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IN THIS ISSUE

Some don't like it hot

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Temperature rise of electrical switchgear is usually the limiting factor in determining the current rating. The rating determined in the standard tests provides a basic means of comparing products from different manufacturers. It is important to understand this point as temperature rise achieved when the switchgear is installed may be completely different to that under standard test conditions. This means that when electrical equipment is installed the switchgear may need to be derated. The higher the current levels the greater the temperature problems, as the heat loss from all conducting parts becomes significant and eddy current loses add to the problems.

As the possible number of installed configurations is unlimited it is not possible for the switchgear manufacturer to provide ratings under all conditions. The standards recognise this aspect and it is clearly the installers responsibility to ensure correct operation.

In a switchboard with multiple tiers it is possible to calculate the acceptable heat loss per unit length of the board for a given internal temperature rise.

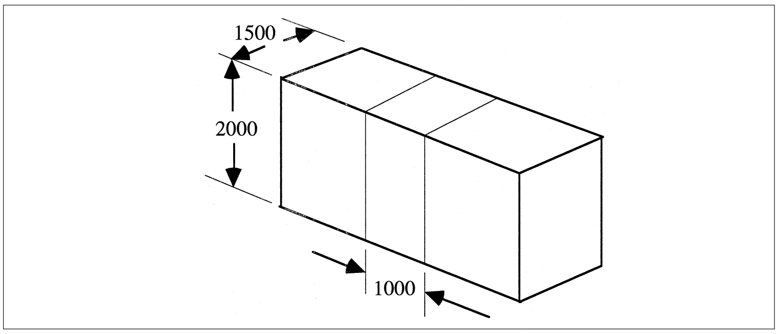

Figure 1. The heat loss per unit length of switchboard can be calculated.

The enclosure

In any switchgear enclosure, the maximum internal heat loss is determined by the ability of that enclosure to dissipate the heat. For the enclosure to transfer heat to the surrounding environment the enclosure must be at a higher temperature.

A typical result is that the internal temperature of the enclosure is 20°C higher than the outside temperature.

In a switchboard with multiple tiers it is possible to calculate the acceptable heat loss per unit length of the board for a given internal temperature rise. From the guide given in IEC 890 the loss is calculated to be 450 watts for a mid temperature rise of 20°C in the example shown in **figure 1**. If ventilation is added (500 cm^2) the internal loss can be 2000 watts for a 20°C rise.

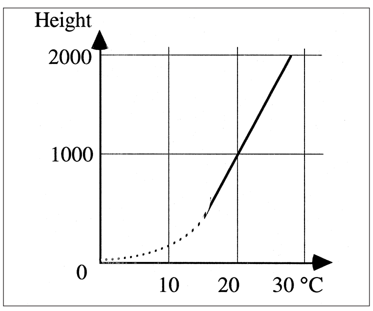

Figure 2. Temperature rise of the air inside the enclosure.

The measurement of equipment watts loss is not easy.

It is assumed that, the top, front and back of the switchboard are the available cooling surfaces. In a long board the ends do not assist the cooling of the centre sections.

The internal temperature in the enclosure will increase from bottom to top. The typical gradient is shown in **figure 2**

The sources of heat

While the concept of determining the heat loss of the installed equipment, calculating the internal ambient and checking the performance of the equipment at this temperature, and upgrading as required may sound simple but there are some problems. The measurement of equipment watts loss is not easy. The measurement of resistance using DC techniques will not produce a figure which can be used with any accuracy. The resistance with AC currents can be much higher but the measurement techniques for AC are quite difficult. As the resistance will vary with current it is important to measure the resistance at the operating current level. The normal method is to measure the current and voltage drop across the device under test, and then calculate the resistance from R= V/I. In the case of AC the measurement of low voltages in the vicinity of high currents is prone to be inaccurate due to induced voltages in the connection leads.

The current and voltage are not in phase and there is usually distortion in the current wave-form and this must be accounted for. Because of these measurement problems, manufacturers have been reluctant to publish figures for high current equipment and those that are published may not always be correct.

Busbar systems are a considerable source of heat and at high currents the losses may be higher per unit length of switchboard than the switchgear in that section. At high currents, busbars also have a far higher AC resistance than that for DC.

An often overlooked effect is the internal heating of the steel used in the construction of the enclosure. If high current conductors are located close to steel considerable eddy currents and hence heating can be produced (**see figure 3**). In actual tests on switchboards containing high current bar systems the steel close to the bars has been found to heat rapidly and reach temperatures higher than the actual busbars.

