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TECHNICAL NEWS

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Quarterly Technical Newsletter of Australia's leading supplier of low-voltage motor control and switchgear.

IN THIS ISSUE

KEEP COOL - DERATE

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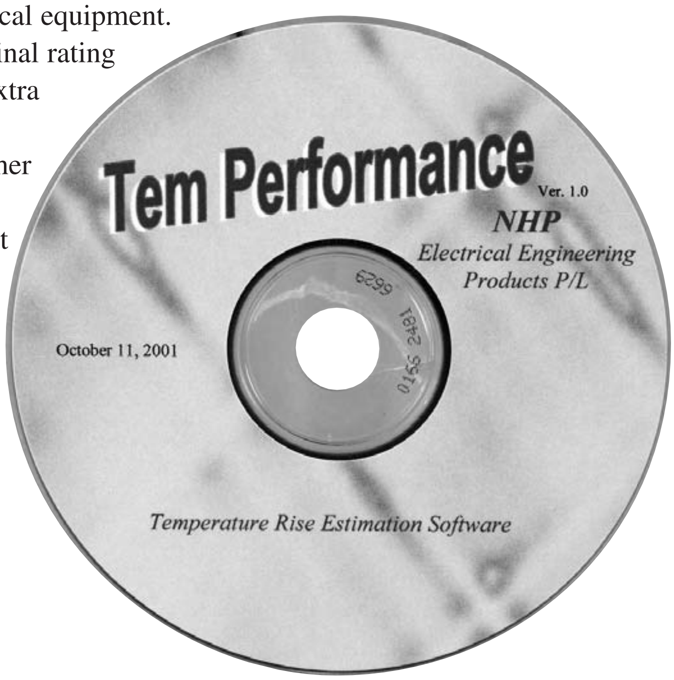
Introduction

The maximum current electrical equipment can carry is usually limited by temperature. Manufacturers can only provide nominal ratings for electrical devices and it is the switchboard design or installation that determines the actual rating. Failure to understand this can result in equipment having a shorter than expected life. Determining the installed rating can be quite difficult but software programmes such as the new NHP Tem Performance are available to assist.

Nominal Ratings

The performance standards define type tests to determine a Nominal current rating for the various items of electrical equipment.
If the device is run at its Nominal rating in a situation that will cause extra temperature rise, damage may result. To compensate for higher temperatures the maximum current the device is running at may need to be reduced. The Nominal rating is intended to provide a guide as to size comparisons between similar pieces of equipment. It will be found however that some devices
have capacity in reserve and will not require derating in some situations.



NHP "Tem Performance" Temperature Rise Calculation software

Installed Current Rating

There is no one current rating for a copper conductor or an electrical device. The nominal rating is based on testing under a standard set of conditions without temperatures exceeding acceptable limits.

The limitation to copper's ability to carry current is the temperature rise with the limit usually set by another material. In the case of a simple cable it is the insulating material that sets the limit.

In the case of a switch it is the constructional materials in contact with the copper. The performance of the copper itself must be considered where the rigidity is important and softening must not take place. Any contacts or joins in the copper are also the weak link in the system and failure of a joint will be promoted by elevated temperatures.

Heat Loss

For electrical purposes the lower the resistance the better the material is for carrying current. Taking copper as 100, the relative conductivity of copper compared to other materials is shown in Table 1.

Table 1

Copper	100 %
Aluminium	61 %
Steel	10 %
Brass	30 %

Relative conductivity (typical)

Conductivity is only part of the story as the current flow through a conductor is not even. This is caused by the magnetic forces produced by the current flow. These forces act to push the current flow into the extremities of the conductor (skin effect) resulting in the heat produced by the current increasing.

This effect produces what is called the AC resistance. This may be more than double the resistance expected from the material.

The maximum temperature a conductor reaches is determined by the point at which the heat in, is matched by the heat lost. To lose heat the conductor has to be hotter than the surrounds. The hotter it is the more heat it loses, so a point is reached where heat out equals heat in. The emissivity is a measure of the ability of a surface to radiate heat compared to the ideal black body. Bright copper is not very good but improves as a tarnish is formed. Coatings such as electrical insulating materials can improve the emissivity of copper conductors and improve current rating by increasing the heat lost at a given temperature.

