MOLDED CASE CIRCUIT DEVICES

There are three common Molded Case Circuit Devices:

1) Molded Case Circuit Breaker (MCCB)
2) Molded Case Switch (MCS)
3) Motor Circuit Protector (MCP)

Physically each of these devices looks the same as all three use the same construction platform that includes:

- Over toggle operating mechanism that operates similar to a light switch
- Internal contacts for opening and closing the electrical circuit
- Arc chutes to extinguish the electric arc when the contacts part
- The molded case and cover itself
- Line and load cable terminations

Figure 1 shows a detailed section view of the internals of a molded case device.

Arc chutes are inherent to all devices that interrupt an electrical circuit. As the contacts part to open a circuit, either in normal operation or in an over-current condition, an electric arc is drawn in the air gap between the contacts. The arc chutes are a series of metal plates that break up the arc, extinguishing it.

Figure 2 is a high speed photograph of an arc being extinguished. The arc chutes are the horizontal metal plates shown in the picture.

INSTANTANEOUS OVERRIDE

Molded Case Circuit Breakers (MCCB), molded case switches (MCS), and motor circuit protectors (MCP) all include an instantaneous over current function, also known as “fixed magnetic” or “instantaneous override”, for self protection. This fixed magnetic is not adjustable and acts as a high limit.

The fixed magnetic protection opens the molded case device and overrides all other device settings should the magnitude of the over current condition approach the short-circuit interrupting rating of the breaker. The short-circuit interrupting rating is the maximum current a breaker can open without damage. More importantly, this fixed magnetic override is present in all molded case devices (MCCB, MCP and MCS) regardless of trip unit selection or the exclusion of the instantaneous function in the trip unit. This is a self protection function for the molded case device.
MOLDED CASE CIRCUIT BREAKER

All molded case devices utilize that same general components and construction. The difference lies in the protective operation of each device. A MCCB includes both thermal and magnetic protection and are constructed and tested per UL 489. This UL standard includes an interrupting rating which is the maximum short-circuit current that the MCCB can safely interrupt.

Figure 3 is the time-current curve (TCC) for a molded case circuit breaker. The upper section of the curve is the “thermal” short circuit protection. The thermal protection uses a bimetallic element, similar to a thermostat. In a normal current flow condition, both sides of a bimetallic element are the same temperature. Therefore, the element is not deflected. However should current flow across the element increase high enough where the downstream electrical systems needs protection, one side of the bimetallic element heats faster than the opposite side causing the element to deflect which trips the MCCB. This protects the circuit from low level faults and provides a short ride through time allowing the fault to clear without opening the breaker. The thermal protection is the upper part of the TCC shown in Figure 3 and is adjustable.

The magnetic action is achieved using an electromagnet in series with the load current. Should the current flow be large enough, as during a high over-current event, the electromagnet is quickly charges opening the breaker. The lower section of the TCC in Figure 3 is the This action where the elements quickly separate is known as instantaneous or magnetic action.

Both the thermal and magnetic protection can be adjusted to the left and right as shown. However the bottom of the curve is the fixed magnetic protection which is not adjustable.

MOLDED CASE SWITCH

The difference between a MCCB and a MCS lies in the Underwrites Laboratory (UL) testing requirements. MCCBs are tested to UL standard 489 while a MCS are tested to UL standard 1087. Both UL standards include the following tests:

1. Load break and non-load break mechanical endurance testing where the open/close mechanism is tested for a minimum number of operations
2. Tamper proof enclosure test
3. Short circuit test
4. Overload test where 600% of the rated current at rated voltage where the device opens. This is the fixed magnetic protection test.

The difference lies in that UL 1087 does not require any type of post operation calibration test. The reason this test is part of UL 489 is MCCBs include a trip unit to open the
breaker in overcurrent conditions.

A molded case switch does not contain a trip unit where a molded case circuit breaker will have a either a thermal-magnetic trip unit or an electronic trip unit. The MCS includes only the fixed magnetic trip function which operates under high fault currents where the interruption of electric power is needed immediately. The fixed magnet protection is not adjustable. Figure 4 is the TCC for a MCS.

**MOTOR CIRCUIT PROTECTOR**

MCPs do not include any thermal protection and include both fixed magnet protection and adjustable magnetic protection. The thermal protection is the motor overload device downstream of the MCP. Figure 5 shows the adjustability of the magnet protection curve.

NEC 430.52 requires the following motor short circuit protection:

**Instantaneous Trip Circuit Breaker.** An instantaneous trip circuit breaker shall be used only if adjustable and if part of listed combination motor controller having coordinated motor overload and short circuit and ground fault protection in each conductor and the setting is adjusted to no more than the value specified in Table 430.52

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**FIGURE 4—Molded Case Switch Protection Curve**

**FIGURE 5—Motor Circuit Protector Trip Curve**
NEC Table 430.52 allows for a maximum instantaneous setting of a MCP of 800% of full load current for a typical three phase motor. However there are exceptions.

1) Energy efficient non-design B motor are allowed to be adjusted up to 1300% of FLA

2) Energy efficient design B motor are allowed to be adjusted up to 1700% of FLA

Another highlight of the NEC requirements is the testing of the combination of MCP, overload and contactor for enclosed motor control, also known as a “combination starter”. This is important because mixing different manufacturers of MCPs, contactors and overloads, in general, are not tested together. So all devices need to be sourced from the same manufacturer to maintain a system overload rating.

Table 1 below, summarizes the protections of each molded case device.

### 100% RATED MOLDED CASE BREAKERS

Point of clarification: UL 489 which is the standard to which all MCCB are tested, includes a test in open air to the current rating as printed on the breaker nameplate. So where does the 80% rating come from?

*Article 100 of the National Electric Code (NEC) states “Continuous Load: A load where the maximum expected to continue for 3 hours or more 80% is not mentioned anywhere in the NEC. However the term “80% rated” refers to the NEC requirement that an overcurrent protective device is sized at 125% of the continuous load that it feeds. The 80% rating is the inverse of 125%.

For example, a 200A continuous load will require a molded case circuit breaker to be sized at 125% of the 200A load. Therefore the breaker size is 250A. There are two ways to apply a molded case breaker to feed this load:

1) 80% rated, 250A breaker or
2) 100% rated 200A breaker

The 100% rating requires an additional heat rise test in an enclosure. Therefore the enclosure size may change from housing an 80% rated breaker to a 100% rated breaker in the same molded case circuit breaker frame size. This is due to the possible need for more air movement as part of the UL heat rise test.

For example, a 1200A, 80% rated Eaton NG molded case circuit breaker mounted in an Eaton Powerline C switchboard is requires a 36” wide feeder structure. If a 100% rated NG breaker is mounted in same switchboard, the feeder section now is 45” wide to meet the heat rise requirements of the NEC test for the 100% rated breaker.

Note that most 100% rated breakers do not require the increased width, however some breakers or combinations of 100% frame breakers may require a wider structure. Consult Eaton to verify switchboard widths.

<table>
<thead>
<tr>
<th>Instantaneous Override (Fixed Magnetic)</th>
<th>Molded Case Switch</th>
<th>Motor Circuit Protector</th>
<th>Molded Case Circuit Breaker</th>
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**TABLE—1 Molded Case Circuit Device Protection Summary**

Dan Costello, PE LEED® AP  - Eaton Corporation
Wisconsin Application Engineer
Cell 414-350-2474
DanielPCostello@Eaton.com