SQUARE D™

Low-voltage circuit breaker injection testing

Making the case for secondary injection testing

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Introduction

Circuit breakers are critical safety devices, whether we're talking about the 15 amp (A) or 20 A units in our basement load center or the 1200 A and larger versions installed in industrial switchgear.

While regular maintenance and testing should be a part of all circuit breaker installations, this process becomes more essential as their size and the critical nature of the application goes up.

Any circuit breaker failure can pose significant hazards, but dangers rise exponentially for both property and personnel should an industrial- or utility-scale device fail to interrupt power during a fault event, given the high current levels present in such applications.

This is why facility managers can face demands, on multiple fronts, to incorporate circuit breaker testing into their regular electrical system maintenance programs, including:

- **Insurance providers** could include circuit breaker testing alongside annual thermographic evaluations in their coverage provisions.
- As specified by both **local authorities having jurisdiction and national organizations**, such as the National Fire Protection Association's NFPA 70B 4.1.3, codes and standards can refer to the need to have an electrical preventive maintenance (EPM) strategy in place.
- **Manufacturer recommendations** will likely recommend testing to ensure ongoing safe operation of installed circuit breakers – and codes and standards might refer to those recommendations in their own requirements.

Schneider Electric has testing recommendations that vary by environment, ranging from every five years to biannually or annually when breakers operate in harsher conditions.

What is injection testing?

Regardless of the schedule, facilities personnel have options for testing installed circuit breakers. This involves injecting some level of current into the device while it's disconnected to ensure it will trip when exposed to fault-current situations:

1. **Secondary injection** testing uses minimal power through a secondary current path and trip unit while the circuit breaker can remain in place in its panel or switchgear.
2. **Primary injection testing** injects a specified amount of current through the primary current path, which requires the circuit breaker's removal from its panel or switchgear. This testing approach might be done:
    - At current levels that are only somewhat higher than those used with secondary injection testing to verify the primary current path, current transformers (CTs), and connection to the trip unit is working properly, as well as the display and metering accuracy.
    - At a much higher current – 10 times the fault current – to actually trip the circuit breaker.

For many in the industry, primary injection testing only refers to using high current to demonstrate real-time breaker operation.

However, Schneider Electric Services recommends using a low current to verify a circuit breaker's trip chain. This is what is meant by the phrase "primary injection" in our product and testing documentation.

This guide explains each of these testing options in detail and outlines **why Schneider Electric believes secondary injection testing is the optimal choice** for facilities managers using microprocessor-based circuit breakers in most applications.

What is secondary injection testing?

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Secondary injection testing involves using a secondary current path rather than the primary path through the busbar to which a circuit breaker is connected.

This means breakers can remain in place – though they're de-energized during testing.

This testing procedure description needs to briefly explain the vital role current transformers (CTs) play in microprocessor-based circuit breakers. CTs are coiled windings wrapped around the circuit's conductor, making up part of these circuit breakers' control systems. They monitor the secondary current generated by the magnetic field as current passes through the conductor. The amperage of this secondary current is a specified ratio of the primary current.

When that primary, and thus secondary, current exceeds the set pickup levels – say 10 A for a 100 A circuit breaker – the CT provides a signal that the electronic trip unit analyzes to determine the tripping action of the circuit breaker.

Secondary injection testing takes advantage of this signaling process. During the test, a small amount of power is injected through a port at the front of the circuit breaker connected to the trip unit's control center. This power simulates conditions the circuit breaker's CT would signal to the trip unit in an overcurrent situation.

A second evaluation can follow this test to ensure the CT's signaling process is operating correctly – to ensure, in this example, the 10:1 ratio is maintained. A known amount of current is pushed through the primary circuit as a load to see if the CT's display is registering one-tenth that amount.

This is called trip chain verification – and technically what Schneider Electric Services' documentation refers to as "primary injection." Combining these two tests helps assure that both the CTs and trip units operate correctly.

Secondary injection has several advantages, starting with the fact that the de-energized circuit breakers can remain in place during testing, see **Figure 1**. As a result, there are time savings without removing and reinstalling the devices.

