# HOW AMBIENT TEMPERATURE AFFECTS HYDRAULIC MAGNETIC CIRCUIT BREAKERS AND THERMAL BREAKERS

## WHITE PAPER

**To protect against electrical faults, both hydraulic magnetic circuit breakers and thermal circuit breakers have their place.**

**However, for applications where harsh environments and wide ranges of ambient temperature are possible, magnetic hydraulic circuit breaker delivers advantages in circuit protection that cannot be matched with thermal circuit breakers.**

## CORE DESIGN DIFFERENCES

### Thermal Circuit Breakers

In the normal operation of thermal circuit breakers deflection of a thermal sensing element (e.g., bimetal) will cause the circuit to open when a predetermined calibration temperature is reached.  Temperature rise in the sensing element is caused principally from load current $1^2R$ heating. The thermal element also integrates heating or cooling effects from external sources.

The size of the thermal element, its configuration, and its physical shape and electrical resistivity determine the current capacity of the circuit breaker. In some cases, a heater coil is placed adjacent to, and electrically in series with, the thermal element to augment self-heating of the thermal trip element. This is especially true in ratings below five amperes.

*Figure 1*

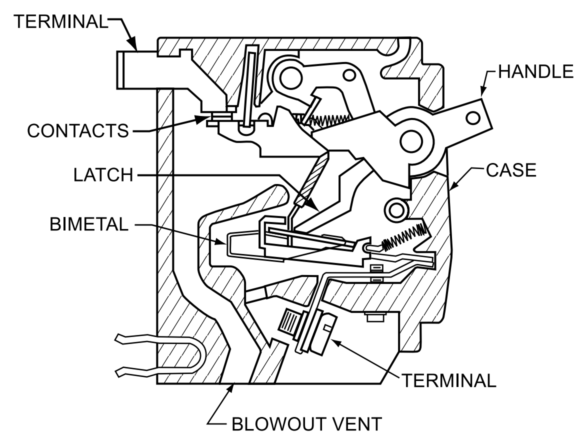



*Diagram of a standard thermal circuit breaker*

The most common thermal element used is a “sandwich” of two or three different metals. The low expansion side may be invar (a nickel steel alloy), the center may be copper for low resistivity or nickel for high resistivity. Metals used in the high expansion side vary considerably.

### Hydraulic Magnetic Circuit Breakers

The operating principle behind hydraulic magnetic circuit breakers is different. The magnetic time-delay circuit breaker operates on the solenoid principle where a movable core held with a spring, in a tube, and damped with a fluid, may be moved by the magnetic field of a series coil.

As long as the current flowing through the unit remains at or below 100 percent of the rated current of the unit, the mechanism will not trip and the contacts will remain closed. If the current is increased to a point between 100 percent and 125 percent of the rated current of the unit, the magnetic flux generated in the coil is sufficient to move the delay core against the spring to a position where it comes to rest against the pole piece. The movement of this core against the pole piece increases the flux in the magnetic circuit enough to cause the armature to rotate from its normal position. As the armature rotates, it trips a pin which, in turn, unlatches the collapsible link of the mechanism, thus opening the contacts.

The delay tube is filled with a silicone fluid which controls the speed at which the delay core moves within the delay tube assembly, so different delay curves can be obtained by using fluids of different viscosities.

When high current surges occur in an electrical circuit, the magnitude of the flux produced in the magnetic circuit should be sufficient to trip the unit without the delay core changing position. For protection of UL appliances such as those listed previously, protector delay curves that provide instant trip at surges of 600 percent or more should be applied.

## FOCUSING ON THE IMPACT OF AMBIENT TEMPERATURE

Thermal circuit breakers are dependent upon temperature rise in the sensing element for actuation, meaning they are – by nature – affected by ambient temperature. While temperature (ambient) compensated circuit breakers – in which a thermal responsive element is introduced to compensate for changes in external temperatures – can be deployed, that does not change the underlying issue.

