ESCO ENERGY SERVICES
An ESCO Group Company

Testing Low Voltage Breakers

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During its 20-40 year service life, a circuit breaker must be constantly prepared to operate. Typically, long periods of inactivity often elapse during which the breaker's mechanical and electrical components never move. The circuit breaker is the active link in a fault clearance situation. When a fault occurs on the electrical system, the associated fault current must be interrupted quickly and reliably. This action is referred to as fault clearing. If a breaker fails to clear a faulted circuit, the resulting damage can be very serious in terms of both personnel injury and equipment damage. Even though circuit breakers are comparatively reliable, circuit breaker failures can and do occur. Therefore, circuit breakers must be tested and maintained to ensure proper operation during these faults.

Many circuit breakers provide longer service lives than expected. If you can ascertain that a breaker is in good condition, you can continue to use it rather than replace it at its end-of-life. For the remainder of this discussion, we will concentrate on low voltage power circuit breakers.

Different maintenance strategies

There are three basic maintenance strategies that are typically applied to circuit breakers:

<u>Corrective Maintenance</u> – With this strategy, maintenance is performed as the breaker fails to operate. Although considered short-sighted by most maintenance professionals, this is a prevalent maintenance philosophy in most medium to small industrials. Justifying the performance of preventive maintenance is a comparative exercise which typically involves comparing short-term savings in maintenance costs to potential repair costs and production losses. The unfortunate result in applying this maintenance strategy is that there may be inoperable circuit breakers in the electrical system. When older circuit breakers are included in the electrical system, there is a very high probability that some of the breakers are inoperable.

<u>Time Interval-Based Maintenance</u> – With this strategy, maintenance activities are performed at a predetermined frequency, regardless of the conditions under which a circuit breaker operates. If this method is applied too strictly, however, it may lead to excessive work efforts and costs.

<u>Condition-Based Maintenance</u> – With this strategy, the condition of a circuit breaker is evaluated through maintenance testing and inspection. The results, supplemented with statistical data and cumulative experience, are then used for maintenance planning.

Condition-based maintenance provides excellent opportunities to improve reliability and cut costs, but it requires effective diagnostic methods, like the performance of an infrared (IR) survey.

Suggested Electrical Tests

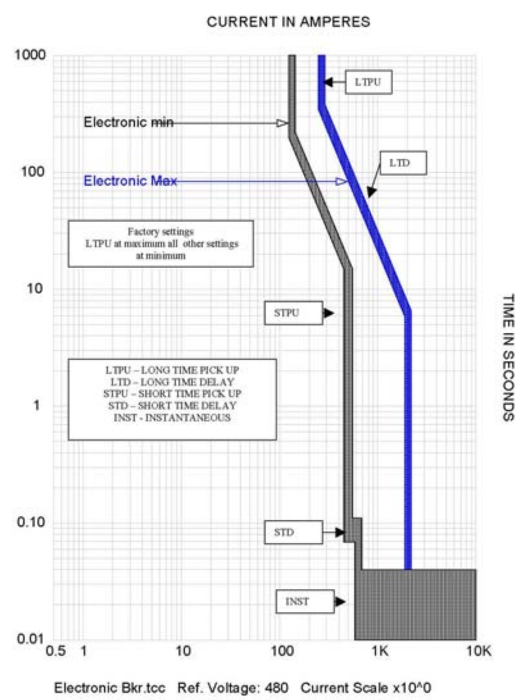
Many circuit breakers provide longer service lives than expected. If you can ascertain that a breaker is in good condition, you can continue to use it rather than replace it. There are some basic electrical tests that should be performed on low voltage circuit breakers.

Contact resistance – This test should be performed from line-to-load terminals for each phase with the breaker closed. The values should be within 50% of each other and comparable to similar circuit breakers.

Insulation resistance – This test should be performed phase-to-phase and phase-to-ground (i.e., case, if applicable) with the breaker closed. For 480V breakers, acceptable values should be greater than 100 megohms.

In addition to these basic tests, either primary injection testing or secondary injection testing should also be performed. To perform either test, the circuit breaker being tested must be de-energized and isolated from other breakers and circuitry. Many 480V breakers have trip units associated with them. These trip units can consist of any or all of the following trip setting capabilities:

- Long-time Pickup and Delay – This setting is associated with circuit and equipment protection from an overload condition. The time delay is provided to mitigate spurious operations.
- Short-time Pickup and Delay – This setting is associated with circuit and equipment protection from over-current conditions, typically in excess of 300% of rating. The time delay is provided to mitigate spurious operations and nuisance tripping associated with large motor starts, etc.
- Instantaneous Pickup – This setting is associated with circuit and equipment protection from fault conditions. This trip function protects against phase-to-phase and phase-to-ground faults.



- Ground-fault Pickup and Delay – This setting is associated with circuit and equipment protection from ground fault conditions. The time delay is provided to mitigate spurious operations.

