E-T-A
Circuit Protection & Control

WHITE PAPER

DIRTY DOZEN: The 12 Most Common Mistakes of Specifying Circuit Protection for Equipment

E-T-A Circuit Breakers

USA
1551 Bishop Court
Mt. Prospect, IL 60056
(847) 827-7600
fax: (847) 827-7655
usinfo@e-t-a.com

CANADA
100 Leek Cr., Unit 11
Richmond Hill, ON L4B 3E6
(905) 764-9510
fax: (905) 764-8003
caninfo@e-t-a.com

www.e-t-a.com

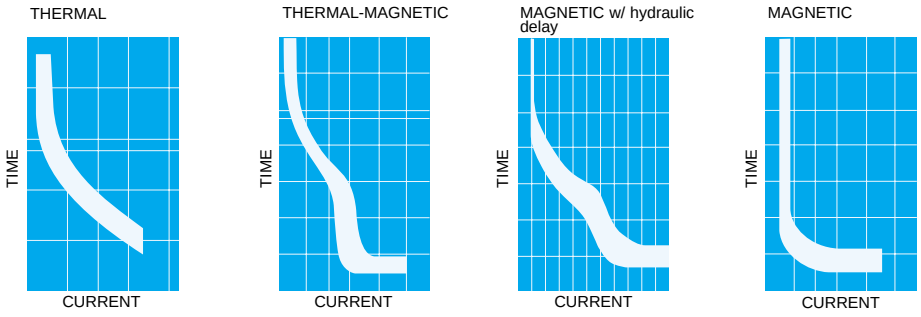
DIRTY DOZEN: The 12 Most Common Mistakes of Specifying Circuit Protection for Equipment

It's only a circuit breaker. Yet there is enough complexity and confusion when it comes to specifying circuit protection that many engineers are designing equipment with too little or too much protection. Under protected circuits leave equipment vulnerable to damaging electrical surges. Over protected circuits add cost and can lead to nuisance tripping. Like Goldilocks and the three bears, the goal is to specify circuit protection that is 'just right.'

As a leading manufacturer of circuit breakers for more than 50 years, E-T-A Circuit Breakers has helped countless engineers navigate the specification process. Over the years, we have encountered many misconceptions, and we have selected the 12 most common pitfalls for this white paper. It is our hope that, by sharing our expertise, you will avoid these mistakes and protect your designs with 'just right' circuit protection.

1. Specifying the wrong circuit breaker type for the application

The number one mistake design engineers make is specifying the wrong circuit breaker technology for the application. There are four choices of circuit breaker technology: thermal, magnetic, thermal-magnetic and high performance. Each has a different trip profile in relation to time and current, and each has distinct mechanical characteristics.



Magnetic circuit breakers operate via a solenoid, and trip nearly instantly as soon as the threshold current has been reached. This type is appropriate for printed circuit board applications and impulse disconnection in control applications. Often, a magnetic circuit breaker is combined with a hydraulic delay to make it tolerant of current surges. Preferably, the circuit breaker is mounted in a horizontal position to prevent gravity from influencing the movement of the solenoid. If mounted in a non-horizontal position, derating may be needed.

Thermal circuit breakers incorporate a heat-responsive bimetal strip or disk.

This type has a slower characteristic curve that discriminates between safe temporary surges and prolonged overloads. It is appropriate for machinery or vehicles where high current in-rushes accompany the start of electric motors, transformers, and solenoids.

Thermal-magnetic circuit breakers combine the benefits of a thermal and magnetic circuit breaker: a delay that avoids nuisance tripping caused by normal inrush current, and fast response at high currents. High overcurrents cause the solenoid to trigger the release mechanism rapidly, while the thermal mechanism responds to prolonged low value overloads. They have a characteristic two-step trip profile that provides fast short-circuit protection of expensive electrical systems while minimizing the risk of disrupted system operation.

Where reliable operation under adverse conditions is required, high performance circuit breakers provide high interrupting capacity and excellent environmental specifications. Typically these circuit breakers are specially designed for aerospace, defense, and similar heavy-duty applications where extreme vibration, mechanical shock, and other conditions are present, and where circuit breaker performance is absolutely critical. For high performance applications, thermal circuit breakers have a compensating element that eliminates sensitivity to ambient temperature.

Many engineers seek specification assistance from the support desks of circuit breaker manufacturers. However, be wary of advice from manufacturers who make only one type of circuit breaker. E-T-A Circuit Breakers has expertice in all circuit breaker technologies, and our application engineers will recommend the right type of circuit breaker, regardless of technology.

