MESA

MINE ELECTRICAL
SAFETY ASSOCIATION INC.

MINING ELECTRICAL SAFETY 2017 CONFERENCE

10 – 12 JULY 2017

PULLMAN KING GEORGE SQUARE HOTEL,
BRISBANE

mesaqld.com.au

High Voltage Trucks
Protection and Fire Prevention

- Truck specifications
- Electrical protection system’s
- Truck Fire Case Study
- Investigation findings
- Actions
- Learning’s

Paul Edwards

Fires Reported in Queensland

During 2016 there were 305 fires reported from surface coal mines in Queensland, with 90% of these involving fixed plant and mobile equipment.

Of the 77 electrical fires reported there were 60 fires which involved mobile equipment.

Truck Specifications

A Typical Ultra Class Truck

- Gross Weight: 600t with a 363t payload
- Engine: MTU 20V – 2,800kW
- Kato Alternator:1,450V @ 2 MW
- Electric dynamic braking: 4,500 kW
- Siemens wheel motors: 2 x 2,000 kW
- DC Bus: 2,500 V

Truck's Drive System

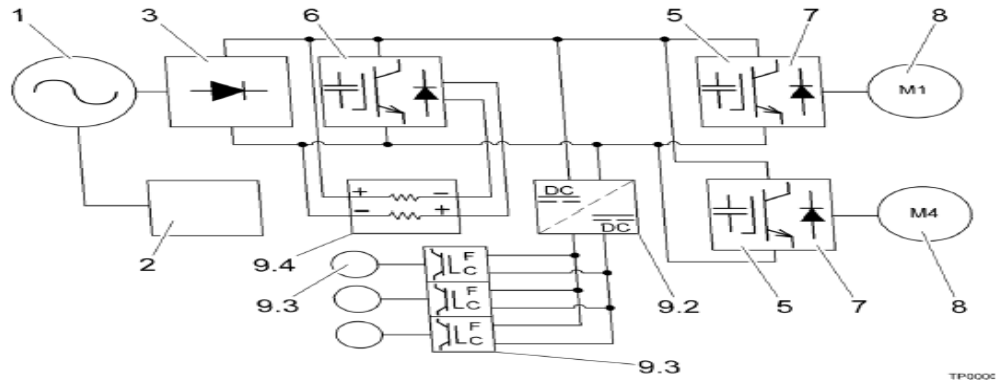
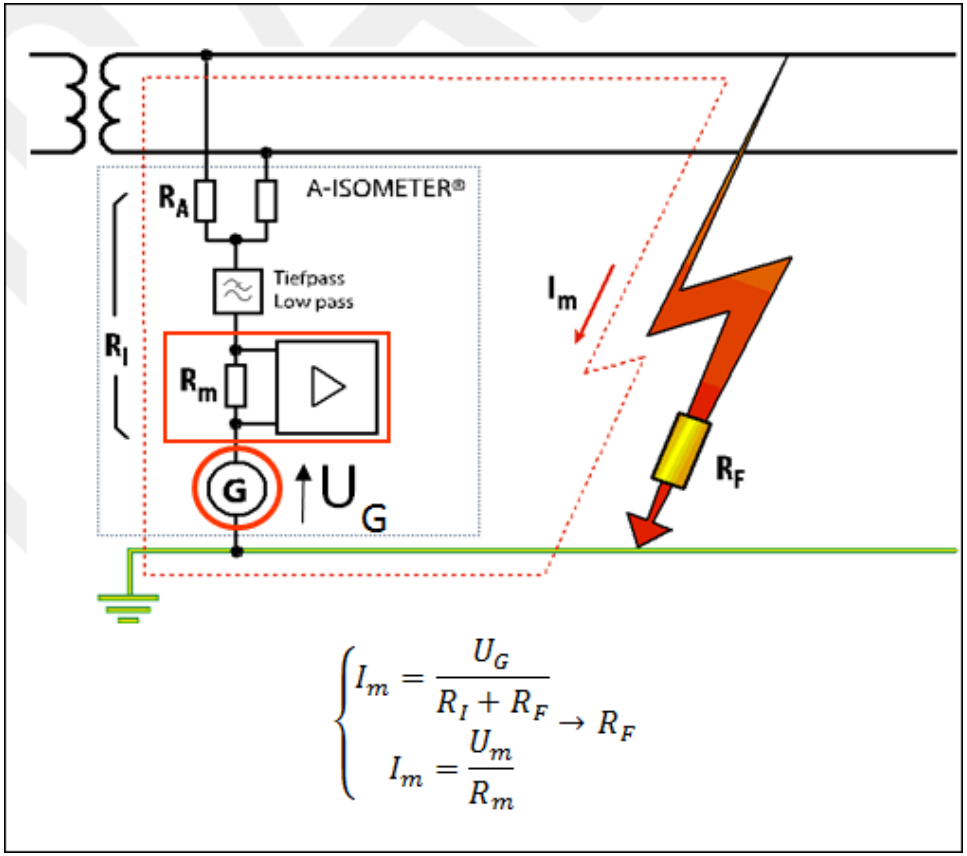


