Breakers Key To Process Integrity

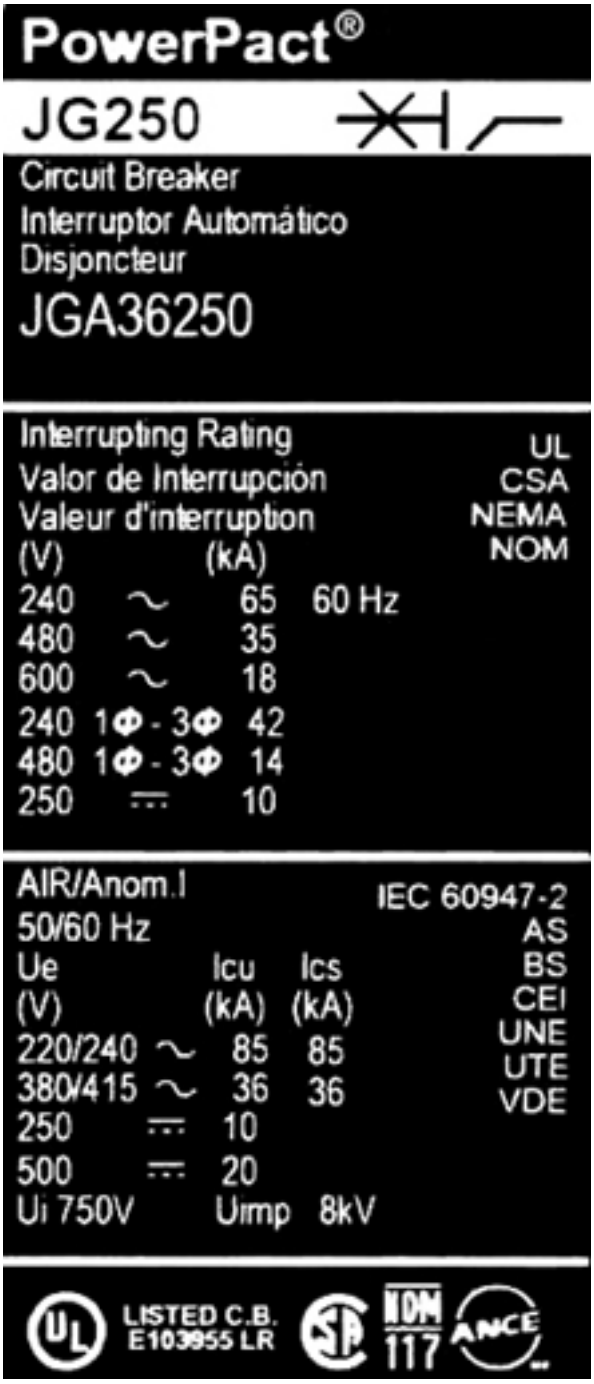

Figure 1

Every processing facility is comprised of large investments in technology, equipment and automation, all of which are necessary to control sensitive processes. Whether a facility is manufacturing a chemical, resin, plastic, paint or pharmaceutical, the end product is really the culmination of multiple interdependent subprocesses. If any subprocess deviates from the norm, it affects those that follow.

Facility managers accept immense responsibility to help ensure processes run smoothly, safely and securely. While equipment maintenance is necessary, scheduled downtime must be carefully coordinated, typically months in advance. But even a brief period of unscheduled downtime can carry with it dire consequences, such as the safety of employees and community, along with the negative publicity that can go global via the Internet. It also doesn't begin to cover the costs to reverse the situation.

Crucial to maintaining process integrity is the circuit breaker. Installed throughout a plant's electrical distribution system, they help protect equipment, personnel and, ultimately, processes from the damage of ground faults, overloads and short circuits, which can lead to downtime. When properly applied, circuit breakers are coordinated to isolate issues down to the smallest portion of the process, minimizing the effects of circuit interruptions, equipment damage or personnel injury. Proper selectivity coordination is usually the result of a coordination study that examines a plant's electrical loads and distribution system, and concludes with proper breaker ratings and trip set points.

While proper coordination is important in limiting outages to the smallest possible area, it is useless without properly applying circuit breakers and maintaining the integrity of the electrical system. Some facility managers see an unplanned breaker trip as a nuisance. Instead, it should be considered a warning and call to action that something in the electrical distribution system needs to be addressed. If it's not, the repercussions could be immense.