Taken as a whole, the problem of selecting the correct thermal breaker is more complex than simply matching the breaker rating with the wire rating. One must also consider the ambient operating temperature, the allowable voltage drop, and the heat sinking provided.

The challenge becomes even more pointed when the most critical factor – ambient temperature – is unknown.

Equipment manufacturers ship products globally from multiple manufacturing sites, and do not know into what environment their equipment will be placed. This means that a 10A-rated circuit breaker may trip as early as 7A in high-temperature environments or as late as 13A in a colder environment.

***Figure 2***

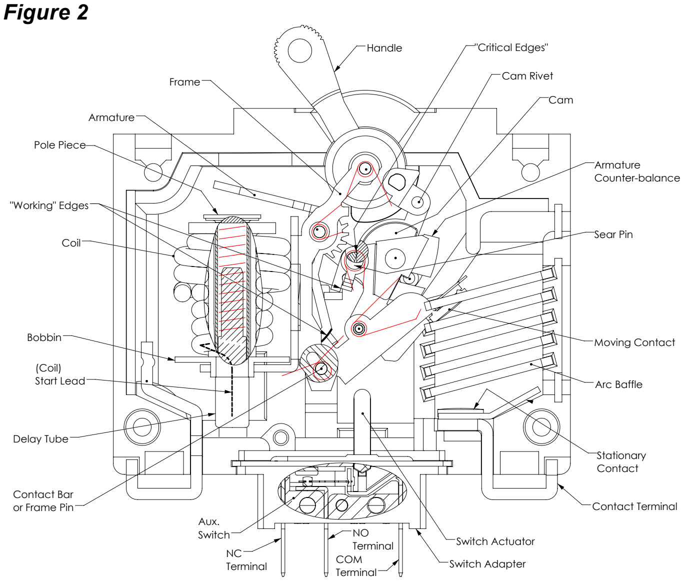
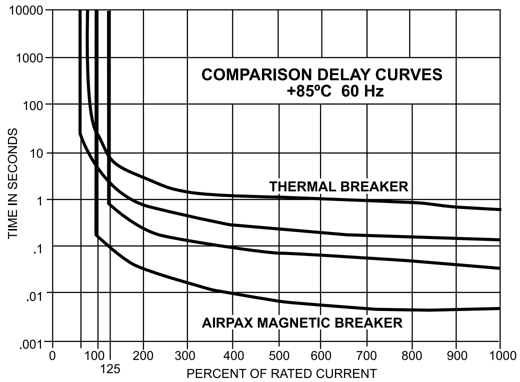



*Diagram of a Magnetic Hydraulic circuit breaker*

**Thermal circuit breakers need to be de-rated depending on ambient temperature. In hot environments, the current rating is oversized to combat nuisance tripping, so from an electrical protection point of view, carries a risk. To combat colder environments, the circuit breaker can have a slower trip time and as result can be underrated to overcome this but again affects the real purpose of electrical protection.**

**By comparison, a hydraulic magnetic circuit breaker does not face those same challenges and is consistent in rating and performance from –40° C to +85°C.**