Enclosure Design

For cooling, the top and sides of the enclosure are the most effective. The top surface is best as it is the hottest. The bottom is considered to have no effect. If the enclosure is placed against a wall the cooling possible from that surface is approximately halved.

Ventilation

Vents in the enclosure allow convection air currents to flow and assist cooling. The vents are best placed near the top and the bottom of the enclosure.

Fans

Fans can be an effective way of removing heat from an enclosure. If it is assumed that all the heat produced in the enclosure is removed by the flow of air from outside the enclosure then the temperature rise of the air flowing in and out of the enclosure can be calculated using Graph 1. If the heat produced in the enclosure is 600 watts and the fan used has a capacity of 200 cu m/hr giving 3 W/cu m/hr, then from the graph the rise in cooling air temperature will be 9°C. The installed equipment needs to be able to cope with this increase.

What do I do

Nominal current ratings are determined under basically ideal conditions. The item is tested by itself and may have test conductors of large proportions connected. In the typical application there will be other equipment close by, adding to the heat generated.

In a switchboard, careful design is required to ensure that the temperatures resulting from this heat do not exceed the permissible temperatures for the device in question.

The accepted approach is to take the temperature rise of the enclosure then subtract this from the permissible rise of the electrical device to calculate a derating. The aim is to control the maximum temperature so if the ambient is hotter, the temperature rise of the device must be lower. (See Graph 2).

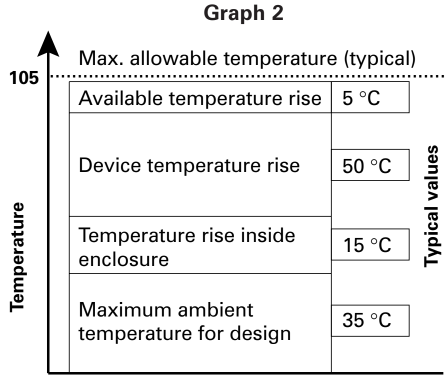
For many electrical products the current rating at different operating temperatures is published. The nominal rating is usually the rating applicable at 40 °C with a derating applied as the temperature increases.

The difficulty is in trying to determine what the temperature in the enclosure will be and assistance in calculating this can be found in AS4388 (IEC890). The calculations require the watts loss or heat input from all current carrying parts to be known as well as the size of the enclosure and degree of ventilation. The NHP Tem Performance programme is based on the calculation method in the standard and it provides a calculated temperature rise of the enclosure. To assist in the equipment selection it also considers the effect on the rating of installed components at the circuit amps entered into the program. As the circuit amps is lowered the thermal margin or additional temperature that the device will work in becomes higher. A warning is given if the selected device is likely to overheat.

As with the devices in the switchboard the temperature must rise to a level that allows heat lost from the switchboard to equal the heat input. Heat is lost by radiation and convection from the external surfaces and if vents are provided, by the convection flow of air through the board.

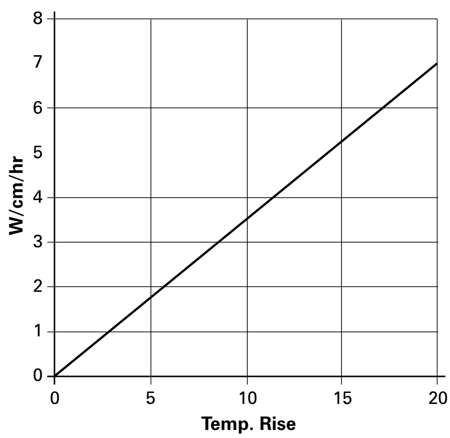
By allowing this natural cooling the temperature inside the switchboard becomes hotter at the top so it can be found that a device may be too hot if installed in the top but perform satisfactorily if fitted near the bottom. (See Graph 3).