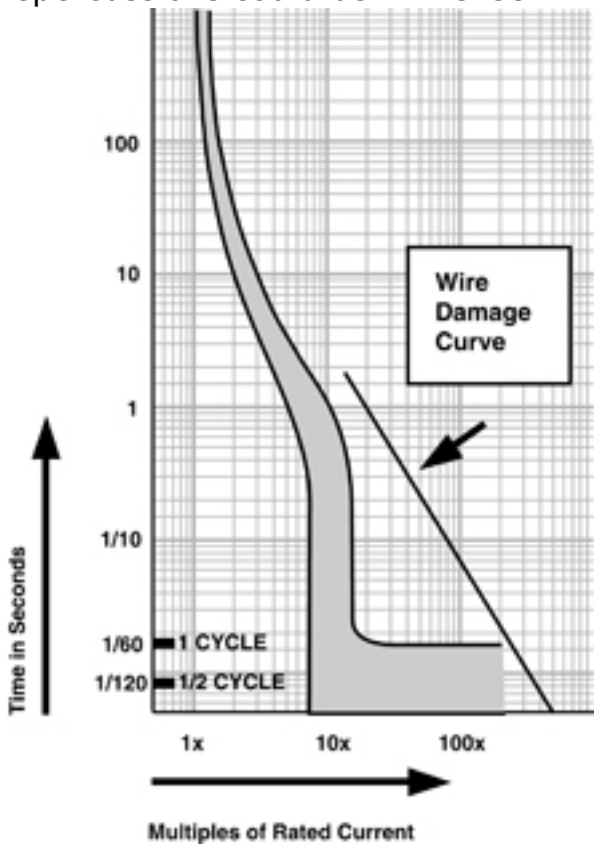

Figure 2

Voltage & Interrupting Ratings

The low-voltage power distribution systems in processing plants are typically 480 or 600 V, and have fault current levels that can exceed 65,000 A, requiring robust circuit breakers. Voltage and fault current ratings are printed on breaker faceplate labels; breakers must be rated at or higher than the distribution system's available voltage and fault level at the breaker location. (See Figure 1.) It is essential for circuit breakers to be appropriately sized if they are to help protect a facility and all of its equipment, machinery and personnel. Voltage levels are easy to determine, but the required fault current level at the breaker location can only be determined by a proper coordination study.

Helping protect wires and equipment in the electrical distribution system is a key responsibility of the circuit breaker. An appropriately sized device is selected by what is commonly referred to as an ampere or continuous current rating. Careful consideration of the current rating is essential, as the protection settings of the breaker must align with the damage curves for the wire and conductors. Proper sizing places a boundary for the level of current conductors can carry, and helps ensure wire insulation does not overheat or melt.

Equally damaging to conductors is an elevated, but temporary surge of current that is often required by electrical equipment (e.g., motors and transformers) when energized. By design, circuit breakers allow as much as 13 times their rated current to advance (typically for fractions of a second) past the elevated surge of current before settling back to operational current. It helps ensure a quick response to intermediate faults that could occur when equipment is energized, helping prevent escalation, which can cause thermal or mechanical stresses.

