

WHITE PAPER Standards for Circuit Breakers and Supplementary Protectors

Electrical engineers do not want to see designs go up in smoke. Naturally, engineers protect their equipment with what they believe to be appropriate circuit protection. However, there is widespread misunderstanding of industry standards for circuit protection and the meaning of terms such as “circuit breakers,” “supplementary protectors,” “circuit breakers for equipment” and “branch circuit protection.” In some cases, this confusion results in the specification of the wrong type of circuit protection and increases the risk of overheating, premature failure and catastrophic faults.

To understand the source of the confusion and to learn how to specify circuit protection correctly, we need to review standards and how they are applied.

Branch Circuit Protection

The National Electrical Code (NEC) is primarily concerned with the safety of hard-wired branch circuits within a building. Article 100 defines a branch circuit as “the circuit conductors between the final overcurrent device protecting the circuit and the outlet.”

For overcurrent protection devices in a branch circuit, the requirements are spelled out in a standard called UL 489, “Standard for Molded-Case Circuit

Breakers and Circuit Breaker Enclosures,” published by Underwriters Laboratories, Inc.

UL 489 encompasses circuit breakers “intended for installation in a circuit breaker enclosure or as parts of other devices, such as service entrance equipment and panelboards.” According to UL terminology, devices meeting this standard are considered listed products.

For approval, UL 489 requires the device pass a series of calibration, overload, endurance and short-circuit tests. (See Figure 1.) The minimum short-circuit test must be performed at 5000A. Overload tests are performed at six times the current rating of the device or 150A minimum. Devices rated up to 600V and 6,000A are covered in this standard. Additionally, most UL 489 devices are used in electrical distribution panels; therefore, the minimum current ratings available are seldom less than 15A. During UL 489 testing, the device must survive short-circuit testing and continue to provide future overload protection.

In service entrance panels, available short-circuit fault currents measure 50,000A or greater. However, as power is distributed throughout a building, the available short-circuit currents diminish. If an electrical outlet is just 20 feet away from the power source, Ohm’s law states even with limitless available short-circuit current AWG 14 copper wire limits the maximum available fault current at the outlet to no more than 1200A at 120V.

Supplementary Protection

Although the NEC recognizes “supplementary overcurrent protection used for lighting fixtures, appliances and other equipment or for internal circuits and components of equipment,” it does not specifically define supplementary overcurrent protection. Nonetheless, the NEC implies that it is used in conjunction (in series) with a branch circuit overcurrent device upstream of the equipment. The requirements of supplementary protectors are described in UL 1077, “Standard for Supplementary Protectors for Use in Electrical Equipment.”

UL 1077 defines supplementary protectors as devices intended for use as overcurrent, over-voltage or under-voltage protection within an appliance or other electrical equipment where branch circuit overcurrent protection is already provided or is not required. In UL terms, UL 1077 compliant devices are labeled as recognized components.

Similar to UL 489, UL 1077 supplementary protectors must pass a series of calibration, overload, endurance and short-circuit tests. (See Figure 1.)

Because most UL 1077 circuit breakers are rated 20A or less and are used in electrical appliances or other types of utilization equipment, the overload and short-circuit tests are generally performed at lower levels than those required by UL 489. To pass the short-circuit test under UL 1077, the device must safely interrupt short-circuits at least one time without causing a fire hazard. Unlike UL

489, it does not necessarily need to survive the test. In 1999, UL introduced a new category to UL 1077 that includes survivability and recalibration approvals.

Not All UL 1077 Supplementary Protectors Are Alike

UL 1077 allows manufacturers to obtain approval for different circuit conditions.

For example, an overcurrent supplementary protector can be short-circuit tested with or without a backup fuse or circuit breaker. A supplementary protector can be overload tested at 1.5 times its rating for general use or 6 times its rating for across-the-line motor starting. It may trip at less than 125 percent of its rating or greater than 135 percent, etc.

“Fit For Further Use”

When UL 1077 was revised to meet changing market requirements and safety considerations, UL added a category of overcurrent supplementary protectors known as “recalibrated after short-circuit testing” which are also described as “fit for further use.”

Overcurrent supplementary protectors rated “fit for further use” survive a three cycle short-circuit test and continue to provide overload and short-circuit protection in future operations. Not all manufacturers of UL 1077 approved circuit breakers strive to meet this more stringent classification. Before selecting a manufacturer, it is essential for the design engineer to verify which tests the circuit breakers are subjected to. If the data sheet provided by the manufacturer does not provide this information, the UL Recognized Component Directory for Supplementary Protectors can be used as a reference in determining the suitability of the protectors as “fit for further use” and/or for motor starting applications, etc.

Most supplementary protectors are used in electrical or electronic equipment that is plugged into an outlet. The outlet is wired to a UL 489 listed circuit breaker in an electrical distribution panelboard. Since the distance between the panelboard and the outlet can easily be 50 feet or more, the resistance of 50 feet of AWG 12 or 14 wiring reduces the available short-circuit current at the outlet to well under 1000A. When the continuous current rating of equipment exceeds 20A and is hard wired to the electrical distribution panelboard, or has a convenience outlet for service and test equipment, the meanings of branch circuit and branch circuit protection become blurred. Prior to the publication of the “fit for further use” standard, inspectors were uncertain if the supplementary protectors in industrial and commercial equipment would adequately protect certain loads after short-circuit faults. As a result, some local governing authorities began to require branch circuit protection within utilization equipment. Because the term branch circuit protection is interpreted as requiring a UL listed device, UL 489 circuit breakers are being used in equipment that would be better protected by “fit for further use” rated UL 1077 supplementary protectors.

In order to meet the requirement for branch circuit protection as well as for economic and convenience reasons, a manufacturer may replace an 8A supplementary protector circuit breaker with a 15A listed circuit breaker. The manufacturer meets requirements and may gain additional short-circuit protection; however, overload protection is lost. If the circuit is a motor load or other type of load where overloads often occur, conditions such as a locked rotor may go unnoticed and unprotected causing motor failure or, worse yet, overheating of wire insulation, fires and catastrophic short-circuits. In contrast, a “fit for further use” UL 1077 supplementary protector will protect the equipment during short-circuits and during common overloads.

UL 489A

In the same way the “fit for further use” classification was created to address real world applications, UL 489A is an outline of investigation established in response to the needs of communications equipment. Communications equipment, such as a telecommunication base station, uses DC rather than AC power. Low voltage DC fault currents are far more sensitive to resistance than AC currents. In most telecommunications applications, a circuit breaker with 2000A interrupting capacity is more than adequate, yet UL 489 requires a minimum interrupting capacity of 5000A. UL 489A addresses this concern by allowing such ratings to be determined by the user and device manufacturer.

Conclusion

As electrical and electronic equipment increases in complexity, it is necessary to protect the operator from the effects of equipment failure and protect the equipment from costly damage and downtime. With a clear understanding of UL standards and requirements, the design engineer is assured optimal performance and safety.