Time-Travel — It's Not Just Science Fiction

by Rod Olinger
Electro-Test, Inc.

High-voltage breakers play a critical role in protecting upstream equipment and minimizing the damage to downstream equipment when things go wrong. Whenever called upon, they are expected to perform instantly. Breakers perform two primary functions. One function is switching normal loads on and off. The other is interrupting overload or short-circuit current.

High-voltage breakers are usually very reliable. Industry average data, provided by the IEEE 493 reliability standard, indicates that fewer than two out of 100 high-voltage breakers fail annually. Nevertheless, we are all aware of the awesome damage that can result from a breaker failure. Personnel can be killed or maimed, fire and physical damage can be extreme, and the financial impact caused by an unplanned shutdown can be devastating. Consequently, we know how important it is to perform maintenance and keep breakers in good condition.

One study summarizing a huge amount of data indicated clearly that the majority of problems with high-voltage circuit breakers are mechanical. The study reported 70 percent of breaker failures involved mechanical malfunction, 19 percent involved electrical malfunction, and 11 percent occurred due to conditions on the primary circuit. This may seem surprising since a high-voltage breaker that has been in service for thirty years may have as little as 10 seconds or as much as 10 minutes of actual operating time. Over a period of 30 years the operating time is relatively as long as the blink of an eye. However, imagine what happens to lubrication or various elements of corrosion over a period of many years with that mechanism sitting idle.

Time-travel has been well established as providing valuable information to indicate the mechanical condition of a high-voltage breaker. The measurement of the operating velocity of the breaker can indicate as much as 80 percent of the breaker operating characteristics. However, in the typical time-travel test a significant amount of the available information is lost.

Typically, when this test is performed, the breaker is operated (tripped) to take it out of service. The actual time-travel test is then performed after the test equipment is installed and upon the second operation of the breaker. There is often a significant difference between the initial or live time-travel measurements and the second operation. It is the first or live measurements that are most informative. The initial operation is more indicative of the actual operation in service and the condition of lubrication. The friction due to the initial operation can temporarily cause a lubrication film to form even when the lubrication has lost most, if not all, of its lubricating properties.

So what are the options? It is possible to measure the time-travel upon the initial operation of the breaker. This "live" test captures the information that may be unique to the initial operation. This option must be considered carefully due to the obvious hazards involved. Under the right circumstances the hazards can be managed, but this should only be undertaken by the most experienced technicians with a complete understanding of the breaker and knowledge and training on the specific hazards.

Due to safety concerns, the time-travel measurements must be taken from the control cabinet. It is required that some part of the operating mechanism extends into the control cabinet. Transducers, either rotating or linear, must be installed to a part of the operating mechanism that is proportional to the operation of the breaking element.

Installing transducers correctly requires expertise for a couple of reasons. All trip signals to the mechanism must be defeated, including the manual trip, to prevent the operation of the breaker during the installation of the transducers. Additionally, selecting the location for installation of the transducer and its actual installation are important. When performed by someone with expertise, the installation takes three to five minutes.

The selection and installation of transducers impacts both safety and accuracy. A linear transducer must have its transducer rod clamped to an operating rod with linear motion. This can expose the technician to high speed moving objects. A rotational transducer would have its transducer rod installed at the center point of a rotating shaft. If no other parts move across the area of the end shaft, the relative speed and distance of movement is very small. The rotational transducer rod would be mounted in a drilled and tapped hole at the center of an operating end shaft. The transducer would then be mounted within two to three inches of the operating mechanism and around the transducer rod.

With the transducer installed, the live test can be performed. Before the test is initiated equipment should be set up to measure a few more operating parameters. The breaker load current should be recorded at the time of operation through the installed control transformers. The trip coil current at the time of operation should be recorded. The dc control voltage should be recorded at the time of operation.

Upon completion of the live test, a second test is performed with transducers installed in both the control cabinet (for the live test) and in the location specified by the manufacturer. These are compared with the live test to give relative values.

An alternate solution is to permanently install the transducers in the control cabinet at the next routine outage for maintenance. Then the transducers are available for the next opportunity to conduct a live test. Comparative tests between the transducers installed in the control cabinet and the factory position would be made at the time of installation.

How far can we take this concept to limit down time and have good condition information? With the transducer installed in the control cabinet, the next step is to permanently connect a simple data recorder to the transducer. The time-travel could then be recorded anytime the breaker trips.

Permanently connecting a simple data recorder to the transducer is the direction the industry will likely go. In the near future, the simple data recorder will be replaced with a simple data processor and the high-voltage breaker will become an intelligent field device (IFD). The onboard data processor will automatically record the breaker time-travel and compare the data to established limits. If the time-travel is outside the set limits the IFD will report it to the main computer and action will be outlined to respond.

Time-travel analysis is the equivalent to a crystal ball that can look into both the past and the future. The trick is learning to read that crystal ball. Can the details of the operating mechanism, such as damping, total-travel, overtravel, rebound, instantaneous velocity, and average velocity be seen?

When the equipment is installed correctly and the results are received, two more critical tasks are necessary. First, the data must be analyzed. Then, the appropriate action must be taken. Performing these two critical tasks is another topic altogether.

Reference

CIGRE, Final report of the second international enquiry on high-voltage circuit-breaker failures and defects in service. Group 06SC131994

Rod Olinger is the Manager of Training Services for Electro-Test, Inc. and is focused on providing custom training to clients. Rod has been working in field service and training in the power industry for over twenty years. He is a NETA Certified Sr. Technician, Level IV.