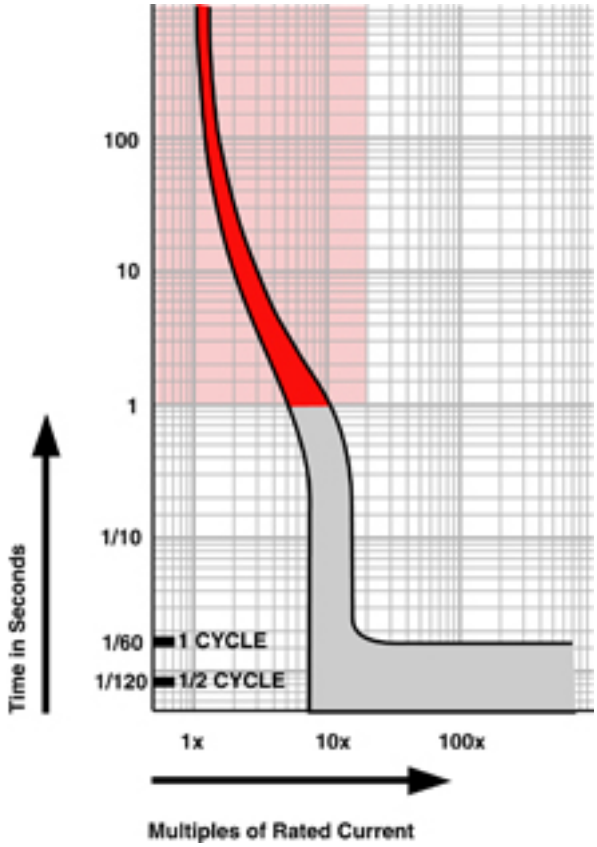

Figure 3

Time-Current Curves
A time-current curve (TCC) is a valuable tool used to understand the boundaries a specific circuit breaker places on the electrical current with respect to duration of time. TCCs utilize a logarithmic scale plotted in an inverse relationship between time and current. The literal shape of the TCC is closely aligned with the current limitations of conductors to help protect them from thermal and mechanical stress. (See Figure 2.)

In some applications, it is important to change the shape and slope of the TCC to better coordinate with other breakers or circuit protection devices. There are three basic zones within a TCC, and many industrial circuit breakers can be set to adjust these zones as necessary:

Long-time settings. This setting is for overload faults, which typically occur when too many loads are applied to a specific circuit. (See Figure 3.) For example, when two times the continuous current rating is detected, the circuit breaker trips within approximately 10 to 50 seconds. The greater the overload, the shorter the time it takes to trip. To determine what level of current is needed for a circuit, the National Electrical Code requires electrical loads be characterized to obtain the value. Since the long-time setting helps primarily protect from thermal damage, there may be extra consideration for installations in hot or cold environments, which could require a re-rating factor.

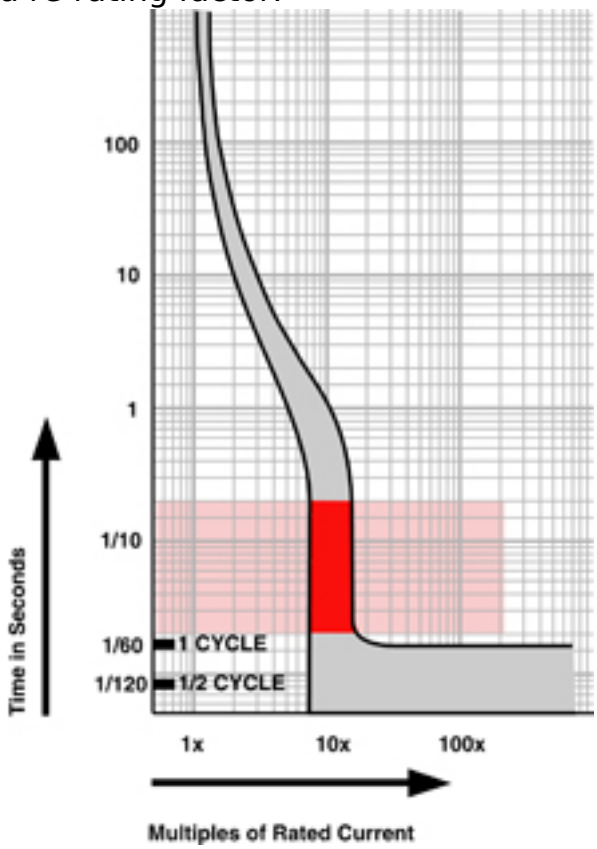

Figure 4

Short-time settings. This setting is for when low-level short circuit events are caused by in-rush currents or arcing faults. (See Figure 4.) This is common due to the heavy current draw required for electric motors or transformers common in processing

facilities. This trip boundary is quick, typically allowing currents to reach 7 to 13 times the rated current for fractions of a second. If that current level continues for a second or more, permanent damage may be sustained.

Instantaneous settings. This setting is the maximum level of current to which the circuit can be exposed—when that threshold is reached, it immediately trips the circuit breaker. (See Figure 5.) Instantaneous settings become important when many breakers are located within the same circuit as part of a network. They help align trip curves to allow downstream breakers enough time to clear a fault for these types of installations.

