B&R Enclosures Pty Ltd

Rail Cabinet Temperature Rise
Investigation Report
April 2013

INTRODUCTION

Victorian railways have traditionally used single skinned cabinets built to VRIOGS (Victorian Rail Industry Operator's Group Specification) for both metropolitan and regional installations. With the implementation of new technologies in the rail industry, heat rise within signalling cabinets has become an issue due to the more electronic nature of control equipment.

Electronics by default operates better and lasts longer if it runs within the specified temperature outlined by manufacturers. It becomes critical to control the ambient temperatures around electronic equipment as heat tends to decrease the mean time between failures (MTBF). Every degree improvement in operating termperature goes to increasing reliability and reducing any maintenance cycle. To improve overall operational efficiencies it is important to better understand the thermal effect of rail cabinets.

B&R are experienced in supplying rail cabinets to Victorian Rail. Recently a request was made to investigate how the fitting of sunshades on these cabinets could help with internal temperatures especially as these cabinets are mounted in direct sunlight alongside the railway lines. The effects of solar irradiation needed to be better understood. B&R, together with VLine set up an experiment with temperature sensors placed in strategic positions within a cabinet before and after the fitting of sunshades. This allowed a before and after comparison of the temperatures.

Figure 1 and 2 show the testing cabinet before and after the installation of the sunshades.

Figure 1 | Rail cabinet without sunshades.
Readings taken from 6/2/2013 to 27/2/2013

Figure 2 | Rail cabinet with sunshades.
Readings taken from 1/3/2013 to 18/3/2013

2.0 LIMITATIONS

Drawing definitive conclusions from one set of data readings always has its limitations and caution is recommended in interpreting these results. Sometimes what can seem logical (common sense) can prove to be incorrect, primarily due to false understanding of all the variables that make up the system.

For example, no sensors were placed on critical electronic components such as micro-processors and electrolytic capacitors, therefore it is not possible to fully understand the effects of termperature at these levels. Generally equipment has a specified operational temperature range and as long as these limits are not exceeded the equipment will operature trouble-free for many years.

3.0 SUNSHADES EXPLAINED

The external sunshades are designed to provide an insulating air barrier and shield the cabinet surface from the extremes of solar irradiation. During previous sunshade testing it has become known that the top of cabinets experience high degrees of heat removal, more than one would initially expect.

The solar irradiation onto the sunshades causes the air between the sunshade and the cabinet to warm up. As hot air rises, this causes airflow to occur between the two surfaces as shown in Figure 3. Any air movement over the surface of the cabinet has the effect of extracting more heat from within the cabinet. This effect is more noticeable at the top of the cabinet as the top surfaces are the major mechanism for the dissipation of internal cabinet heat. This chimney effect draws cold air from the bottom, rising up towards the top surface of the cabinet, extracting more heat in the process. It is therefore possible to record dramatically cooler temperatures at the top of enclosures due to the effect of the sunshades.

The vertical flue design is achieved by means of a full-height support/mounting channel on both left and right hand sides of each sunshield panel which provides a 50mm air gap between the outer surface (solar shield) and the inner surface (cabinet wall).

In addition to side sunshades, roof and door sunshades are also provided. A roof sunshade is an important component offering weather protection as well as protection from direct solar irradiation. The roof of the enclosure being a horizontal surface receives a higher percentage of daylight hours and therefore greater solar irradiation than vertical surfaces.