Fig. 8.1-136: Schematic: AC Drive System

Legend:

1. Traction Alternator
2. Field Regulator
3. Main Rectifier
4. Chopper Module
5. DC Link Capacitor
6. Brake Chopper
7. Power Stack(s)/IGBT Inverter(s)
8. Traction Motor(s)
9. Auxiliary Power Conversion
   - 9.1. Frequency Converters
   - 9.2. DC/DC Converter
   - 9.3. Main Blower Assembly
   - 9.4. Resistor Grid Box Assembly

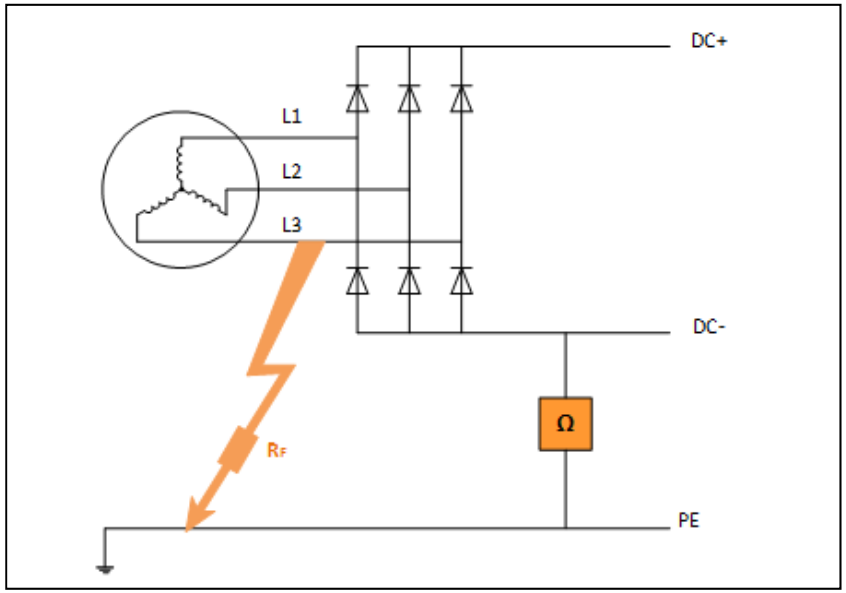
Insulation Monitoring System

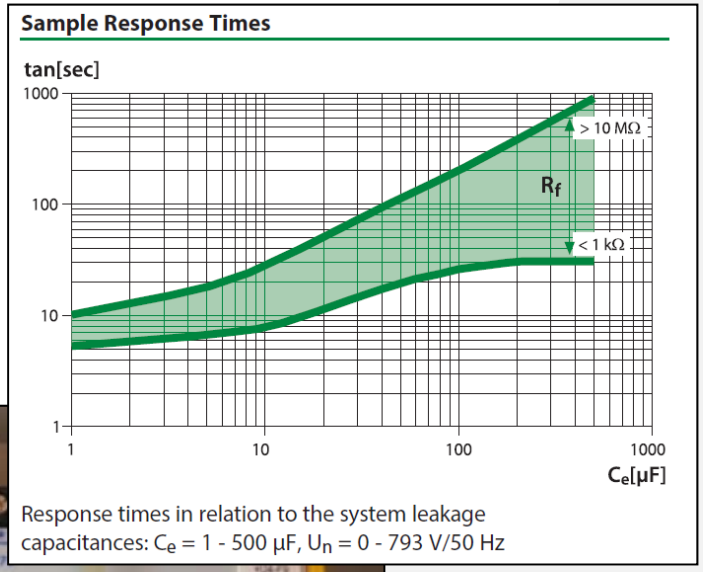


$$\begin{cases} I_m = \dfrac{U_G}{R_I + R_F} \rightarrow R_F \\ I_m = \dfrac{U_m}{R_m} \end{cases}$$