Graph 2

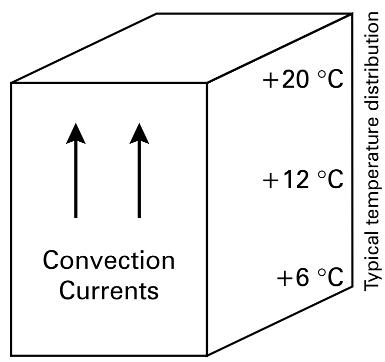


If the enclosure temperature rise increases and there is no available temperature margin then the device must be derated so the maximum temperature is not exceeded.

Graph 1



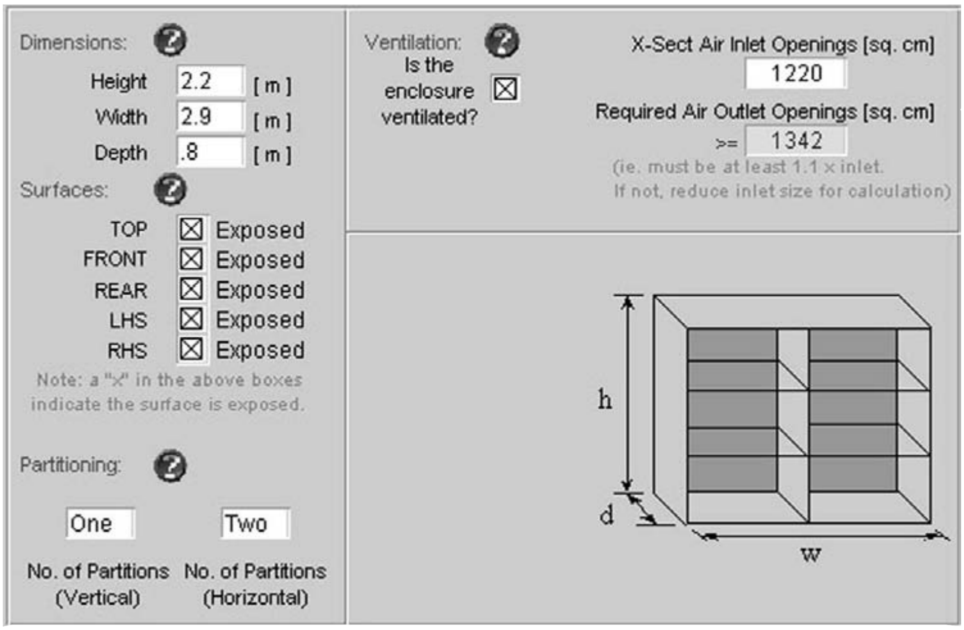
Graph 3



Temperatures are higher near the top of the enclosure. Devices can perform better if installed low.

Design the enclosure

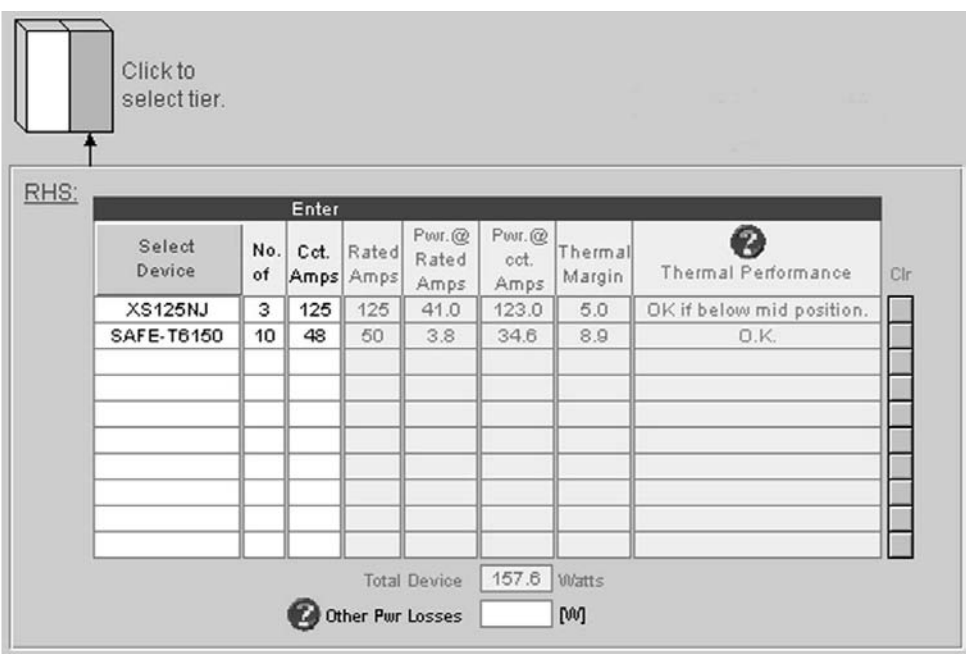
The Tem Performance programme requires the enclosure size, the exposure of the outside surfaces, the partitioning and the size of any vents to be entered. This allows the enclosures ability to transfer internal heat to be calculated.