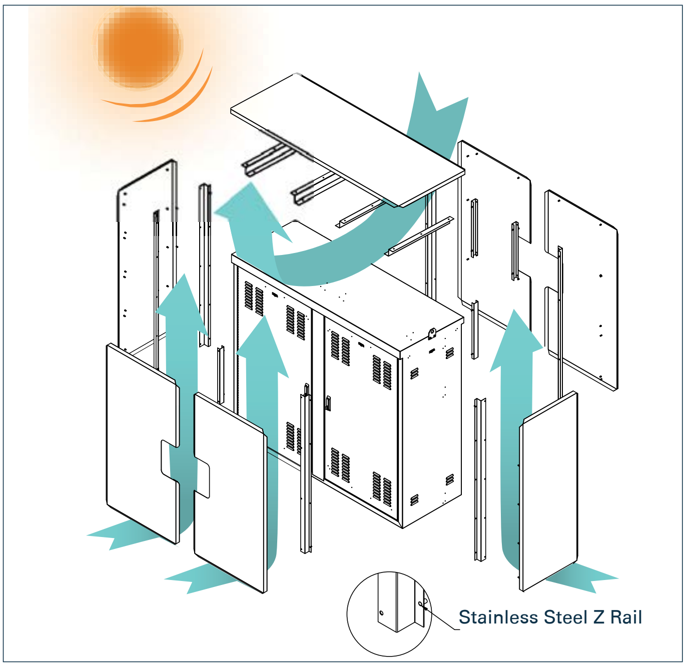


Figure 3 | Enclosure with sunshades demonstrating air flow direction.

4.0 MEASUREMENTS

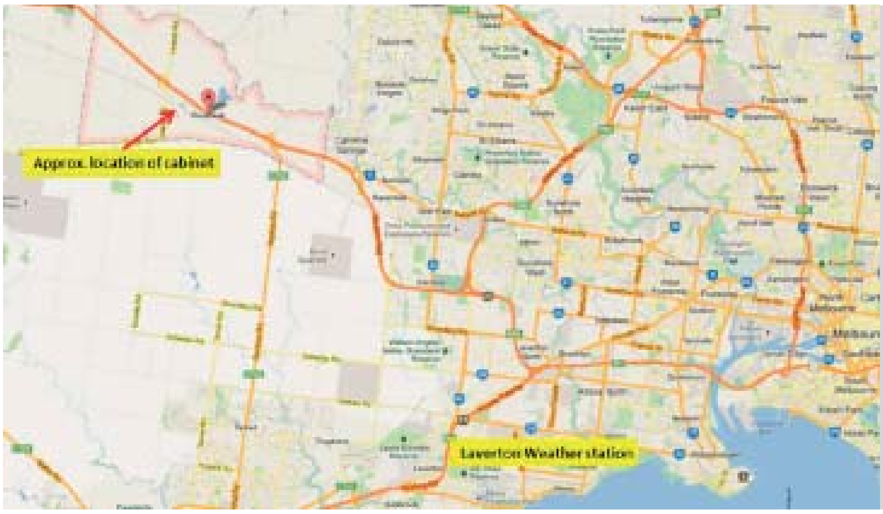
The investigation has delivered a comprehensive set of data with 22 days of readings without sunshades and 18 days with sunshades. In total, over 30 thousand data points were collected. These data points were extracted from 8 sensors distributed inside around the enclosure as shown in Figure 4 below.

Figure 5 shows the locations of the cabinet and data capture area. Laverton Bureau of Metrologies (BOM) data was used the recording of ambient temperatures and solar exposure.

Measurement locations within the cabin at:
3. Inside on bottom surface
4. On non-a ctive equipment
5. On active equipment
6. Inside LHS roof
7. Inside RHS roof

A/L Suspended LHS
R/L Suspended RHS
A Inside on bottom surface

Figure 4



Rockbank is situated some 20km NE of Melbourne shown here.

Figure 5

Alteration	Date	Time
• Thermocron sensor buttons readings commenced	06/02/2013	00:00
• Sunshades installed	28/02/2013	11:00
• Thermocron sensor buttons removed	19/03/2013	09:00
• Thermocron sensor buttons stopped and data extracted	20/03/2013	

5.0 LAVERTON METEOROLOGY READINGS

No ambient sensor was positioned around the test cabinet and therefore the closest Meteorological station, Laverton was used as the ambient reference. To some degree the two sensors at the bottom of the cabinet should reflect the ambient temperature but in practice these were found to be significantly different to the Laverton readings graphically represented in Figure 6.

The Laverton readings also included solar irradiation energy per day and this together with the daily temperature was used to determine, as near as possible, two days that were very similar with and without sunshades (shown in Figure 7). These days occurred on 9 Feb 2013 when no sunshades were used and 3 March 2013 when sunshades were fitted. These similar days are used later in the data analysis.

