIS	Vacuum
	Reactor
	Resistor
IR THERMOGRAPHY	In-Tank
	Compartment
DYNAMIC RESISTANCE	All

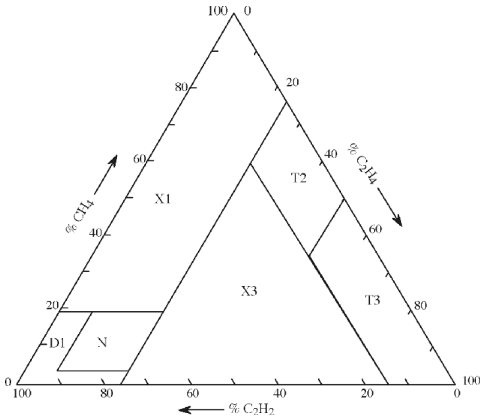
PROBLEMS										
Linkage/Gears							G	G	G	G
Timing/Sequence	G							E	E	E
Control/Relays							E			
Motor							G			
Brake							E			
Lubrication							E			
Contacts alignment							G	G	G	G
Arcing				M	G	E		E	E	E
Overheating/Coking		G	L	M	E	E		L	M	L
Contact wear	M							E	M	L
Transition	E							E	E	E

L-Low
M-Moderate
G-Good
E-Excellent

Diagnostic testing of OLTC (Ref: CIGRE 445)

DISSOLVED GASES ANALYSIS (DGA)

A number of research have been conducted to use Dissolved Gases Analysis (DGA) as a diagnostic tool for OLTC. Thermal stresses and discharges occurring in OLTC will produce gases and dissolved in oil. The interpretation method such as Duval Triangle has been developed for both main tank and OLTC compartment, and are still being improved. The triangle has been divided



into 6 regions including of zones of normal operation, severe coking of contacts, light coking and abnormal arcing.

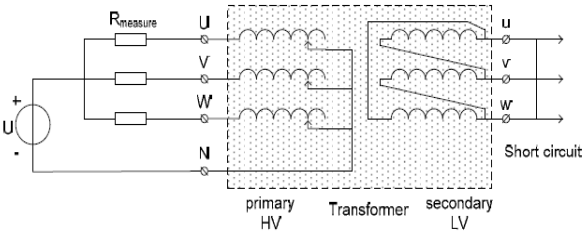
Zone	Identification
N	Normal Operation
T3	Severe thermal fault T3 (T>700°C)), heavy coking
T2	Severe thermal fault T2 (300°C<T<700°C)), coking
X3	Fault T3 or T2 in progress with light coking or increased resistance of contact, Or severe arcing D2
D1	Abnormal arcing D1 (outside of zone N)
X1	Abnormal arcing D1 or thermal fault in progress

Interpretation scheme of Duval Triangle for OLTC

IEEE C59.139 has established interpretation of gases dissolved in load tap changer. The typical limit of gases in normal, caution and warning level has allows abnormal switching activity or suspected fault in OLTC are to be determined.

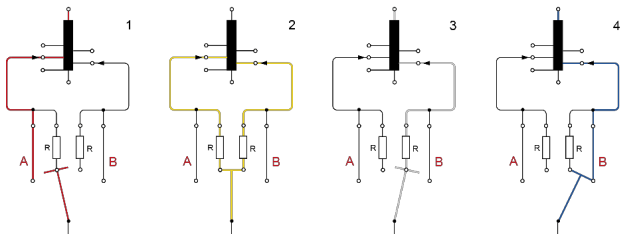
DYNAMIC RESISTANCE MEASUREMENT (DRM)

The dynamic resistance can be regarded as enhancement of ordinary winding resistance measurement. It is off-line diagnostic technique used to examine the condition of the tap changer contacts during its motion (hence dynamic) and has an advantage to detect several OLTC defects. By injecting a test current and recording the flow of current through the tap changer, the DRM instrument measures the fast switching process of the diverter switch; including any switching interruptions due to broken commutating resistors or broken leads and contact wear of the contacts. Therefore, it provides a deeper insight into the OLTC's dynamic condition.

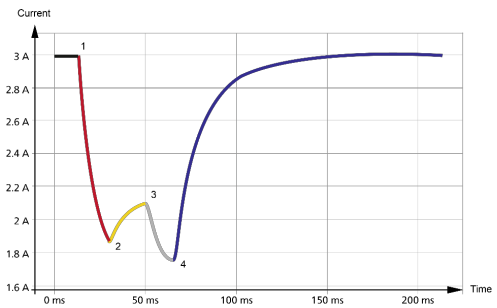


Set-up for dynamic resistance measurement

By analysing the recording current, it is possible to draw a number of conclusions related to the condition of the OLTC. The two sources of resistance variations affected the measurement parameters are transition resistors and resistance of the regulation winding. Any changes of the resistances in the circuit due to the degradation or other OLTC defects will change the recorded current.



