DEPARTMENT OF LABOR AND INDUSTRY

Circuit breakers in low ambient temperatures

Recently, the department was asked about the use of panelboards and circuits breakers in outdoor locations subject to the very low ambient temperatures such as those we experience in Minnesota.

Some of the marking requirements are found in the product standard, UL 489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures and others in section 240.83 of the National Electrical Code.

Per the UL Standard, the maximum temperature marking is required for all thermal-magnetic circuit breakers. The marking is optional for electronic trip circuit breakers unless they have been tested and listed as only suitable for a 25°C ambient, in which case they must be marked 25°C.

The marking indicates the maximum ambient temperature that a particular circuit breaker has been tested for at its marked ampere rating. For higher ambient temperatures the marked ampacity rating of the breaker must be reduced, but what about lower temperatures?

There are two main concerns when applying thermal-magnetic circuit breakers in cold ambient temperatures:

1) the effect on current rating, and
2) the effect on mechanical performance

How Does Cold Affect Current Rating?

For thermally sensitive devices such as circuit breakers, fuses and motor overload relays, manufacturers publish rerating curves. These curves allow the installer to know how the device will perform in other than its rated ambient temperature. Breaker manufactures publish rerating data down to -10C/+14F (figure 1). That does not mean that the coldest temperature breakers can be applied in is -10C; rather it is just the limit of the data the manufacturer has available.

How Does Cold Affect Mechanical Performance?

In colder ambient temperatures parts may shrink or become brittle and lubricants may harden, raising a concern about the operation of mechanical devices in such applications. Breaker manufactures select lubricants that have a wide operating range. Sample tests have been done down to -50°C (-58° F) where an overcurrent was applied. Even though their handles were caked with ice all the breakers tested tripped.

The circuit breaker standard, UL 489 does not address extreme ambient temperatures which means that device manufacturers develop their own tests for their products. In contrast both UL 943 for GFCIs and UL 1699 for AFCIs require that those devices operate down to -35°C (-31°F).

Is it fair to assume that if GFCIs and AFCIs operate at -35°C (-31°F) then standard breakers will as well?

Other References

The IEEE Blue Book and the IEEE 3004.5 Recommended Practice for the Application of Low-Voltage Circuit Breakers in Industrial and Commercial Power Systems both state that MCCBs can typically be applied down to -5°C (23°F) without consulting the manufacturer.

NEMA AB 3 Molded Case Circuit Breakers and Their Application states that for electronic trip circuit breakers the manufacturer should be consulted if the ambient temperature is below -20°C (-4°F) suggesting that the mechanisms will operate down to at least that level.

Summary

When a panelboard is carrying current, the temperature inside the enclosure will be warmer than the ambient temperature outside the enclosure, and when the circuit breaker is carrying current the "micro ambient" temperature inside the molded case will be warmer still.

The department has no evidence that the operation of thermally sensitive devices such as circuit breakers, fuses and motor overload relays will be negatively affected when installed in low ambient air temperatures.