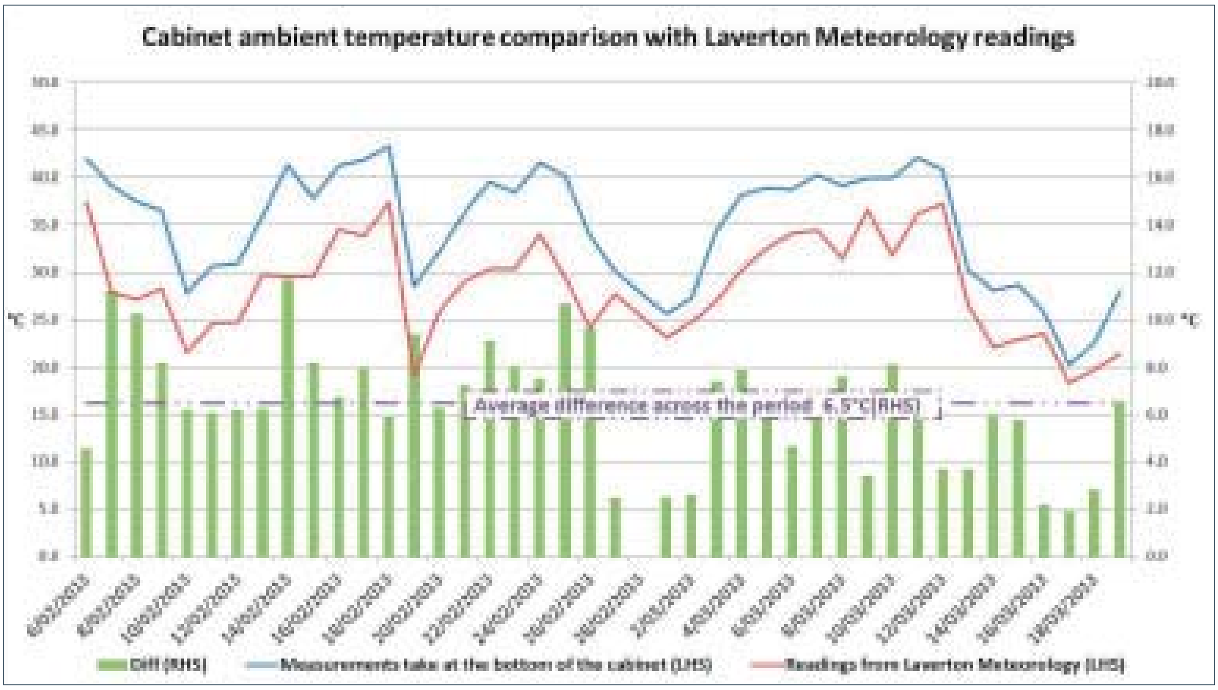


Figure 6

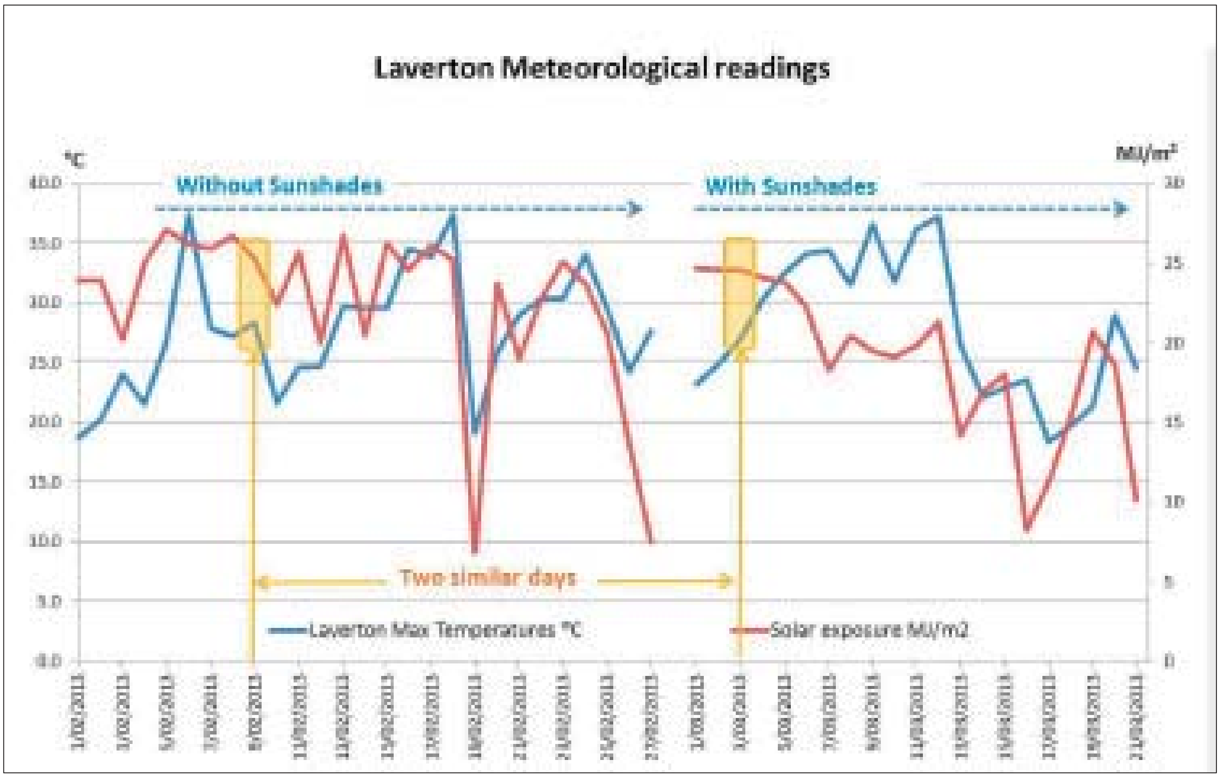
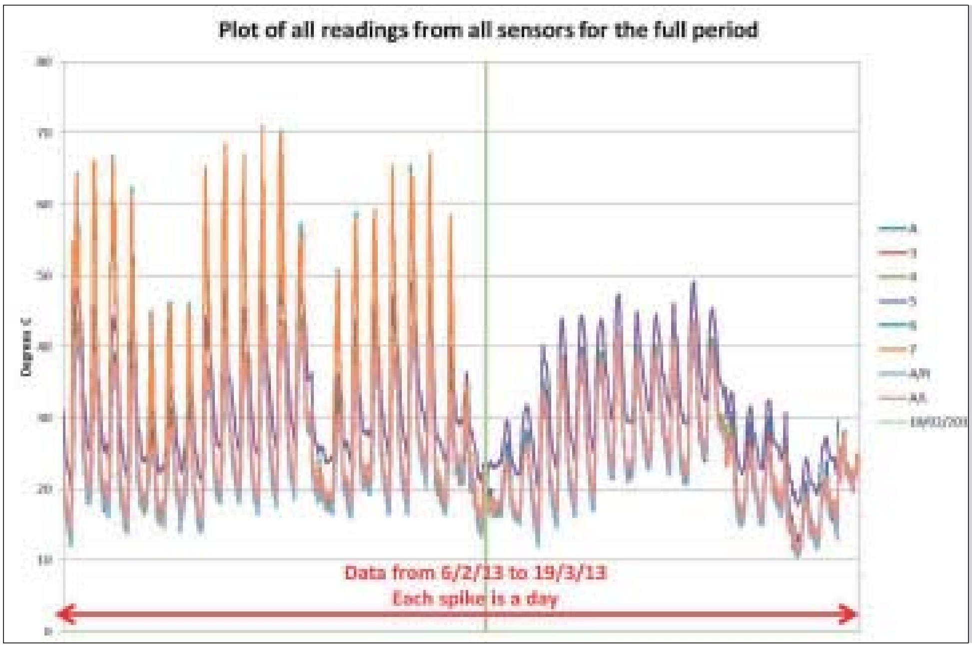


Figure 7

6.0 RESULTS AND DISCUSSION

The interpretation of the data is highly complicated as every day is different, no two days are identical. Variations in ambient temperature and solar irradiation vary each day and therefore it is not possible to be absolutely categorical with conclusions. In most cases average data is used to try and determine a trend/pattern.