<u>Primary Injection Testing</u>

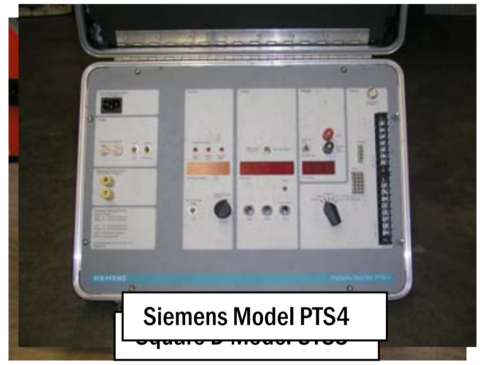
MultiAmp CB-8160

For primary injection testing of low voltage circuit breakers, high current is injected at a low voltage (typically 5 to 10 V) at each phase of the breaker. The level of current to be injected is either per manufacturer's recommendations or in accordance with the manufacturer's published time-current curves. The associated testing circuit path is typically supplied through the line contacts and returned through the load contacts of the circuit breaker for each phase. Proper operation of the components within the circuit breaker—current transformers, conductors, connection points, trip unit operation and mechanical trip mechanisms—is encompassed by performing the primary injection test for each phase of the breaker. Based on the time-current curve for the breaker, each test current level will have a required time response for determining acceptability.

Primary injection testing has been the preferred method for circuit breaker testing since it verifies the sensors, wiring, and trip device as well as the conduction path in the breaker. Primary injection testing is typically performed by experienced test technicians using specially-engineered injection test sets with integral measurement equipment and a transformer, which makes the test sets very heavy and difficult to move around. Primary injection testing has also been described as potentially destructive since it involves applying large currents to the breaker. The concern is that the stress of large currents on the breakers could eventually lead to premature failure of the breaker. Unfortunately, primary injection testing may be the only means of testing some low voltage circuit breakers, (i.e., molded-case, thermal and thermal-magnetic breakers).

<u>Secondary Injection Testing</u>

Some trip units allow for testing the trip functions of the breaker utilizing a secondary injection test. Secondary injection testing is different from primary injection testing in that high currents are not applied through the line and load contacts of the breaker. Secondary injection testing normally involves disconnecting the trip unit from its normal monitoring circuitry and connecting it to a specialist test set that can inject, measure, and record the operation of the circuit breaker. The advantage of secondary injection testing is that the testing process does not include injecting high currents to operate the trip unit and trip the circuit breaker. A perceived disadvantage of secondary injection testing is that the current transformers and some of the connection points are not tested.



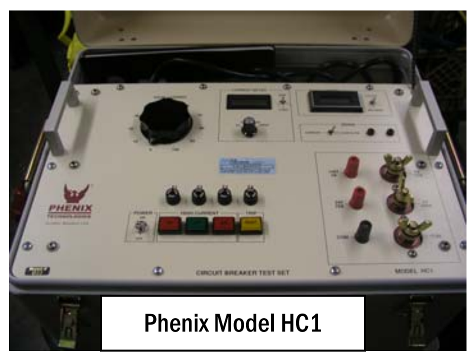
Siemens Model PTS4

GE Model TVRMS

Specialty test equipment (pictures of several secondary test sets from breaker vendors are provided) and knowledgeable test technicians are still required in performing secondary injection testing. The test technician must have significant knowledge of the actual protection scheme and philosophy. Furthermore, disconnecting and reconnecting the trip unit should only be performed by a qualified test technician.

<u>Secondary Injection Testing with Primary Verification</u>

Secondary injection testing, when it can be applied, is a much safer and faster way to test breakers in the field. If one could develop a testing methodology which utilizes secondary injection testing and verifies proper operation of the current transformers and the other connection points of the circuit breaker, it would allow the industry to safely perform this valuable testing more economically. With the advent of electronic trip units which include a power monitoring capability and display, a testing methodology is available to accommodate this testing process.



Phenix Model HC1

1. Inspections and contact resistance testing is performed to verify conductors and some connection points.
2. Secondary injection testing is performed to test and verify the proper operation of the trip unit and the mechanical trip mechanism.
3. Low current primary injection (at ~25% and 50% of full load rating) is performed with a more portable current test set to verify proper operation of the current transformers and remaining connection points.

4. If deemed necessary, CT saturation tests could also be performed to provide verification of CT capability during a fault condition.

This methodology, “secondary injection testing with primary verification”, provides a safe and reliable process for determining circuit breaker health without the induced stress of high current primary injection. This testing methodology will not be applicable to all installations.

In conclusion, even though circuit breakers are comparatively reliable when compared to other electrical devices, circuit breaker failures occur. When a breaker fails to operate, the resulting damage can be very serious in terms of both personnel injury and equipment damage. Therefore, circuit breakers must be tested and maintained to ensure proper operation during these faults.