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# TECHNICAL NEWS

INDUSTRIAL SWITCHGEAR & AUTOMATION SPECIALISTS

NHP

## Terminal temperatures

### How hot are they?

Excessive temperatures are often the cause of failures in electrical equipment. High temperatures can cause the degradation of insulating materials, the failure of joints and a reduction of strength. Unfortunately the standards for electrical equipment can lead the unwary in to applying switchgear in a manner that will lead to high temperatures and possible failure. Fortunately most electrical equipment runs at currents less than the design maximum and service problems do not arise. However, in applications required to withstand high loadings for long periods there can be a high risk of failure.

### CURRENT RATING

All electrical switchgear has a current rating assigned to it. It is marked on the device and looks simple enough. It should however have a warning about this rating along the lines of, 'the current rating of this device is only nominal and was determined under test conditions that may not be matched in service. It is possible that when installed the installation conditions will be such that if run at the nominal current rating excessive temperatures will arise, a derating should be applied'.


*Cables or bars? What's the difference?*

**FEATURING**

Current rating
Comparison table
Conductor ratings

**Written by Bill Mairs**

National Manager
Technical Department

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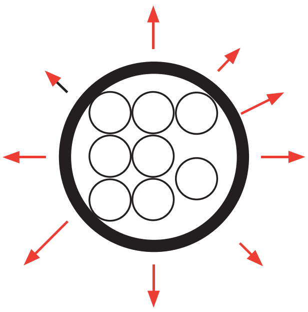
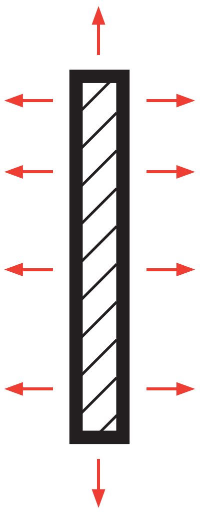


CABLE



COPPER BAR

***Fig 1***

*Bars provide larger surface area for cooling*

For the purchaser a major point of comparison between devices from different suppliers is the price per amp. The standards set test conditions for current rating and this helps ensure these comparisons are valid. The problem is that the standard test conditions allow the best or highest nominal rating to be assigned.

**Considering circuit breakers rated to AS60947.2 there are several ratings related to current.**

1. Conventional free-air thermal current (Ith)
2. Conventional enclosed thermal current (Ithe)
3. Rated current (In)

The rated current (In) is required to be marked on the circuit breaker and is defined as being equal to the conventional free-air thermal current (Ith). The implication of this is that should the circuit breaker be mounted in an enclosure it will run hotter and may exceed permissible temperatures. The next issue in the test conditions specified for Ith the test connections are specified and these have larger cross sections than what might be selected for a conductor for the particular current (refer table 1 below).

While conventional testing does allow circuit breakers from different manufacturers to be compared it does complicate the application of the circuit breakers. Failure to understand the issues can lead to excessive temperatures and reduced life.

## HOW TO APPLY

The correct selection and installation of a circuit breaker in a switchboard to AS3439 Switchgear Assemblies is the responsibility of the switchboard manufacturer. This responsibility is defined in the standard. A warning that installed ratings may be different to the marked current In is also provided.

For an assessment to be made on the likely performance of switchboard equipment reference can be made to AS4388 (a method of temperature rise assessment). This standard outlines a method for determining the likely internal temperature rise in a switchboard. From this calculation adjustments can be made to equipment selection by applying deratings or selecting higher rated devices to achieve the required ratings. A table within the standard also highlights the need for conductors connecting directly to switchgear to be of generous proportions (refer table 1 below).

## CONDUCTOR RATINGS

For a simple length of cable the current rating is determined by the permissible insulation temperature. This also applies to insulated flexible busbar. The typical maximum temperature being 105 ° C. For bare busbars the limit is again typically 105 ° C as this is considered the maximum temperature copper can reach without annealing taking place. Annealing can reduce the mechanical strength of the copper and reduce its ability to withstand forces produced by short circuits.