For example the overall plot of all the data in one graph suggests that the enclosure definitely runs cooler with sunshades and this conclusion is correct in the majority of instances.



The green vertical line represents the day sunshades were fitted.

Figure 8

6.1 DAILY AVERAGES

The plots below shows the maximum, minimum and average temperatures with the sensors segmented as follows: Figure 9, 1 0 and 11 show the spectrum of temperatures recorded during the testing phases.

Top Active	Sensors 6 & 7 were averaged to obtain a representative top temperature. These sensors did track each other relatively closely thus allowing this generalisation.
Active	Only one sensor, sensor 5 was used on the active equipment. This sensor was placed on the bottom portion of the active equipment and therefore would only be expected to record temperatures close to the internal ambient temperatures at this point. Ideally it would have been better to have a few sensors above the active equipment to record the temperature they were dissipating.
Non-active	Several sensors were placed around the middle of the cabinet in the non-active equipment area. Sensors NL, R/L and 4 all tracked each other well and are averaged here to create a single non active reading.
Bottom	Two sensors were positioned at the bottom and again these were averaged to create one reading for the bottom of the cabinet.

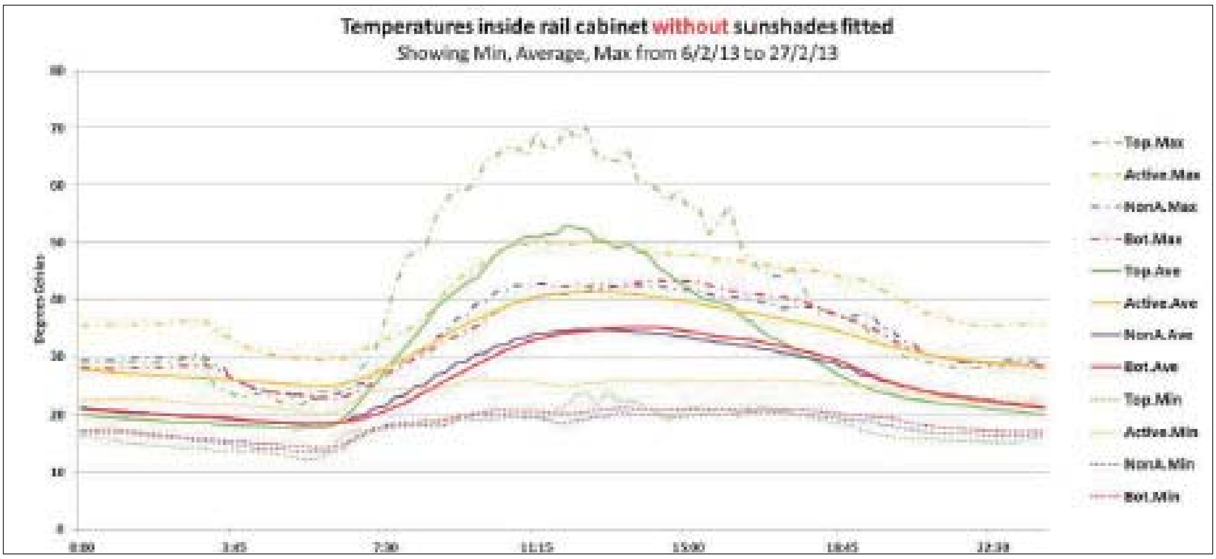


Figure 9

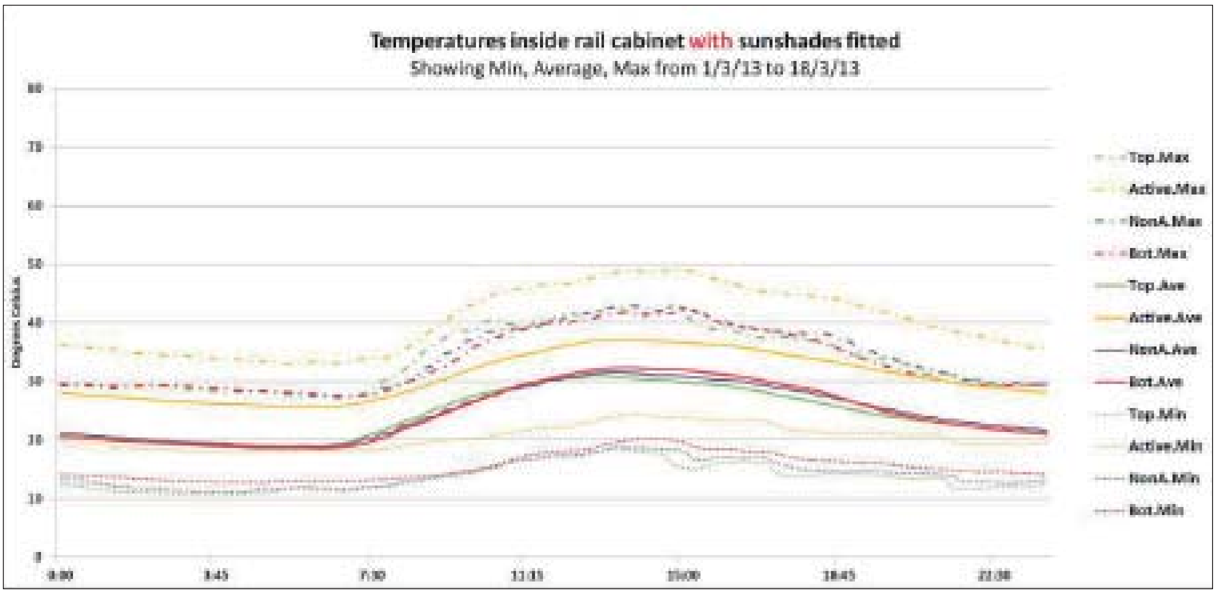
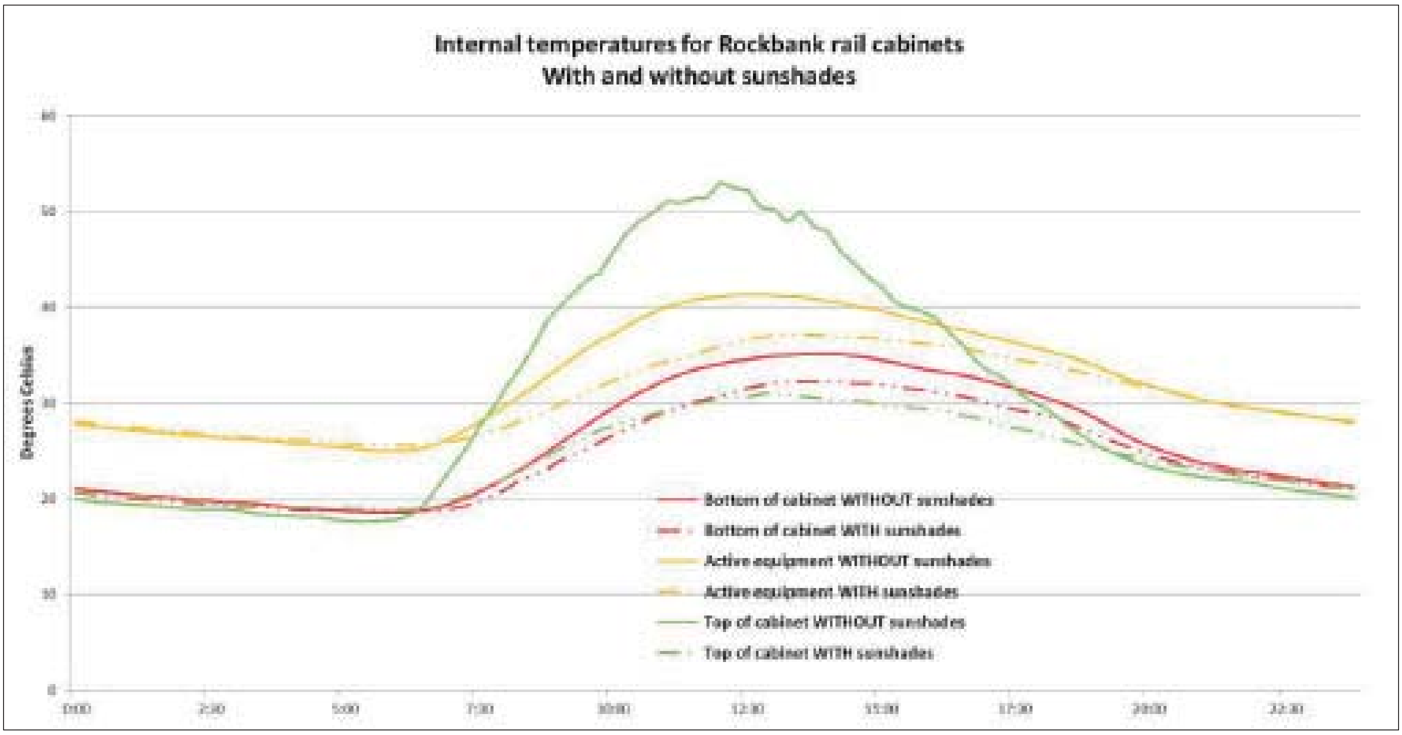