Select the devices

A library of devices allows the switchgear to be selected. If a device is not in the library it can be added to the device list for the particular calculation or an estimated power loss for a group of devices added at the bottom of the list.

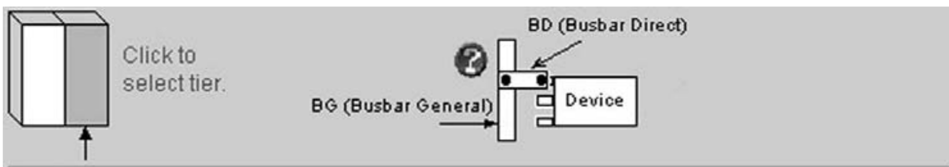
As each device is added, the programme indicates how the thermal performance is going. This allows reselection of devices as you go, to achieve satisfactory thermal performance. The next step is to select the conductors and this too will interact with the device selection / performance.



5

Connecting Conductors

Standard tests for Nominal current ratings are with defined conductor sizes. In the case of busbar connections the sizes used have a comparatively low temperature rise at the test current. They can act as a heat sink to the device under test. To allow for this, conductors connecting directly to devices need to be larger than those in say the general busbar system. The standard provides guidance as to sizes for the two different situations and Tem Performance provides selection tables to accommodate this.



RHS:

Select Conductor	Enter Cct. Amps	Enter Length [m]	Rated Amps	Pwr.@ Rated Amps	Pwr.@ cct. Amps	Thermal Margin	Thermal Performance	Clr
[1 X (50 x 6.3)]BG	855	1	848	58.0	58.9	24.2	OK	
[1 X (12.5 x 2.5)]BD	120	1	127	15.1	13.5	10.2	OK	
(10)CG	48	8	50	124.8	115.0	13.9	OK	

Total Conductor 187.5 Watts

Caution

In calculating the expected temperature rise the answer is approximate as there are many factors to be considered and assumptions are made in the calculations. The answer is however a useful guide to determining installed ratings in a particular application.

Also on the CD

Fault Calculations

This calculation program provides a simple and quick means to determine the approximate prospective fault levels at the transformer terminals, the main switchboard and the distribution boards of an electrical installation. Knowing the fault level is essential for correctly selecting circuit breakers for the application.

Power Factor Correction

If the existing or expected load conditions of an installation are known this calculator will provide the required capacitor bank size to correct the power factor.

6

I would like to request a copy of the **Tem Performance CD**
(Temperature Rise Estimation Software including Fault level & PFC calculations)
Please complete the following form and **fax to NHP on (03) 9429 1075** marked to the attention of the **Marketing Services Department.**

Name:..Title:.......................................

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Please tick those you would like to receive.

- ☐ Controlling high short circuit currents with current limiting circuit breakers (short circuit co-ordination KT 7)
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- ☐ How does electrical equipment rate (Understanding ratings of electrical equipment)
- ☐ The quality Switchboard (Switchgear and protection devices for Switchboards)
- ☐ RCDs are saving lives (Earth leakage protection; RCDs)
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- ☐ Application guide to lamp selection (Industrial pushbutton controls)
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- ☐ Pollution of the airwaves (Unwanted signals and their effects on motor protection devices)
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- ☐ Talk about torque (Motors and torque)
- ☐ Keep your cables cool (Installation of cables)
- ☐ A leak to earth can be electric (Application of earth leakage protection)

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