*Figure 3*



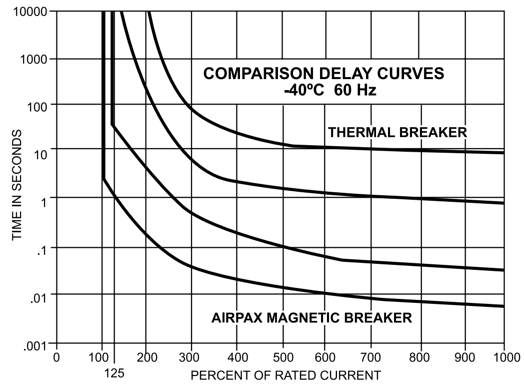




*Figure 4*

***Derating of rated current according to ambient temperature MCBs 1P-1P+N - 2P -3P -3P+N - 4P***

| Temperature (C°) / In (A) | -25 | -10 | 0 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 |
| 1 | 1.3 | 1.2 | 1.2 | 1.1 | 1.1 | 1.0 | 0.9 | 0.8 |
| 2 | 2.6 | 2.4 | 2.3 | 2.2 | 2.1 | 2.0 | 1.8 | 1.6 |
| 3 | 3.9 | 3.7 | 3.5 | 3.4 | 3.2 | 3.0 | 2.8 | 2.5 |
| 4 | 5.2 | 4.9 | 4.7 | 4.5 | 4.2 | 4.0 | 3.7 | 3.3 |
| 6 | 7.5 | 7.3 | 7.0 | 6.7 | 6.4 | 6 | 5.6 | 5.0 |
| 10 | 12.7 | 12.2 | 11.7 | 11.2 | 10.6 | 10 | 9.3 | 8.3 |
| 16 | 20.3 | 19.4 | 18.7 | 17.9 | 17.0 | 16 | 14.8 | 13.3 |
| 20 | 25.6 | 24.2 | 23.3 | 22.3 | 21.2 | 20 | 181 | 16.5 |
| 25 | 32.0 | 30.2 | 29.0 | 27.7 | 26.4 | 25 | 23.0 | 20.6 |
| 32 | 41.6 | 393 | 37.6 | 35.8 | 33.9 | 32 | 29.4 | 26.3 |
| 40 | 51.9 | 49.0 | 46.9 | 44.7 | 42.4 | 40 | 37.0 | 32.8 |
| 50 | 65.5 | 61.7 | 59.0 | 56.1 | 53.1 | 50 | 46.6 | 40.8 |
| 63 | 83.1 | 78.6 | 75.0 | 71.2 | 67.2 | 63 | 58.1 | 51.2 |

***Derating of rated current according to ambient temperature MCBs 1P+N in one module***

| Temperature (C°) / In (A) | -30 | -20 | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 7.2 | 7.09 | 6.91 | 6.73 | 6.54 | 6.31 | 6 | 5.66 | 5.33 | 4.94 | 4.5 |
| 10 | 12 | 11.8 | 11.5 | 11.2 | 10.9 | 10.5 | 10 | 9.44 | 8.89 | 8.23 | 7.5 |
| 13 | 15.6 | 15.4 | 14.9 | 14.5 | 14.1 | 13.6 | 13 | 12.2 | 11.5 | 10.7 | 9.75 |
| 16 | 19.2 | 18.9 | 18.4 | 17.9 | 17.4 | 16.8 | 16 | 15.1 | 14.2 | 13.2 | 12 |
| 20 | 24 | 23.6 | 23 | 22.4 | 21.8 | 21 | 20 | 18.8 | 17.7 | 16.5 | 15 |
| 25 | 30 | 29.5 | 28.8 | 28 | 27.2 | 26.3 | 25 | 23.6 | 22.2 | 20.6 | 18.8 |
| 32 | 38.4 | 37.8 | 36.9 | 35.9 | 34.9 | 33.6 | 32 | 30.2 | 28.4 | 26.3 | 24 |

Within the circuit breaker, the hydraulic magnetic circuit breaker also allows for numerous options, such as the adjustment of the coil windings so a precise current rating can be achieved.

The hydraulic magnetic circuit breaker can also have additional components added to dampen the electromagnetic flux associated with inrush current to avoid nuisance tripping, such as a steel shunt plate fixed to the top of the coil to shunt the effects of high inrush current or through mechanical method of an inertial wheel attached to the armature to physically dampen the armature movement from high inrush currents. These options can be valuable in avoiding nuisance tripping in circuits where start up inrush currents are high.

In addition, these components can offer an integrated aux switch, relay trip and voltage coils to remotely trip them if required, whereas thermal breakers require an additional half pole module.

Each device type has its place. But for equipment that can be shipped globally, having a temperature stable solution is critical – which is why hydraulic magnetic circuit breakers are the most effective power control component in telecommunications, data and servers, transportation and rail, defense, marine, power generation, and more.