Operation of OLTC diverter switch

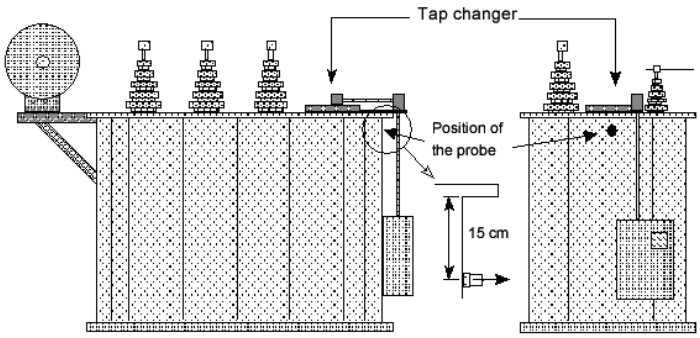


Dynamic behaviour of current curve

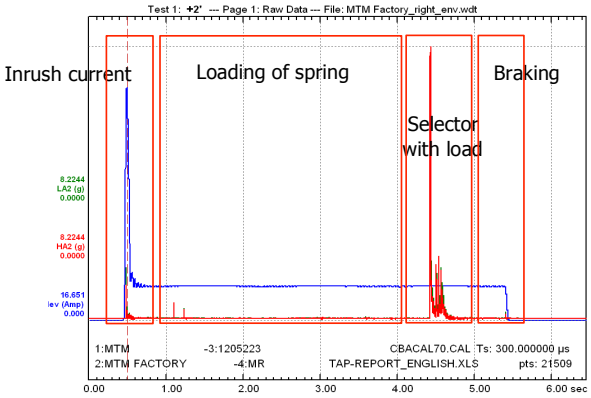
VIBRO ACOUSTIC SIGNATURE

The operation of on-load tap-changers will produce vibro-acoustic wave pattern which corresponding to the sequential operation of their mechanisms. This acoustic signal is transmitted through structural elements and can be recorded with a vibro-acoustic sensor (an accelerometer). A stable OLTC always shows consistent signatures. Any degradation of the OLTC will induce changes in the vibro-acoustic signature and will reveal electrical and mechanical anomalies through a deviation from a "normal" sound.

A high-frequency accelerometer is mounted either on the tap changer compartment or on the tap changer flange for the type of tap changers that is located in the main tank of the transformer. The initiation and termination of acoustic-signature recording are triggered by the LTC motor current. The complete operation has to be recorded for the proper functioning of the tap selector, diverter switch, change-over selector and the overall driving mechanism to be assessed.



Installation of high frequency accelerometer



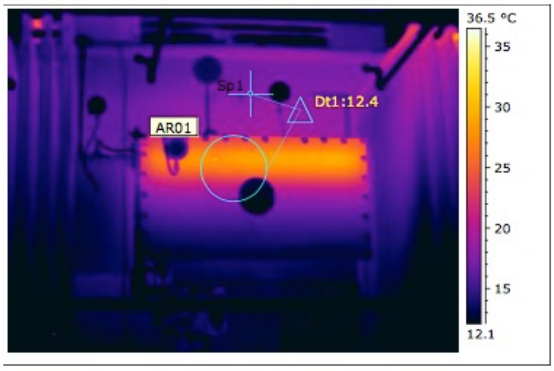
Relation of motor current and vibration signature with tap changer operation

The analysis of the signature requires an in-depth understanding of each significant tap changer event and its acoustics counterpart. A series of mechanical and electrical events produce distinctive vibration and noise patterns. Listening to these vibration and detecting any changes in time may indicate a developing of tap changer malfunctions or wears.

INFRARED THERMOGRAPHY

Infrared thermography is a technique that provides an image of invisible infrared light emitted by objects through radiation. This technique is particularly useful for compartment type of OLTC. It is able to detects abnormal heating of degraded contacts (coking, low pressure) or other malfunctions that cause abnormal increase in temperature.

Such problems are easily discerned on these OLTC designs because the OLTC compartment is normally cooler than the main tank, and any infrared scan that shows to the contrary should trigger an investigation.



IR scan on OLTC compartment shows abnormal condition

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