***Table 1*** *Conductor sizes*

| | **Device testing for Ith** Standard test conductors | | **Typical cable selection** to AS3008.1.1 | | **Typical bar selection** | | **Required bar size** from AS 4388 Table B.3. 7/9 | |
|---|---|---|---|---|---|---|---|---|
| **Current amps** | Size mm² / mm x mm | x section mm² | Table 6 Column 6 | x section mm² | 105 deg max 45 deg ambient | x section mm² | Device to busbar | x section mm² |
| **Cable** | | | | | | | | |
| 125 | 50 | 50 | 50 | 50 | | | | |
| 250 | 120 | 120 | 120 | 120 | | | | |
| 400 | 240 | 240 | 240 | 240 | | | | |
| 630 | 2 x 185 | 370 | 2 x 185 | 370 | | | | |
| 800 | 2 x 240 | 480 | 2 x 240 | 480 | | | | |
| **Bars** | | | | | | | | |
| 125 | | | | | | | 1 - 20 x 3 | 60 |
| 250 | | | | | 1 - 12 x 5 | 60 | 2 - 20 x 5 | 200 |
| 400 | | | | | 1 - 20 x 5 | 100 | 1 - 30 x 10 | 300 |
| 630 | 2 - 40 x 5 | 400 | | | 1 - 40 x 5 | 200 | 1 - 50 x 10 | 500 |
| 800 | 2 - 50 x 5 | 500 | | | 1 - 50 x 5 | 250 | 2 - 30 x 10 | 600 |
| 1000 | 2 - 60 x 5 | 600 | | | 1 - 80 x 5 | 400 | 2 - 40 x 10 | 800 |
| 1250 | 2 - 80 x 5 | 800 | | | 1- 80 x 5 | 400 | 2 - 50 x 10 | 1000 |
| 1600 | 2 - 100 x 5 | 1000 | | | 2 - 60 x 5 | 600 | 2 - 80 x 10 | 1600 |

**Notes:** Table prepared for comparison only. Refer to Standards or actual test data for conductor selection.

AS3008.1.1 Electrical installations - Selection of cables.

AS4388 -1996 A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear.

The passage of current in a conductor causes internal heating and the temperature rises until the rate of heat dissipated by radiation and convection matches the heat input. The ability to dissipate heat depends on the cooling surface area. For a round conductor the cooling surface is at its minimum for a given cross section of copper. If a copper rod with a cross sectional area of 100 mm$^2$ is considered the cooling area per cm length is 113 mm$^2$ but a 100 mm$^2$ copper bar of dimensions 5 x 20 mm has a cooling area of 500 mm$^2$ per cm length. The result is that while the rod and the bar have the same amount of copper the bar can run at a higher current because of the better cooling provided by the larger surface area (refer fig 1 far left).

## THE HEAT SINK

During thermal testing, cables are specified for use with breakers rated 400 A and below. The cable core temperature in these tests is lower than the specified maximum temperature for the terminals. Heat will flow from the circuit breaker into the cable and therefore help control the temperature rise of the terminals. When a bar is used instead of cable and it has better cooling properties, its cross sectional area can be smaller than a cable. While the temperature rise of the bar and the cable may be the same, at a distance from the breaker, the ability of the bar to heat sink the terminals is less than the cable due to the smaller cross section. As an example, the test for a 400 A circuit breaker requires 240 mm$^2$ cables. This cable will have a temperature rise of about 35 ° C. If a bar was selected for a 35 ° C rise at 400 A, a 30 mm x 5 mm bar could be selected. This bar has a cross section of only 150 mm$^2$ and will not provide the required heat sinking (refer fig 2 right).

## BUSBAR TO DEVICE CONNECTIONS

The need to provide heat sinking to achieve circuit breaker ratings is recognised in AS4388. Bar sizes are listed for the link between the circuit breaker and the main busbar system. The sizes are comparatively larger than might be expected but are generally in line with the sizing of standard test conductors specified in the circuit breaker standard.

Cables connecting to circuit breakers do not normally present a problem. If cables are selected from Table 6, Column 6 of AS/NZS3008.1.1 then the sizing should be adequate. Cables with high temperature insulation should not be run at the claimed higher current ratings assigned to these cables but should be applied in accordance to Table 6.

## INSTALLED RATINGS

In addition to consideration of the conductor sizes care must be taken with the enclosure. Depending on the design of the circuit breaker it may or may not have been tested for rating when mounted in an enclosure. Even if tested in an enclosure its arrangement in service may cause extra heating and a derating may need to be applied. A 20 % derating when installed in a switchboard would be typical. As the current goes up the greater the care needed in assessing the installed rating.

## CONDUCTOR COMPARISONS

In Table 1 (refer page left) a range of conductor selections is shown. The first column lists the standard test conductors from the AS/NZS3947 Switchgear standard series. From this table it can be seen that for cables there is not a significant problem. Sizing for the rating test is much the same as if cables are selected from Table 6 of AS/NZS 3008.1.1. When it comes to using bars there is a significant difference between the cross section of bar selected for normal use and a bar used for the device standard test. The in-service recommended sizes in AS4388 must be used to prevent overheating by providing a heat sink.

## OTHER DEVICES

While circuit breakers have been discussed above most other switchgear devices face the same issues.

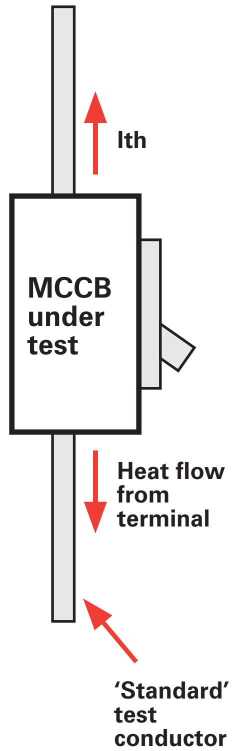



***Fig 2***

*Test conductors provide a heat sink to terminals*