Secondary injection also helps eliminate the risk of damage that can result from repeated disconnection and reconnection – along with the damage high current primary injection testing can cause if not used correctly. Finally, if trip chain verification is required, using a low current test set, the extremely low power levels pose very limited potential for harm to equipment or operating personnel during testing.

Schneider Electric Services isn't alone in this recommendation. The report, "A Balanced Approach to Molded Case Circuit Breaker Maintenance," also supports secondary injection testing in stating:

Figure 1

> "We would also be remiss if we did not mention secondary injection testing, where a signal is placed on the trip circuit simulating an overcurrent situation on electronic trip circuit breakers. **This type of test is completely non-destructive, non-damaging, and is highly recommended** as a routine test on electronic circuit breakers with that capacity. As the industry continues to evolve, we expect to see more and more of this type of breaker (as opposed to a thermal-magnetic trip breaker), and we look forward to seeing more secondary injection testing done on a routine and relatively frequent basis."[1]

1*Babb, M. T., & Trusty, A. D. (n.d.). (rep.). A Balanced Approach to Molded Case Circuit Breaker Maintenance, March 2019

What is primary injection testing?

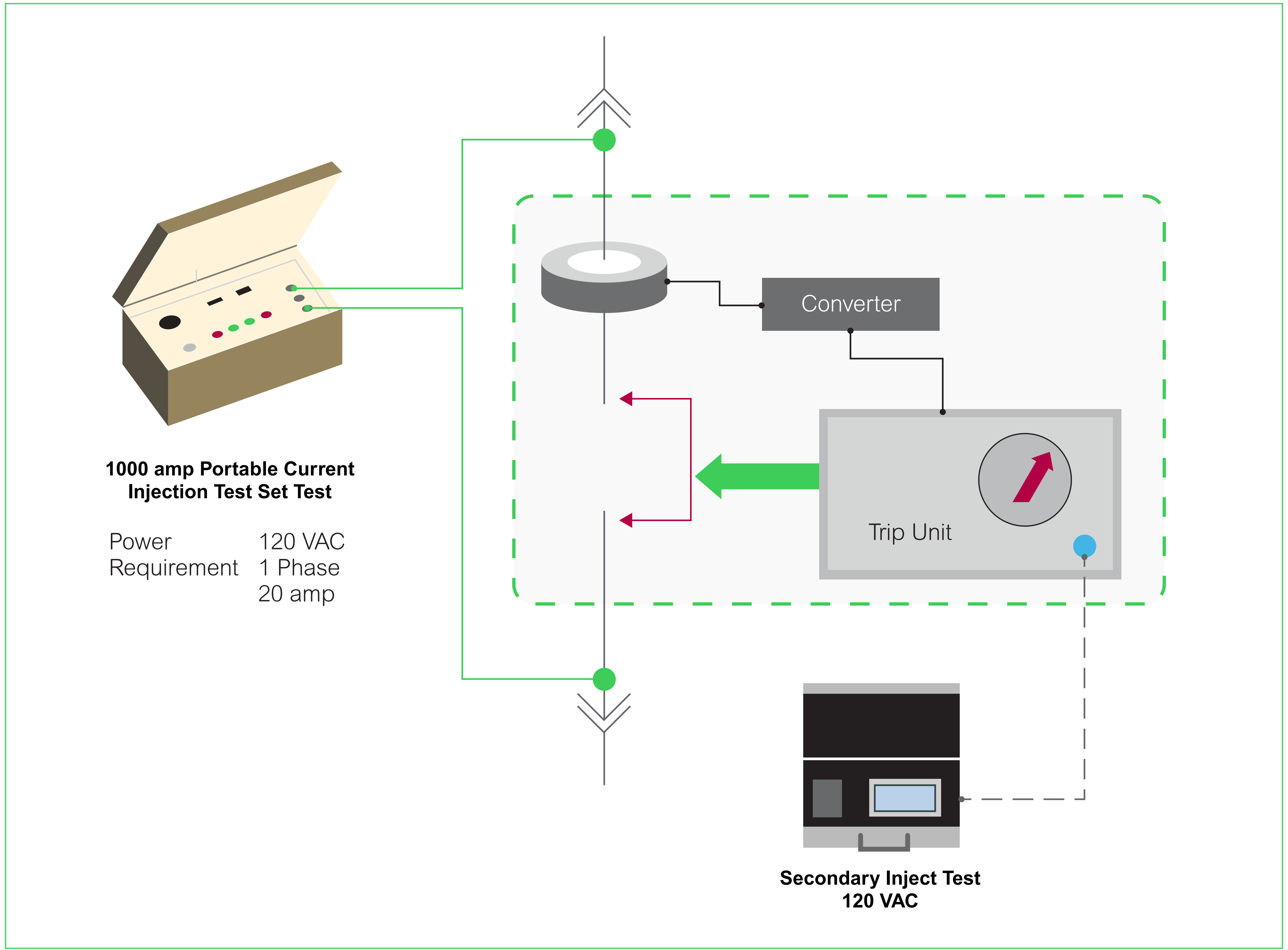
What is primary injection testing?