Figure 10

Conculsions from the above:

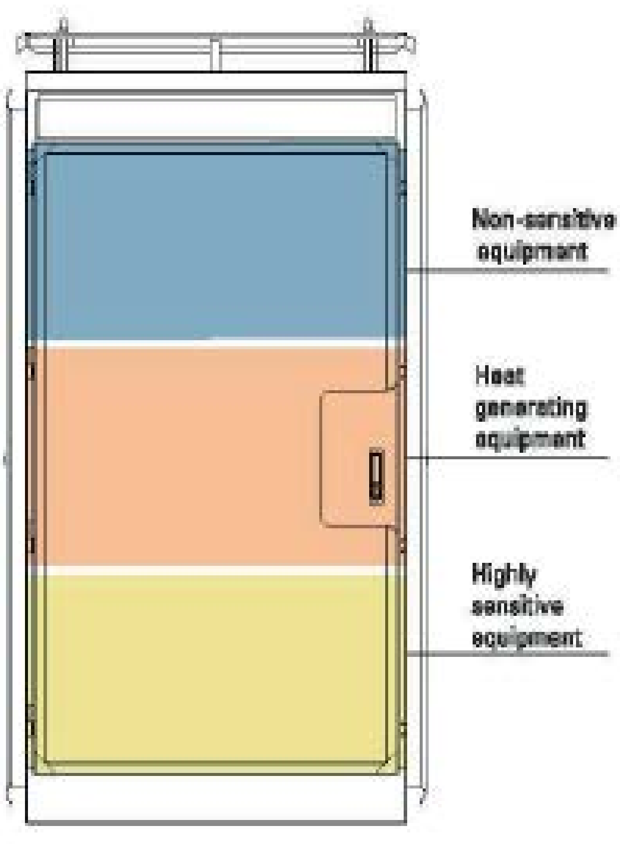
- The top of the enclosure does experience a dramatic decrease in temperature with the fitting of the sunshades, dropping from around 50°C to 30°C.
- The active equipment temperature only has a marginal decrease in temperature dropping from around 42°C to 37°C. It may be fair to state that the sunshades have had minimal effect on the active equipment.
- Both non active and bottom sensors track: each other relatively well and also experience approximately the same 5 degree temperature drop as seen for the active equipment.

If we extract only the average readings (very similar to bottom readings) then the following plot is realised.



Conclusions drawn from this plot

- The top of the cabinet has a strong cooling effect with the sunshades.
- It is important to note that the top of the enclosure is cooler than the bottom when sunshades are fitted enabling the active equipment to run significantly cooler. Unfortunately there were no sensors placed above the active equipment.
- It is clear that the bottom of the cabinet runs cooler and therefore it would be prudent to mount temperature sensitive equipment at the bottom of the enclosure. This is somewhat counter intuitive, but logical. As shown in Figure 12 it is recommended where possible to mount electronic equipment towards the bottom half of the cabinet while placing high heat generating devices like power supplies or Variable Speed Controllers above these sensitive devices. It therefore follows that placing all the cable termination points towards the top of the cabinet is desirable as they tend not to be as affected by higher temperatures.