- The insulation monitoring device is connected between live (DC Bus) conductors and earth.
- The voltage U_G generated by the generator G is superimposed into the system via the measuring resistance R_m, the low pass filter and the coupling resistor R_A
- An insulation fault R_F between system and earth closes the measuring circuit creating measuring current I_m
- I_m causes a voltage drop U_m proportional to the insulation fault R_F at the measuring resistance R_m

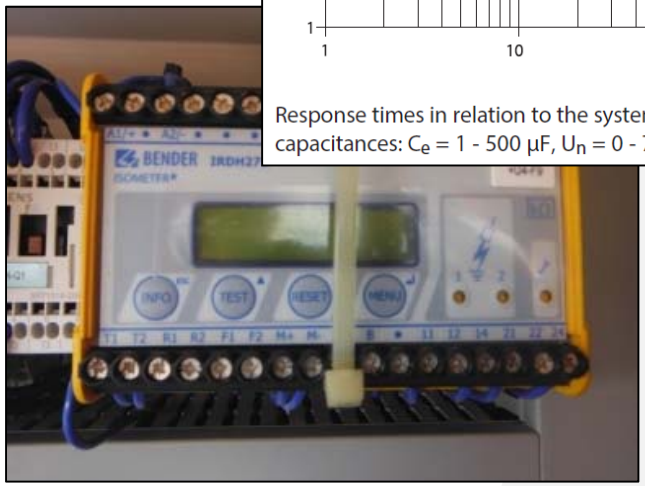
Insulation Monitoring System





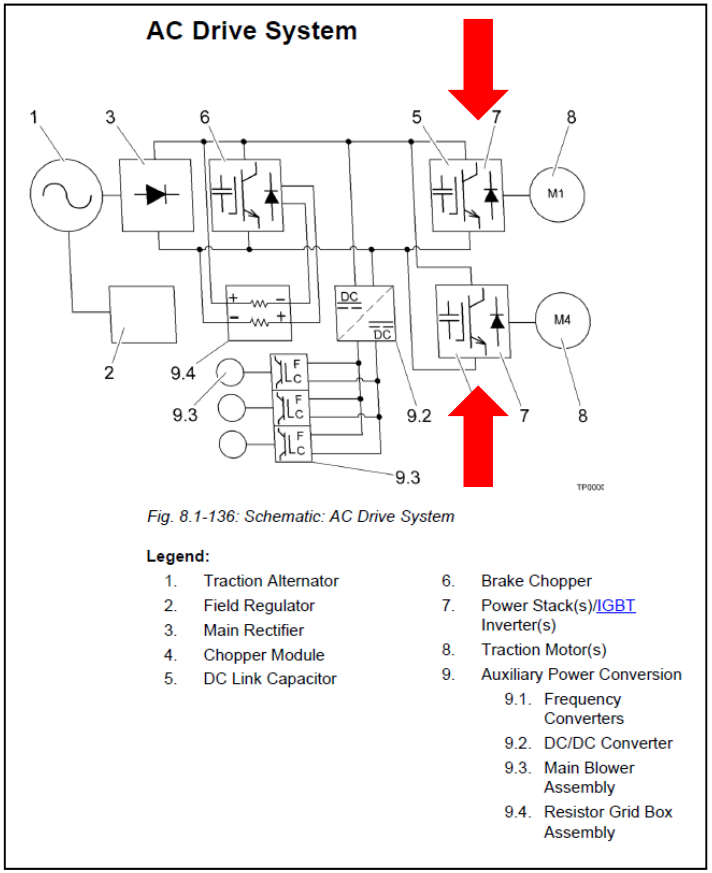
Insulation monitor settings:

- Sensing over 2 cycles was 3 cycles
- Warning from 450 kΩ, Trialling 2 MΩ
- Alarm from 100 kΩ, Trialling 1 MΩ



Peabody

Overcurrent Protection



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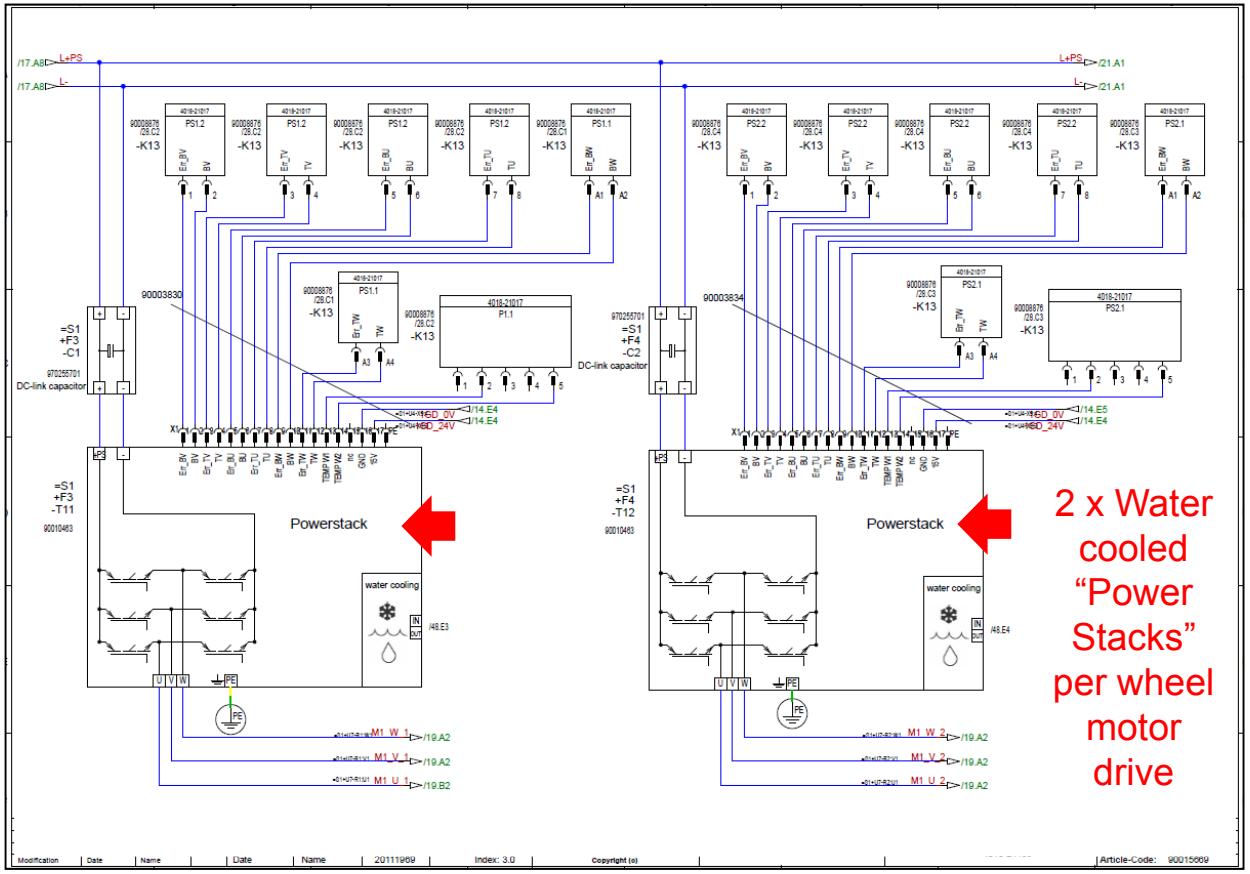
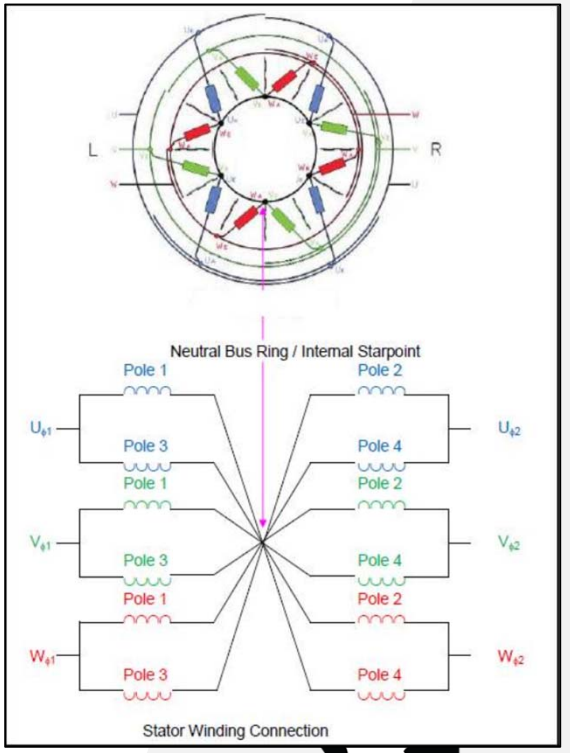
Over current detection will trigger a fault (and turn off the entire drive) if approximately 3,800 A is detected for more than ½ second.