Primary injection testing is the only method available for trip chain verification with thermal/magnetic circuit breakers because they lack the microprocessor-based infrastructure secondary injection requires.

Figure 2 illustrates how low current primary injection can be used to verify the tripping chain continuity for only electronic circuit breakers.

Schneider Electric recommends using low current levels for this procedure. However, some continue to use high current primary injection with newer digital circuit breakers, which Schneider Electric recommends against – and a brief description of the process can help explain why we've come to this conclusion.

Figure 2



Regardless of current levels, primary injection testing requires circuit breakers to be physically removed from their connected equipment.

In larger industrial applications, circuit breakers can weigh hundreds of pounds and require forklifts or other assistance for removal. This is a risk point for receiving accurate results.

What is primary injection testing with a high current?

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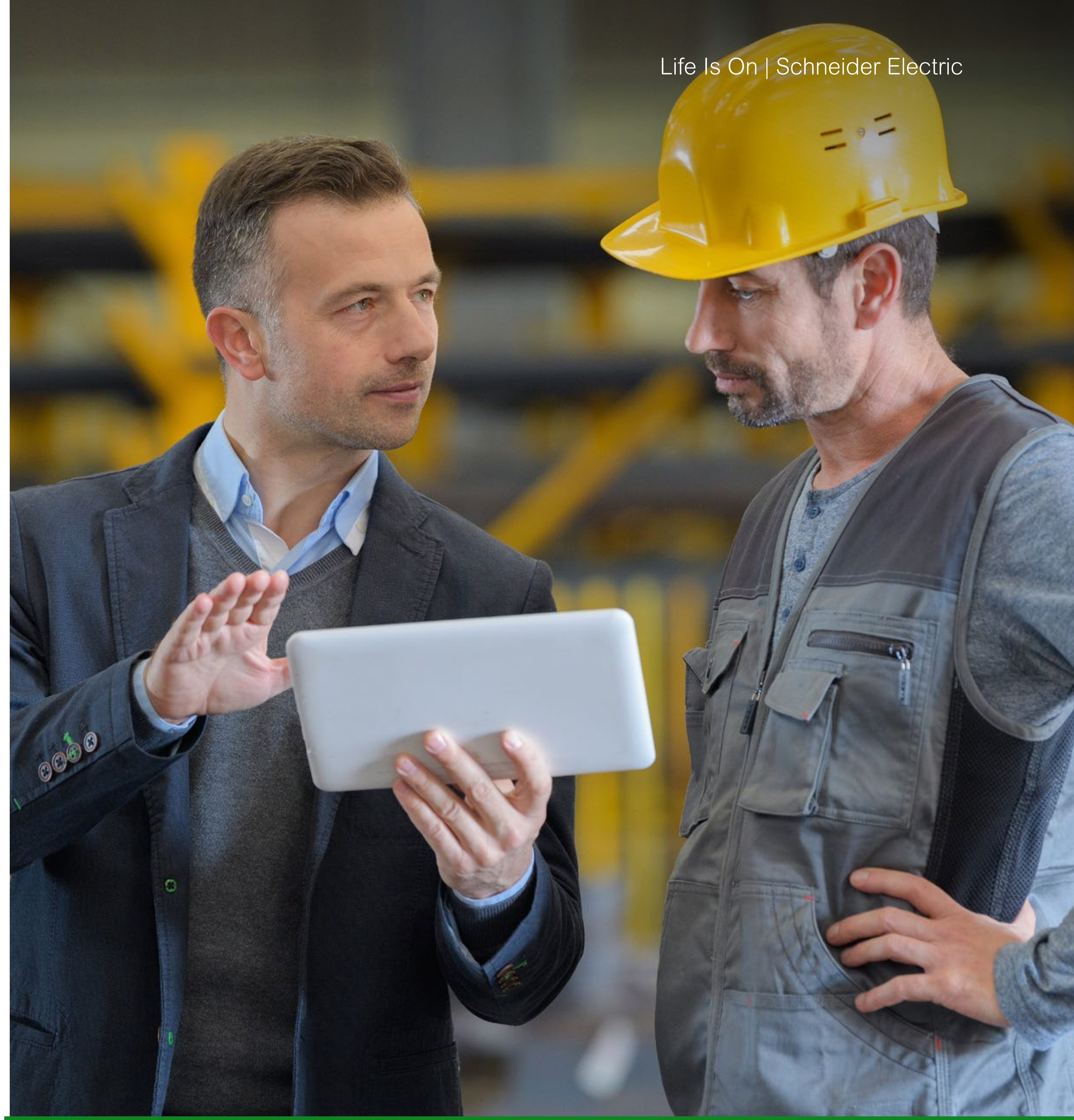
What is primary injection testing with a high current?