6.2 ON SIMILAR DAYS

Every day is different with different ambient temperature, cloud cover and solar irradiation. All of which leads to complexity in trying to compare the effectiveness of sunshades in this application. In an attempt to narrow the variables, two days were chosen that had very similar ambient temperatures and solar irradiation levels.

As shown in Figure 13, while the temperature of the active equipment has a modest decrease in temperature, around 4°C, the top of the cabinet has well over 20°C drop in temperature. This is highly significant in that the active equipment is working in a cooler environment.

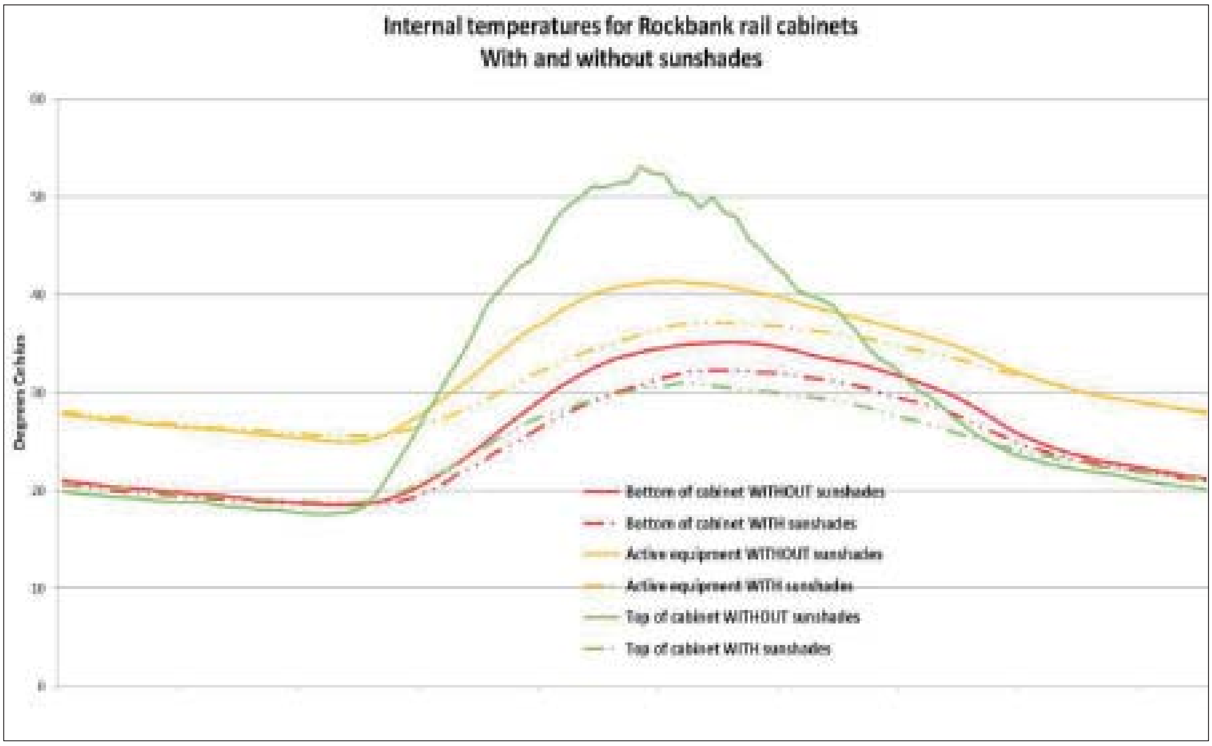


Figure 13

7.0 OVERALL CONCLUSION

It is pleasing to note that the sunshades have a significant effect in reducing the internal temperature of the rail cabinets. The sunshades effectively allow the cabinet to run as if it were an indoor cabinet by removing the heat of the sun from the surface of the cabinet. An additional advantage is the creation of the chimney effect which draws air across the enclosure to increase cooling.

From these tests, it is possible to state that the internal temperature of the cabinet runs much cooler with sunshades but further investigation is needed to confirm that the active equipment benefits from this. Consideration should also be given to the positioning of sensitive equipment within the cabinet.

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