Drive System



2 x Water cooled “Power Stacks” per wheel motor drive



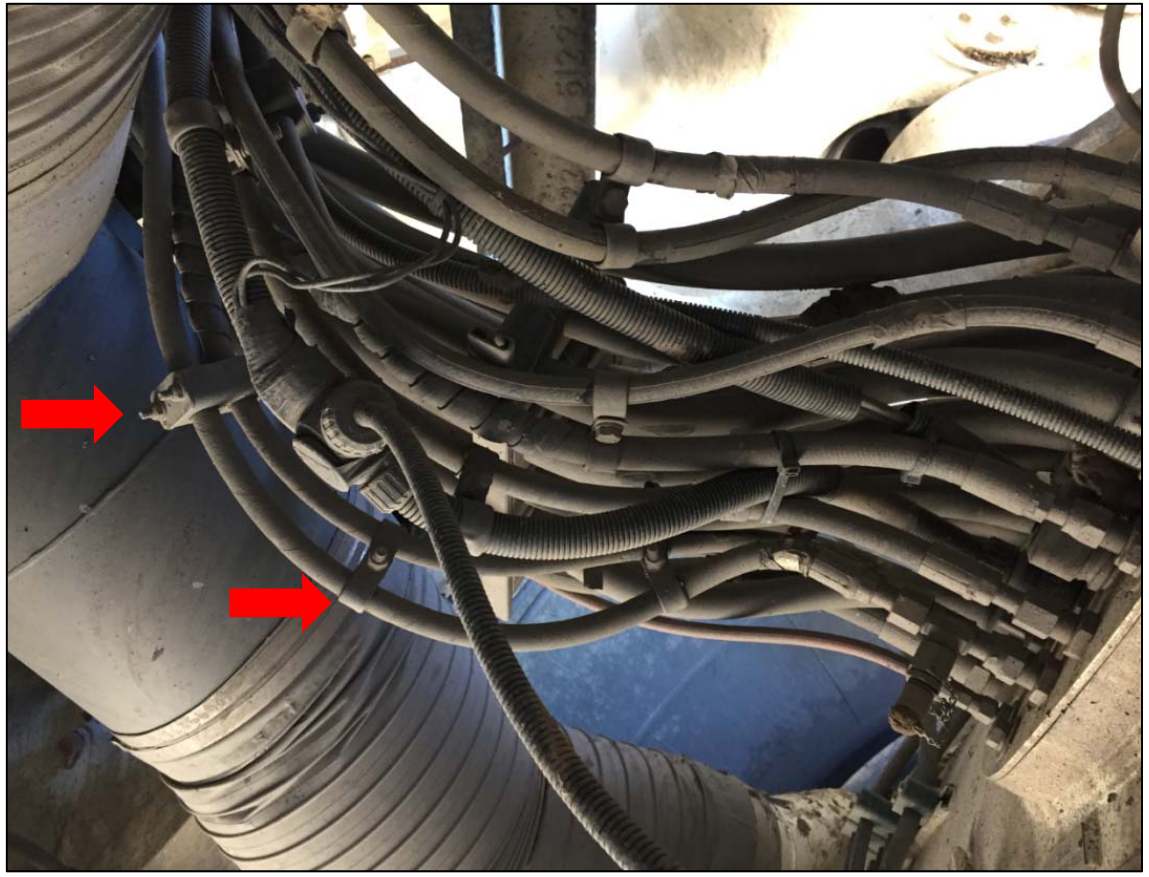
Case Study Truck Fire

Case Study Truck Fire

