

Application Note

Deciding on length of a linear transducer for different types of circuit breakers

Motion of the circuit breaker contacts is measured using motion transducers. The length of a transducer depends on a type of a circuit breaker tested. Actually, it depends on a trajectory of the moving part where transducer is connected. Trajectory may be different from the displacement of circuit breaker contacts, depending on the mechanism construction and access point to connect the transducer. Displacement may differ in different types of circuit breakers. The term “displacement” is defined by the start and end positions of the moving contacts. In the majority of circuit breakers types, one main contact and one arcing contact are movable.

The displacement of SF6, Oil and Vacuum circuit breakers are discussed in detail in this application note.

SF6 circuit breakers

The easiest way to calculate a minimal displacement of these circuit breakers is to replace kV with mm. For example, 72,5 kV SF6 circuit breaker has a minimal displacement of around 75 mm (2.953 inch). Manufacturers also include the safety factor when calculating this distance. A calculation should include over-travel during closing and over-travel during opening operation. Usually, over-travel during the closing operation is longer, it is about 15 mm on both sides. In this case the safety factor $k=1,2$ should always be considered. Having in mind everything stated above, a displacement for a given example like this can be calculated as:

$$L = k * (\text{minimal displacement} + 2 * \text{over travel}) = 1,2 * (75 + 2 * 15) = 126 \text{ mm (4.961 inch)}$$

This value needs to be rounded up to the first bigger size of the transducer available.

Oil circuit breakers

There are two types of circuit breakers that use oil for insulation and arc extinction: “minimum oil” and “bulk oil”. Oil circuit breakers that use oil only as the extinguishing medium are minimum oil circuit breakers. The bulk oil circuit breakers use oil for both, isolation and

arc extinction. The other difference is ground insulation; the “minimum oil” breakers are live-tank, and the bulk oil breakers are dead-tank. The displacement is nearly the same for both types.

These circuit breakers have large contact distances (total travel). The advantage of the bulk oil circuit breakers is that they have at least two breaks per phase for all voltages. The displacement of the bulk oil circuit breakers is almost always measured using the linear transducer. The displacement of the minimum oil circuit breakers can be measured either with the rotary or linear transducer.

Here is the list of minimal displacements for oil circuit breakers and different nominal voltage ranges:

46 kV – 300 mm (11.811 inch)
 69 kV – 380 mm (14.961 inch)
 121 kV – 400 mm (15.748 inch)
 145 kV – 400 mm (15.748 inch)
 169 kV – 400 mm (15.748 inch)
 242 kV – 600 mm (23.622 inch)

Transducer length is calculated as for the SF6 circuit breakers:

$$L = k * (\text{minimal displacement} + 2 * \text{over travel})$$

For example, for 69 kV circuit breaker:

$$L = 1,2 * (380 + 2 * 15) = 492 \text{ mm (19.370 inch)}$$

It can be rounded to 500 mm (19.685 inch).

The linear transducer for displacement measurement of the bulk oil circuit breakers should be at least 400 mm (15.748 inch) and should be capable to measure displacements of up to 800 mm (31.496 inch).

Since such long linear transducers are cumbersome to use, an alternative for oil breakers is to use the digital rotary transducer together with a linear to rotary motion converter accessory. This way, the use of a very long linear transducer is avoided by converting a linear to rotational motion.

The method of operation is very simple. An iron rod, which is used for transferring motion from the moving contacts to linear transducer, is used for transferring motion to the converter accessory in this case. The rod is passed through the converter and it is linked to the wheel in the converter. The wheel and the digital rotary transducer are mounted on the same shaft. The moving of the circuit breaker's contact, i.e. the moving of the iron rod, is converted to the rotational motion of the wheel. The rotational motion of the wheel is transmitted to the shaft of the digital rotary transducer. The transducer converts rotation of the shaft to a digital signal and sends it to Circuit Breaker Analyzer and Timer (CAT) instrument.

Another advantage of digital rotary transducers is that they don't require calibration or setup, unlike analog linear transducers.

Vacuum circuit breakers

Contact distances of these circuit breakers are very short. They are in the order of maximum 40 (1.575 inch) to 50 mm (1.968 inch). A linear transducer for the vacuum circuit breakers should be able to measure displacements of up to 100 mm (3.937 inch).

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