While it's possible to use primary injection testing at lower current levels with microprocessor-based circuit breakers, **thermal/magnetic circuit breakers can only be tested using a high current**. These products are purely mechanical, so testing must subject them to levels of current high enough to force a physical trip in a short time.

The test is similar to primary injection testing with a lower current, except the amount of current delivered to the circuit breaker is exponentially higher.

Circuit breaker manufacturers develop time/current curves to illustrate when a specific circuit breaker model will trip when exposed to overcurrent.



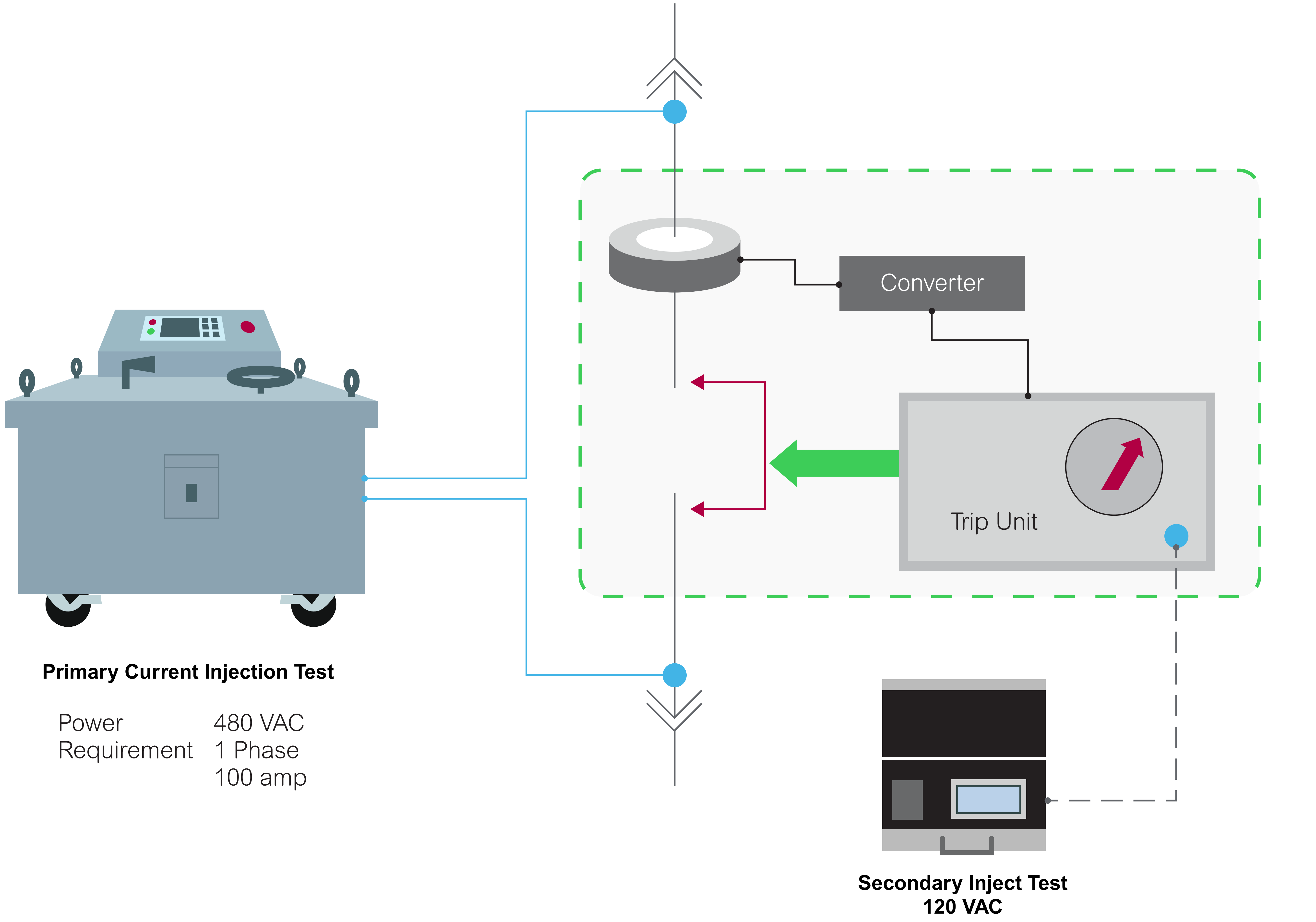
The high current levels required by this testing, see Figure 3, can pose several problems:

- Given current levels that could reach 20,000 A, **the testing process itself can damage the circuit breaker**, especially over repeated instances of this type of testing.
- Any testing equipment capable of generating such a high current **will not be portable**. Instead, circuit breakers being tested typically need to be transported to the testing location using forklifts, trucks, or other means. This raises more risk of damage.
- An additional challenge in this testing approach is simply **accessing a source of such high current.** The testing equipment might need its own source with an ampacity of 200 A to 300 A or more, requiring renting a generator if the facility's power service can't reach such levels.
- It's not unusual for the **testing clamps to be incorrectly sized or attached**, impacting the circuit breaker's test results. This can lead to tests being performed multiple times, posing risks to the circuit breaker's lifespan.
- There's **potential damage** to the circuit breaker, busbar, and conductors when the unit is reinstalled.

Schneider Electric performs this kind of testing on samples of its electronic circuit breakers as part of the UL certification and follow-up process.

However, we can't sell those tested units because the high-current exposure can shorten the equipment's lifespan. And, with today's electronic circuit breakers, this type of maintenance isn't necessary in most field applications.

Figure 3



What Schneider Electric Services recommends

What Schneider Electric Services recommends

Schneider Electric recommends secondary injection testing for electronic trip circuit breakers in most cases. If primary injection testing is required, secondary injection testing should be paired with trip chain verification using a lower-current primary injection test source for LV electronic circuit breakers. This helps assure microprocessor-based circuit breaker aspects function as intended and provides protection if an overcurrent occurs.

Facilities managers might have come up in the industry knowing that primary injection testing with the high current was the only option for testing thermal/magnetic circuit breakers. Still, this necessity isn't the case with today's microprocessor-based technology.

This approach offers benefits for owners as well as maintenance and testing personnel:

More efficiency in terms of of the length of time during which circuit breakers and their connected circuits need to be de-energized.

Secondary injection is safer for facilities personnel since the circuit breakers can remain in place during the testing process. If trip chain verification is required, the lower current primary injection test source provides significantly less risk than the higher current test set.

It's a less invasive process. With secondary injection, there is no need to make a mechanical connection to the circuit breakers' primary stabs.

It avoids the potential for incorrect performance of high-current testing or accelerated equipment failure due to repeated equipment exposure to high currents.

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Schneider Electric
6700 Tower Circle
Franklin, TN 37067

www.se.com

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