Truck travelling to the dump, dozer operator reported the fire to the truck operator.

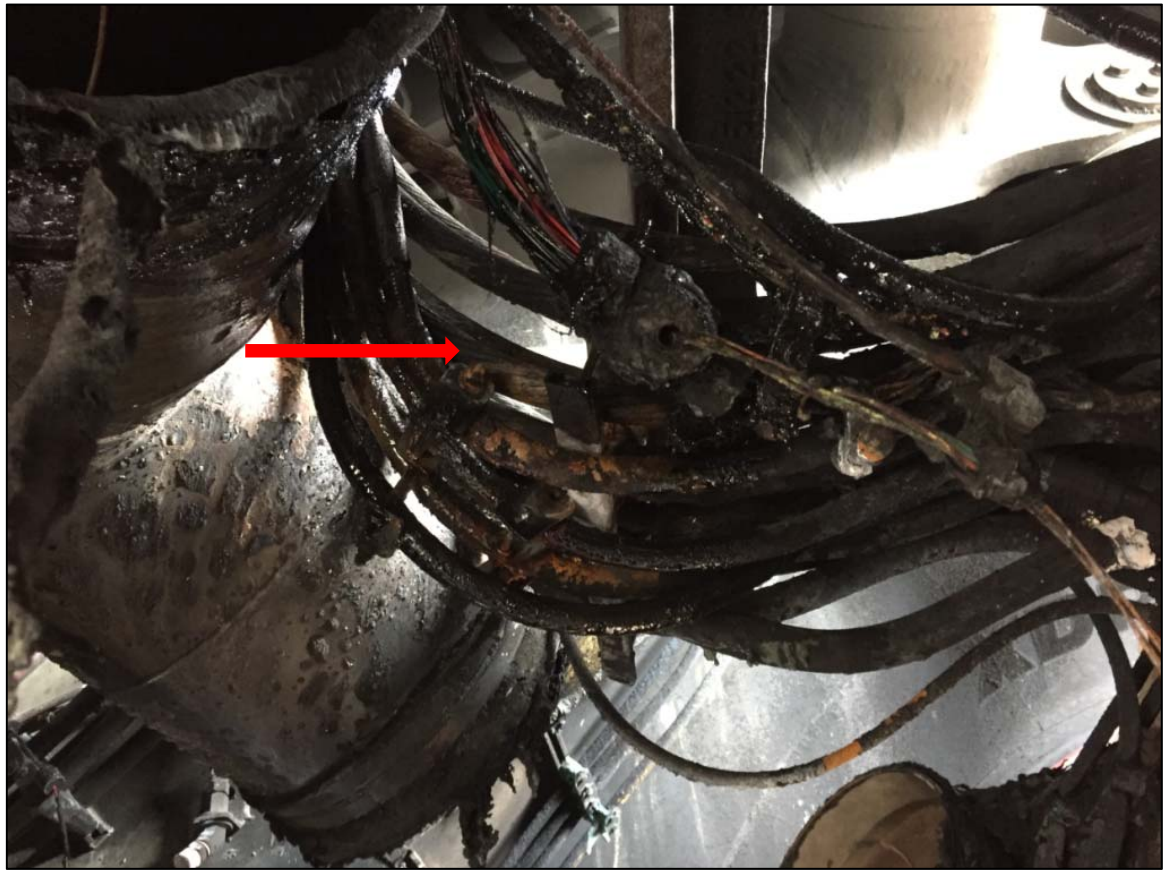
Note: The aluminum truck ID sign has melted. (~530 C)