2. Specifying too high a rating in an effort to avoid nuisance tripping caused by in-rush or transient currents

Most engineers are concerned about nuisance tripping, as they should be, but they often specify a circuit breaker rated much higher than they should. Part of the reason is confusion between fuses and circuit breakers. Engineers are used to oversizing fuses as a way to prevent nuisance tripping. However, there is no need to oversize a circuit breaker.

Unlike a fuse rating, a circuit breaker rating tells you the maximum current that the circuit breaker will consistently maintain in ambient room temperature. Thus, a 10A circuit breaker will maintain a 10A current without nuisance tripping. In fact, a typical 4A circuit breaker with a slow trip profile will tolerate a temporary 10A current surge without nuisance tripping.

Often times, nuisance tripping is caused by in-rush currents associated with certain electrical components -- primarily motors, transformers, solenoids, and big capacitors. In such cases, the designer needs to specify a circuit breaker that has a delay. Thermal circuit breakers have a natural delay, and magnetic circuit breakers can have added hydraulic delays. Match the delay to the duration of the expected in-rush currents.

3. Failure to provide spacing in design

It is important to maintain recommended minimum spacing requirements between non-temperature-compensated thermal circuit breakers. A mere 1 mm spacing between breakers is all that is required. Without this tiny thermal gap, the circuit breakers can heat up and increase the sensitivity of the bimetal trip mechanism. If the breakers must touch each other, derate them to 80% of their normal amperage rating.

4. Over specifying or ambiguously specifying the degree of protection

Terms such as drip-proof, ignition protection, water splash protection, and dust-proof are in common usage but may be misleading unless standard definitions are applied. When specifying, use the established standards as a measure, such as EN 60529 / IEC 529, which defines Degree of protection of Electrical Equipment. Using these standards, decide which protection is correct for the application.

For example, ignition protection makes sense if the breaker is installed in the engine compartment of a boat, but is not needed if installed in the boat panel. A combination switch-breaker installed in medical equipment might need a water splash protection rating, but it probably does not need a rating for continuous immersion in water. Truly watertight and dust-tight circuit breakers are available, but they are expensive and usually unnecessary.

5. Selecting the Correct Actuation

Circuit breakers are reset manually by means of an actuator. There are many types of actuators, including press-to-reset, push-pull, push-push, rocker, toggle, baton, and press-to-reset with manual release. The actuator type is more than a cosmetic consideration. For example, critical applications usually call for push-pull style actuators, because these are the most resistant to accidental actuation. The type of actuator you select will be determined by the location of the circuit breaker, the need for illumination, the need for human operator safety or convenience, and the consequences of accidental engagement.

6. Failing to consider using circuit breakers as on/off switches
Many circuit breakers are designed to be both a breaker and on/off switch. The advantages of a combination device are a reduction in components, less consumption of panel space, reduced wiring and increased protection over ordinary switches.

7. Specifying the wrong type of terminal
Circuit breakers with plug-in style quick connect terminals simplify installation and replacement (they may also be soldered). Screw terminal connections are more secure and suited for high current and high-vibration environments. Quick connect terminals may be used for circuit breakers rated up to 25A.

.250 QUICK CONNECT | COMBINATION .250 OR 2 x .110 | .110 QUICK CONNECT | SCREW TERMINALS | CLAMP TERMINALS

8. Specifying a fuse when a circuit breaker would be better
Although fuses provide inexpensive circuit protection, the cost savings should be weighed against the low total cost of ownership of circuit breakers. Foremost, circuit breakers can be quickly reset, enabling the circuit to be restored with a minimum of downtime. In addition, there is no assurance that a replacement fuse will be of the proper rating. If a fuse is replaced by a higher rated fuse, overheating and catastrophic equipment failure may occur.

Circuit breaker performance is relatively stable over time, but as fuses age, their trip characteristics change. This may lead to nuisance tripping and increased downtime.

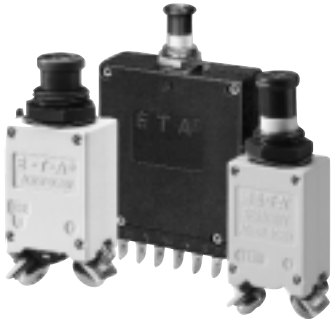
Circuit breakers offer designers more options than do fuses. An auxiliary contact may be added that can communicate an alarm condition to an LED indicator or process software. In addition, a circuit breaker can be combined with a switch, saving space and adding overload protection. Remote trip is another option available with circuit breakers but not with fuses.

Furthermore, unlike fuses, circuit breakers have a variety of types and trip profiles, and therefore can be more precisely matched to loads and environment.

