



### The scope

Medium voltage circuit breakers have, over recent years, seen very significant developments in both their operating function and also in the monitoring aspects of their condition. Overcurrent and overvoltage faults in power systems can inflict severe damage upon electrical equipment unless the fault can be isolated quickly. In the general case of faults of the overcurrent type, over-heating of equipment or damage due to electrodynamic forces may occur.

In order to achieve the above aim in protecting electrical equipment, it is necessary to have some device or material which is capable of changing its electrical conductivity from that of a good conductor to that of a good insulator in a very short time interval.

In essence, the circuit interruption process involves the establishment of an arc discharge followed by controlled extinguishing of the arc, resulting in the formation of a region of high dielectric strength between the terminals of the interrupter. Thus we should consider in turn how an arc can be produced, the properties of the arc generated and, finally, ways in which the arc can be extinguished.

The effect of arcing on the contacts can be quite severe, and the need to ensure low contact resistance when reclosing occurs after arcing means that considerable attention has to be paid to the contact material and design.

The wear of the arcing contacts is a particularly important parameter to measure as part of circuit breaker monitoring systems.

### Failure processes within oil filled switchgear breakers (OCB)

Section	Component	Defect type	Progression	End result
Low voltage	Control-gear contacts/wiring	High resistance connections	Overheating	Eroded/burnt insulation
Bus bar	Connections	Contamination	Surface tracking	Erosion – electrical tree – failure
	Insulators	Cracked/broken	Partial discharge	
	Cable to VT's	Loose connection	Overheating	
Voltage transfer	Not aligned	Incorrect air gap	Partial discharge	Fusing – welding/full arc flash
	Connections	Bad contact	Overheating	
Current transformer	Not aligned	Incorrect air gap	Partial discharge	Fusing – welding/full arc flash
	Connections	Bad contact	Overheating	
	Earth wire	Incorrect air gap	Partial discharge	
Switchgear breaker	Mechanical moving parts clutching	Parts clutching and do not move as per design	Arcing	Failure may involve explosion and fire
	Dielectric materials oil (liquid)	Contamination/decomposition	Sustained arcing	
		Gases generated by oil breakdown	Tracking discharges cause internal pressure	
	External contacts	Bad contact High resistant constant	Overheating and partial arcing	Fusing welding/full arc flash
Internal contacts	Bad contact High resistant contact	Overheating and arcing		

### Mechanical

The mechanical operations can suffer from clutching problems when the mechanical parts do not move to the required specification designed for the breaker. The main problem which occurs in circuit breakers is that the circuit breaker does not open or close completely when activation signals are sent. If these mechanical parts do not move to the required design criteria's, then an arc in the oil circuit breaker burns in a bubble of gas (mainly hydrogen) formed from the chemical decomposition of the oil by the heat of the contact arcing.

### Dielectric

The electrical (dielectric) failure of circuit breakers relates to the deterioration of the insulation materials used in the circuit breakers. In this case, the dielectric materials used is liquid as oil in the breaker. The potential electrical failure mechanisms which can occur include deterioration of the insulation by a variety of means, including pollution (particularly moisture ingress), chemical change and also the application of over voltages to the various components of the OCB.

### Tracking (PD)

In the case of oil circuit breakers, the gases generated by oil breakdown caused by the tracking discharge can generate substantial internal pressure and the failure may involve explosion and fire effects. With such a large volume of flammable material oil fires caused by oil, circuit breaker failures are a major potential problem. In the case of the oil circuit breakers the contamination may arise from the chemical decomposition products of the arcing, including carbon deposits and chemical films, such as oxides, on the contacts.

### Electrical contact

One of the major sources of problems with circuit breakers is that caused by the deterioration of the main switching electrical contacts. The contacts in switchgear are required to provide two main functions that are mutually incompatible.

- On the one hand, the switching contacts have to provide a low resistance electrical joint with negligible heating during normal closed operation.
- On the other hand, when the contacts open to interrupt fault current, they are subject to severe damage from the high temperature arcing which occurs.