Case Study Truck Fire



The affected area should look like this

Case Study Truck Fire



Investigation

- Truck operating normally
- No alarms, truck data corrupted
- No early warning logged via the insulation monitor
- Operator didn't know the truck was on fire until notified by the dozer operator

Case Study Truck Fire

Close up view of the High Voltage harness and hydraulic lines

Peabody

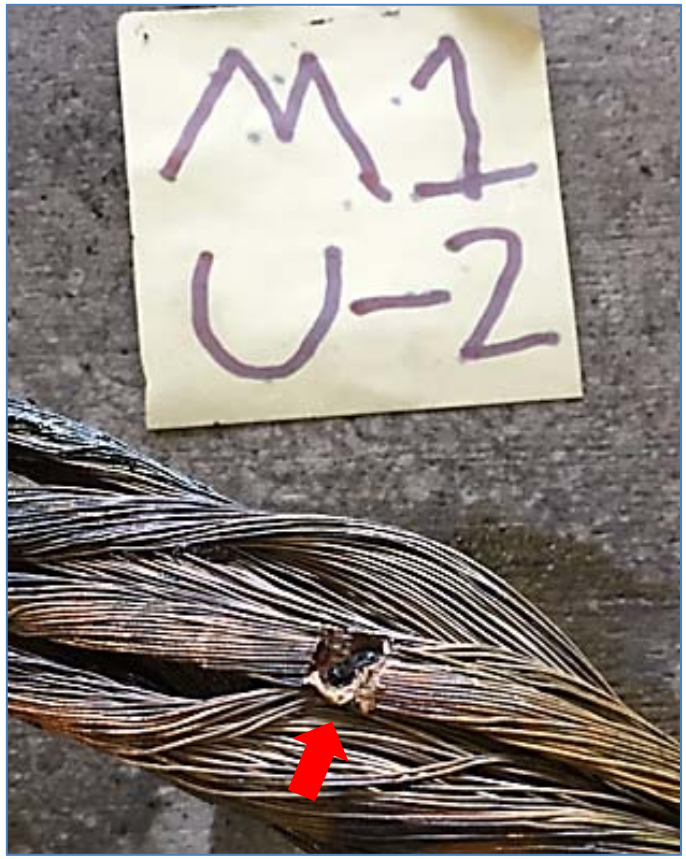
Case Study Truck Fire

View looking down on the High Voltage harness and hydraulic lines

Case Study Truck Fire

High Voltage harness and hydraulic lines removed and inspected

Case Study Truck Fire



Identified cable arcing
on Motor 1 Phase U-2

Case Study Truck Fire

Identified cable arcing on Motor 1 Phase U-2.

This position was in mid air between the major Stauff support clamps.