The sources of heat
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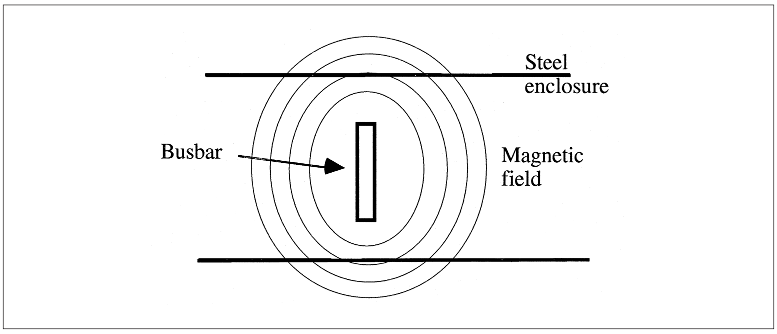

Figure 3. *Magnetic fields can cause severe eddy current heating of steel panels.*

This unwanted effect can greatly increase the power loss per unit length of switchboard.

Busbar systems are a considerable source of heat and at high currents the losses may be higher per unit length of switchboard than the switchgear in that section.

Keep it short

To improve the temperature performance the length of any busbar should be kept to a minimum. Vertical runs of bars create special problems as they greatly increase the heat loss in a small section of the switchboard. Design effort should concentrate on minimising the length of any vertical bars and avoiding any doubling back which is a common mistake. The heat loss can become too great in that section of the board. It is important to consider the thermal problem in this way and not to assume that a particular size of the bar can carry a particular current. Tests have shown this in a dramatic way. A 5000A busbar system which had a moderate temperature as it ran along the base of the switchboard was found to have a temperature 50°C hotter at the top of a vertical section of the same bar section. The actual temperature rise, (above the adjacent air), of the bar was not much greater in the vertical section but the internal ambient was far hotter at the top of this section of the board.

In addition to the problem of the increased bar length in that part of the board there was considerable eddy current heating of the adjacent steel work adding to the heat input in that section. In a three phase system the magnetic field around the conductor(s) is reduced if the conductors are close together but at high currents they are usually spaced far apart to improve the temperature performance. With this wide spacing surrounding steel should not be closer than the spacing between phases and preferably should be two or three times this spacing. This of course is not always possible so the option is to replace the steel with a material which does not suffer from the same degree of internal heating. In some applications stainless steel has been found to greatly reduce the eddy current losses. Aluminium or plastics can also be used as steel replacements. The best material to use will depend on the application.

In some applications stainless steel has been found to greatly reduce the eddy current losses.

Reference test

Manufacturers usually provide some information on ratings when equipment is installed in different configurations (**refer figure 4**).

At high current levels care

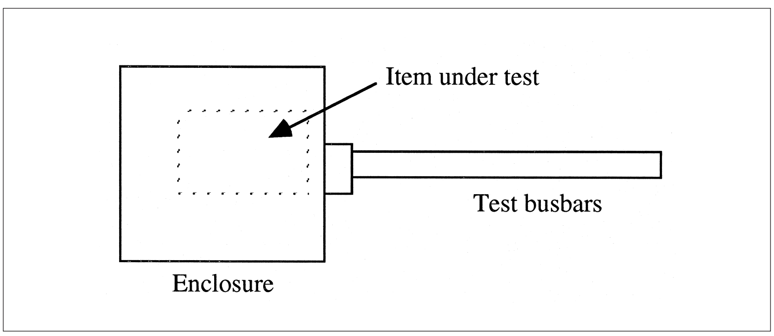

Figure 4. *Typical manufacturers test for enclosed rating.*

Reference test
(continued from page 3)

must be taken to ensure that the actual application is close to the examples provided. The problems of other equipment adding to the heat load and the variation to the busbar connections also increase temperatures which must be carefully considered. While it is possible to perform some calculations to determine expected performance the calculations always include some assumptions and cannot be precise.

Temperature rise testing of the actual switchboard is the best way to confirm performance but even this involves assumptions. It is normal for the total possible load, as determined by summing the ratings of the outgoing units, to exceed the ratings of the incoming circuit.

A diversity factor is usually applied which reduces the loading on the outgoing circuits.

This again introduces an assumption and the test result only applies if the actual loading is the same as the test conditions.

Reference:- IEC 890 A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of lowvoltage switchgear and control gear

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