Finally, fuses cannot be tested without destroying them. How can you be sure the fuse you specify will open if there is an overload?

9. Specifying the wrong type of circuit breaker for a high vibration environment

Typically, the trigger of a magnetic circuit breaker is a hinged metal armature that closes in response to the movement of a magnetic coil. This design makes magnetic circuit breakers (and magnetic-hydraulic circuit breakers) particularly vulnerable to vibration, which can cause the armature to close prematurely.



In contrast, a typical thermal circuit breaker is comprised of a thermal actuator and a mechanical latch. Thermal circuit breakers are therefore highly tolerant of shock and vibration.

If a magnetic circuit breaker is the best type for the application, its vibration resistance can be improved by using a push-pull style actuator. This type of actuator has a latching design.

10. Failure to derate

As a rule of thumb, the circuit breaker should be rated for 100 percent of the load. However, some applications require a circuit breaker to operate continuously in either high or low temperatures. In these cases, follow the manufacturer's guidelines for derating. For example, an application calling for 10A protection requires a 12A rated thermal circuit breaker when it is operated at 50 degrees C.

11. Derating when it is not necessary

The performance of a thermal circuit breaker is sensitive to fluctuations in ambient temperature. It will trip at higher amperage in a cold environment, and it will trip at lower amperage in a hot environment.

One common mistake is to assume that derating is necessary for thermal circuit breakers in environments that experience rises in ambient temperature. Actually, the performance of a thermal circuit breaker tracks the performance needs of the system, assuming it is exposed to the same heat source. For example, motor windings need more protection from overheating at 90 degrees C than the same windings need at 20 degrees C. A cold motor requires more in-rush current to get started, and therefore a longer delay is advantageous on a cold day.

Another misconception is that magnetic-hydraulic style circuit breakers are immune to performance changes in rising ambient temperatures. On the contrary, these circuit breakers contain a dashpot with a liquid core that becomes more fluid at higher temperature, reducing the time of the hydraulic delay.

12. Over specifying interrupting capacity

Interrupting capacity is the maximum amperage a circuit breaker can safely interrupt. Circuit breaker manufacturers publish this specification along with the number of times the circuit breaker will perform this feat. For example, E-T-A publishes two types of interrupting capacity specifications. One is called Icn, or Normal Interrupting Capacity. Icn is the highest current the circuit breaker can interrupt repeatably (three times minimum, per IEC934 / EN60934 PC2). Icn gives a rough idea of circuit breaker quality. The other specification is UL1077 Interrupting Capacity. UL1077 (or IEC934 / EN60934 PC1) is the maximum current a circuit breaker can safely interrupt at least one time without causing a fire hazard.

To comply with various standards, engineers must specify circuit breakers with adequate interrupting capacity. Unfortunately, applying the appropriate standard may be confusing.

For example, UL 489 requires interrupting capacity from 5000A and above. While perfectly appropriate for main power distribution applications, this standard has been perpetuated in other industries, where the short circuit rating, governed by circuit resistance, is much lower. The UL 1077 standard for supplementary protectors covers the short circuit test and lists the current at which the breaker was tested.

Although certain devices such as UL 489 molded case circuit breakers have higher interrupting capacities, they may not be well suited for lower current applications where precise overload protection and adequate short circuit protection is better provided by a UL1077 supplementary protector.

The telecom industry is particularly prone to overspecifying interrupting capacity because some vendors of circuit breakers for DC telecom equipment also market the same circuit breakers for AC power distribution. Although the potential supply of current seems high in telecom applications, the realistic amount of current available is actually far less, due to line loss. In most telecom applications, a circuit breaker with 2000A interrupting capacity is more than adequate.

Summary

If you keep these tips in mind, it is easy to specify the right measure of circuit protection at the lowest cost. Start the selection process by working to truly understand your load. Then decide which type of circuit breaker is best suited to your application. Avoid the common specifying mistakes, and you will be rewarded with a reliable design.

About E-T-A

E-T-A Circuit Breakers is the world's leading manufacturer of circuit breakers for equipment and is the only resource for all circuit protection technologies: thermal, thermal-magnetic, magnetic and high performance. E-T-A circuit breakers are available in more than 150 models and 350,000 different configurations. E-T-A is also a world-leading manufacturer of control and monitoring products, and solid state remote power controllers (SSRPCs). With the North American headquarters in Mt. Prospect, IL the company serves industrial OEMs and end-users.

Contact E-T-A for applications support, or to request a free 395-page E-T-A catalog.
847-827-7600
www.e-t-a.com