

## High-Voltage Electrical Flashover Prevention

### Downer EDI Mining

#### The Problem or Initiative

Following a series of wet-weather events in 2010, two diesel-electric haul trucks in the Downer EDI Mining (Downer Mining) fleet at one of its Bowen Basin projects experienced high-voltage inverter cabinet flashovers.

The flashover events were the result of arcing across high-voltage terminals and busbar OF1, causing the following damage:

- Insulated gate bipolar transistor IGBT module failures (12 in total);
- Vertical busbar failure;
- Capacitor busbar failure; and
- Switching control fibre optic damage.

In total, six inverter cabinet flashovers occurred in 2010; three per truck. Each failure cost \$100,000-\$150,000 to repair, and the trucks were out of service for an average of 500 hours per truck, causing significant loss of production.

Most importantly, however, the flashover events had the potential to cause serious injury to the operators of the trucks, people servicing the vehicles and other workers on the mine site.

A flashover in the haul truck cabinet causes the loss of the retard braking dynamics. This places the operator at risk, as well as all the other vehicles on the road – including both light vehicles and other heavy equipment. There is also the risk of serious injury through: fly objects from severe damage of the cabinets; molten material; and/or electrocution.

Investigation into the cause of the flashover events revealed that they seemed to be occurring after extended shutdowns as a consequence of wet-weather events.

When trucks are operating in dry conditions:

- The cabinets are hot and dry, with an internal temperature of around 80°C; and
- Any dust entering the inverter cabinet sticks to the components due to a static charge.

When there is a wet-weather event sufficient to stop operations, there is usually very high humidity and lower-than-normal temperatures. Trucks are parked up as a safety measure, generally for over 24 hours, as haul roads become wet and slippery.

When this happens:

- The air inside the cabinet contracts, drawing in cold, humid air;
- Condensation forms inside the cabinet; and
- The busbars and metal components cool to the ambient temperature.

Once the weather warms up and the haul roads dry out, so that operations can recommence:

- The ambient temperature warms the cabinet;
- The condensation inside creates a humid environment;
- The large copper busbars are still cold and dusty; and
- Condensation forms on the busbars and dampens the dust.

The trucks are then sent back to work and, in the case of the flashover events, the following occurred:

- Voltages rose on the busbars;
- The dampened dust became a conductive solution;
- Electrical arcs formed, effectively causing a short circuit; and
- Electrical energy discharged causing a large arc blast, which is four times hotter than the surface of the sun.

#### The Solution

Having ascertained that it was the combination of dust and moisture that was the root cause of the problem, various remedies were tried in consultation with, and with the involvement of, the relevant OEMs:

- The initial response was to thoroughly clean all the busbars, and then use smoke bombs to ascertain where dust may be entering the cabinet. Damaged gaskets were replaced, and Silastic2F3 was used to seal any leaking seams.
- Secondly, silicone desiccant gel bags were placed inside the inverter cabinets to absorb any moisture inside the cabinet.
- When neither of these proved effective in preventing the flashover events, attention was turned to the area of the busbars on which the dust was accumulating. Through research and some very innovative thinking, Downer Mining Electrical Superintendent, Elton Cousins, formulated a solution using insulating vinyl stickers. This is illustrated in Figure 1.

Elton approached electronic, electrical and mechanical suppliers, and even the manufacturer of the decals for Downer Mining vehicles for stickers, which were then tested by placing a high-voltage charge each side of them. Ultimately, it was the product from the provider of the decals that proved to have the ideal qualities.

The supplier was provided with a template of what was required, and the stickers were manufactured and trialled on a truck. When there was no flashover event on that particular truck following the next wet-weather event, the stickers were applied to all the diesel-electric trucks that had the potential for flashover events.

To date, Downer Mining has not had another flashover event. With regard to the hierarchy of control, it may be considered that two aspects of this have been applied:

- Engineering control: the busbar has been engineered to stop the arcing; and
- Elimination: The ability for contaminants to access the critical area of the busbar has been eliminated, along with the ability for an arc to short it out.

Image 1: Sheet of insulating vinyl stickers.



Image 2: Busbar showing insulating vinyl stickers in place.

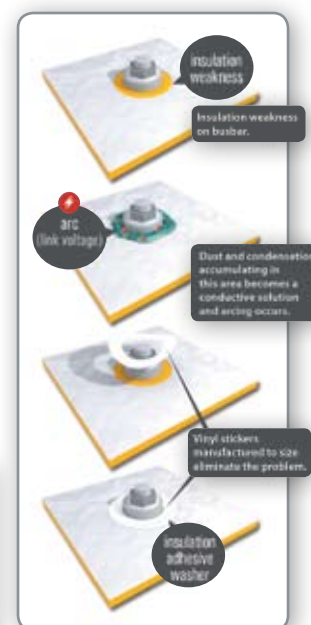


Figure 1: Eliminating the insulation weakness on the busbars.

### Transferability

The vinyl stickers have now been applied to all the diesel-electric trucks that had the potential for flashover events.

The transferability of this innovation has been proven by the fact that the manufacturer of the busbars has now modified its design, incorporating the insulating vinyl stickers, (see below) and is trialling them across other sites.

### Benefits / Effects

This innovation has considerable safety and cost-saving benefits. As detailed above, these simple insulating stickers:

- Eliminate or reduce the risk of a flashover in the haul truck cabinet, thereby preventing the risk of injury to employees and other personnel from:
  - Loss of the retard braking dynamics;
  - Fly objects from severe damage to the cabinets;
  - Molten material; and/or
  - Electrocution;
- Save repair costs of up to \$150,000; and
- Prevent production downtime of up to 500 hours per incident per truck.



Image 3: Busbar with Downer Mining insulating vinyl stickers.

Image 4: New busbar produced by manufacturer with modified design.



### Innovation

The need to find a solution to the arcing problem to eliminate the risk of harm to employees and other workers was time critical. In the absence of an immediate 'off-the-shelf' remedy, and once the more obvious quick fixes had been tried, tested and found to be insufficient to solve the problem, all that remained was to think 'outside the box' and explore less obvious, more creative ways of resolving the issue. This ultimately led to the innovation that is the subject of this submission.

The adoption of this solution by the busbar manufacturer also highlights the originality of the idea, given that this was the chosen engineering modification employed rather than something different.

### Approximate Cost

The solution to this problem cost just \$135 per sheet of 200 stickers, with each sheet having the potential to save up to \$150,000 worth of damage. It requires just one sheet per haul truck.