Breaker Inspection and Testing Is an Important Component of any Electrical Maintenance Program

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A circuit breaker is a device used for the protection of both circuits and apparatus. According to the type of construction, circuit breakers are classified in the following categories:

- air circuit breakers, used at low and medium voltages; and
- oil and gas circuit breakers, usually used at high voltages.

The most common circuit breaker used in medium voltage substation applications is the air circuit breaker. There are a number of exceptions when the use of oil type circuit breakers are required such as coal mines, some chemical processes, bottled gas plants, refineries, and explosive factories.

The basic construction of the breaker depends on the application in which the breaker will be used and can vary according to the manufacturer. Generally, every breaker consists of the following:

- breaker assembly
- control panel
- operating mechanism
- arc chutes
- trip units

Circuit Breaker Inspection and Maintenance
The circuit breaker compartment contains the circuit breaker mounted on a withdrawable carriage which permits the breaker to be taken out of
the enclosure. The front door of the compartment has a viewing window for observing the status of the circuit breaker without opening the door. The door also has a shutter through which the racking handle can be inserted to rack the circuit breaker in or out. The following items should be inspected during regular maintenance:

**Contacts**
The functioning of the circuit breaker depends on the contacts. When closed, practically the entire load current passes through these breakers. As well, they must withstand complete overload or short-circuit current. If the resistance of the contacts becomes high, they will overheat which can cause damage or destroy the complete breaker. Because of these factors, regular maintenance of the contacts is important and should include contact cleaning and smoothing.

**Arc Interrupters**
The arc interrupters play a role in the dispersion and cooling of the arc flame. Regular maintenance of arc interrupters includes cleaning, checking for physical damage and performing an ac high potential test across the arc chute.

**Operating Mechanisms**
The operating mechanisms function is to open and close the breaker contacts. It consists of a series of linkages connected to a power mechanism, either solenoid or a spring device. Inspection should include cleaning, a check for wear and hand closing the breaker to make sure all parts operate freely.

**Auxiliary Devices**
Auxiliary equipment includes control relays, switches and protective relays. During regular maintenance, they should be cleaned and tested for operation. Also, protective relays should be checked for setting to assure they coordinate with other relays in the system.
Breaker Testing, Setting and Calibration

The most common relay used in the protection of the power distribution system is the overcurrent relay. The function of this relay is to sense the overcurrent in the system and, when operating correctly, provide the circuit breaker tripping operation.

According to construction type, relay and trip units can be classified in the next two main categories:

- solid state
- electro-mechanical

The relay operating characteristic is shown as a logarithm function of operating current and time. Such curves normally employ log-log scales to cover a wide range of time and current. Similar curves are published for overcurrent relays having different time-delay characteristics. It is possible to adjust the operating time of relays. This is important since they are normally used to selectively trip breakers that operate in series on the same system circuit.

This adjustment of the operating time and current value is called breaker setting. The electro-mechanical type is usually equipped with two types of trip settings:

- instantaneous current trip settings
- overload current trip settings.

Additional adjustments of operating characteristics to allow for better system co-ordination can be achieved by using a solid-state type of relay or trip unit. These are usually equipped with the following type of settings:

- long-delay current trip setting
- long-delay time trip setting
- short-delay current trip setting
- short-delay time trip setting
- instantaneous current trip setting
- ground current trip setting
- ground-delay time trip setting

A short description of the main types of trip settings is provided below:

**Instantaneous trip settings**
Instantaneous tripping without any intentional delay is used to provide protection against short circuits. It is possible to select various short circuit pickup levels according to the co-ordination needs.

**Overload trip settings**
Overload tripping is used to allow a breaker to protect system components such as transformers, motors, conductors etc. that may fail due to restrictive heating. When an overcurrent condition persists for a specified length of time the breaker trips and breaks the load. A variety of trip times for different levels of current and curve settings are possible in order to achieve the proper system co-ordination.

**Ground fault settings**
The ground fault current is often below the trip level of the overload settings. It is therefore necessary to have separate ground fault protection to prevent damage. Separate ground fault levels of 0.1-0.8 times the CT rating and trip times of no intentional delay are provided with this type of setting. The level setting should be set low enough to provide a trip under ground fault conditions and high enough to prevent nuisance trips under normal conditions. Some ground current will be detected from capacitive current or CT mismatch and spill currents in residual ground sensing circuits. The level must be set higher than this normally encountered value.

After the proper setting is achieved, calibration of the relay or trip units should be performed in order to ensure the acting relay or trip unitwork
at the predetermined value. The relay calibration is the set of complex tests performed on the relay or trip unit to confirm and further adjust its trip characteristic - which should be in the limits suggested by the manufacturer. Each manufacturer of relays has established test and service procedures for the great variety of relays offered. It is therefore impractical to attempt a discussion of specific techniques. The manufacturer's instruction literature should be used as a guide for the relay inspection and test being performed.

The calibration of the solid-state relay generally consists of primary injection testing, testing of all the trip settings that each breaker is equipped with and a final testing. It is important during these testing that the manufacturer's instructions be carefully followed.

Test procedures for electro-mechanical relays usually consist of adjusting the stationary contact, a minimum operating current test and time curve calibration. If the minimum operating test shows that calibration is necessary the damping magnet should be removed and control spring tension should be adjusted.

The purpose of the time curve calibration is to ensure that relay operating time for certain values of current be shown on the time current curves, plus or minus five percent. If the operating time is not within the tolerance for the low values of applied current, the permanent magnet keeper should be adjusted until this operating time is correct. If the operating time is not within the tolerance of the high values of applied current, the electromagnet screw plugs require adjustment.

Because the test results can vary with conditions and type of instrumentation employed, the accuracy of test equipment should never be taken for granted - it can become damaged, depending on the frequency with which it is used and recalibrated. Instrument error may be significant to the degree that adjustment of a device will be made.
based on inaccurate readings. As you can see, recorded data is vital to the evaluation of subsequent test results and decisions for recalibration, adjustment and replacement of the protective devices.

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