Beyond these basic functions, circuit breakers have evolved to provide a myriad of other trip characteristics that add safety and reliability to electrical systems. These include devices to monitor and help protect from ground faults, voltage irregularities or current imbalance; and those that measure power quality, harmonics, and voltage spikes and sags.

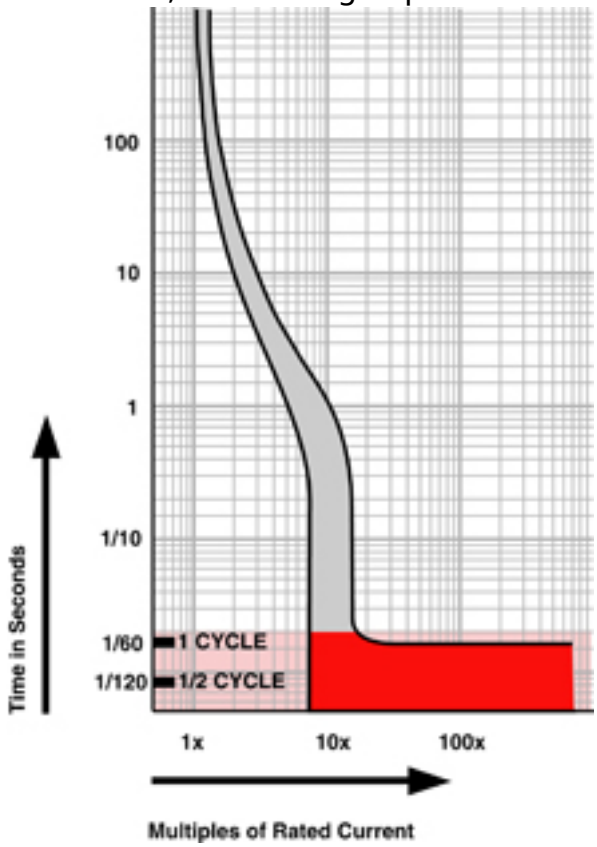

Figure 5

Heeding Warning Signs

Circuit breakers must be properly maintained and applied in order to operate when called upon. Consider the following scenario: A circuit breaker is helping protect a flow pump and senses a fault downstream. If the electrical distribution system is selectively coordinated, the breaker in closest proximity to the problem on the circuit would trip, isolating the fault to the smallest area. From there, the balance of the plant’s power system could be utilized. But what if that breaker had not been maintained or the application was not updated, and the breaker doesn’t trip? An upstream breaker could isolate the fault, thereby shutting down a larger part of the

system than required.

It could be a decade or more since the breaker settings were last inspected for proper application in the system. Ultimately, a circuit breaker is a single piece of equipment, and even if a facility has a top-notch maintenance program, it is important to ensure the breaker is applied with the necessary ratings to help protect the circuit. A processing facility may have undergone a coordination study, but if done years ago, it’s likely that the ratings and trip settings are no longer valid. For example, a breaker may have been rated at 22,000 AIR based on the study, but since then changes have been made to the electrical distribution system. Any change could contribute to higher AIR levels, resulting in an inappropriately sized breaker that no longer meets available fault levels. This maladjustment could have harsh consequences for the subprocess the breaker controls if the fault current increases beyond breaker capabilities.

An updated coordination study, along with a robust power metering and monitoring system, can assist facility managers in making better decisions regarding power usage. Continuous monitoring and study of the system’s electrical performance can help prevent nuisance trips due to overload conditions, ensure proper sizing of breakers for fault protection and even detect an increase in harmonics on the line.

Figure 6

When warning signs are present, it’s key for a facility manager to understand and document the nature of the issue. A series of power system studies may be necessary to ascertain where the problem lies in the system and how best to remedy it. These services are typically available from electrical equipment

manufacturers' service divisions. But the most important thing for a facility manager to do is heed those warning signs. Processors' business models typically rely on volume, not profitability, and a plant that shuts down for a few minutes or a few months is in an unfavorable situation, but one that can be avoided.

Bill Stewart, Schneider Electric North America low-voltage power manager, has 22 years of experience with Schneider and 10 working with petrochemical customers.

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