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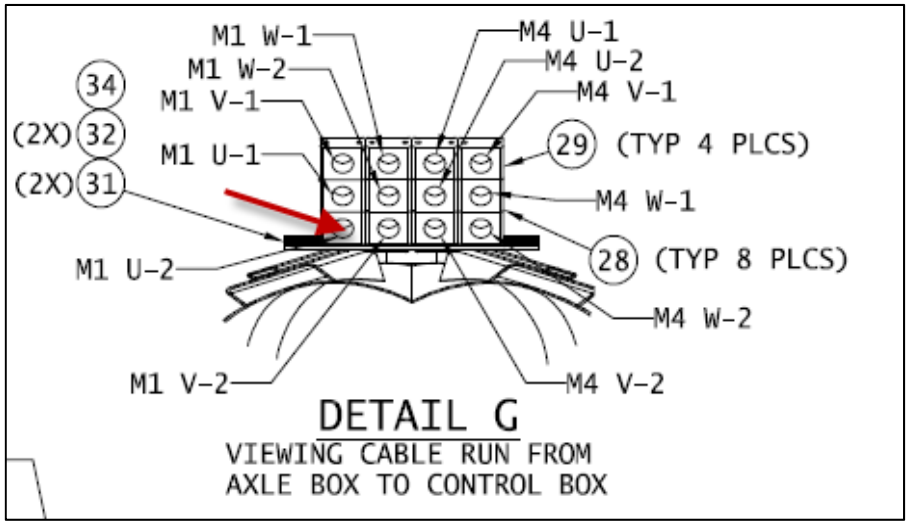
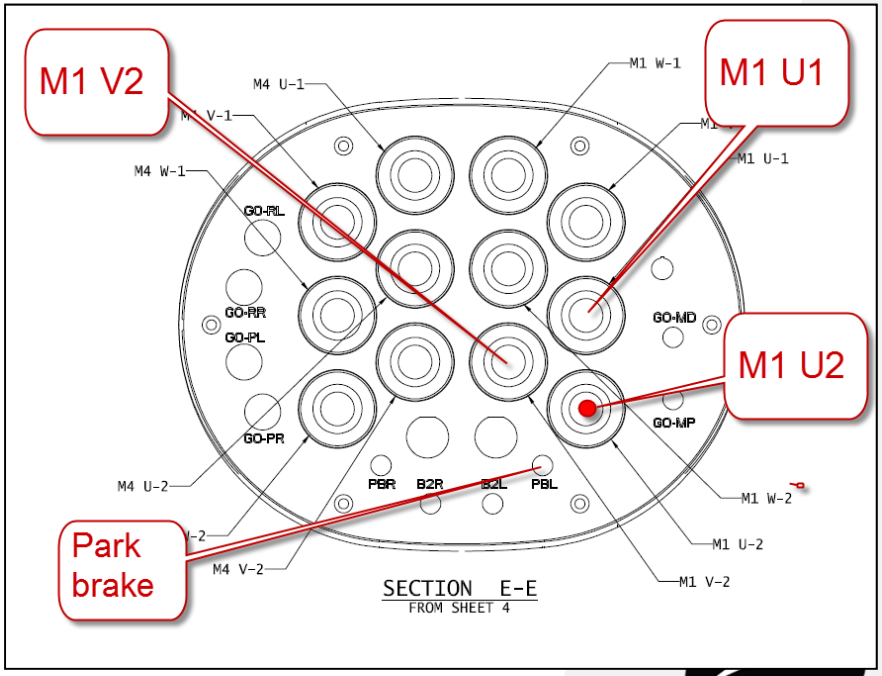
Case Study Truck Fire

Identified cable arcing on
Motor 1 Phase U-2





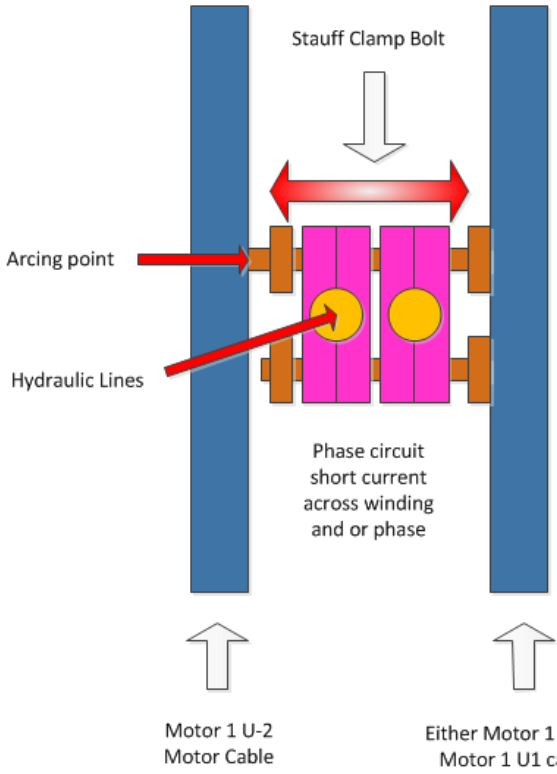
Peabody

Case Study Truck Fire

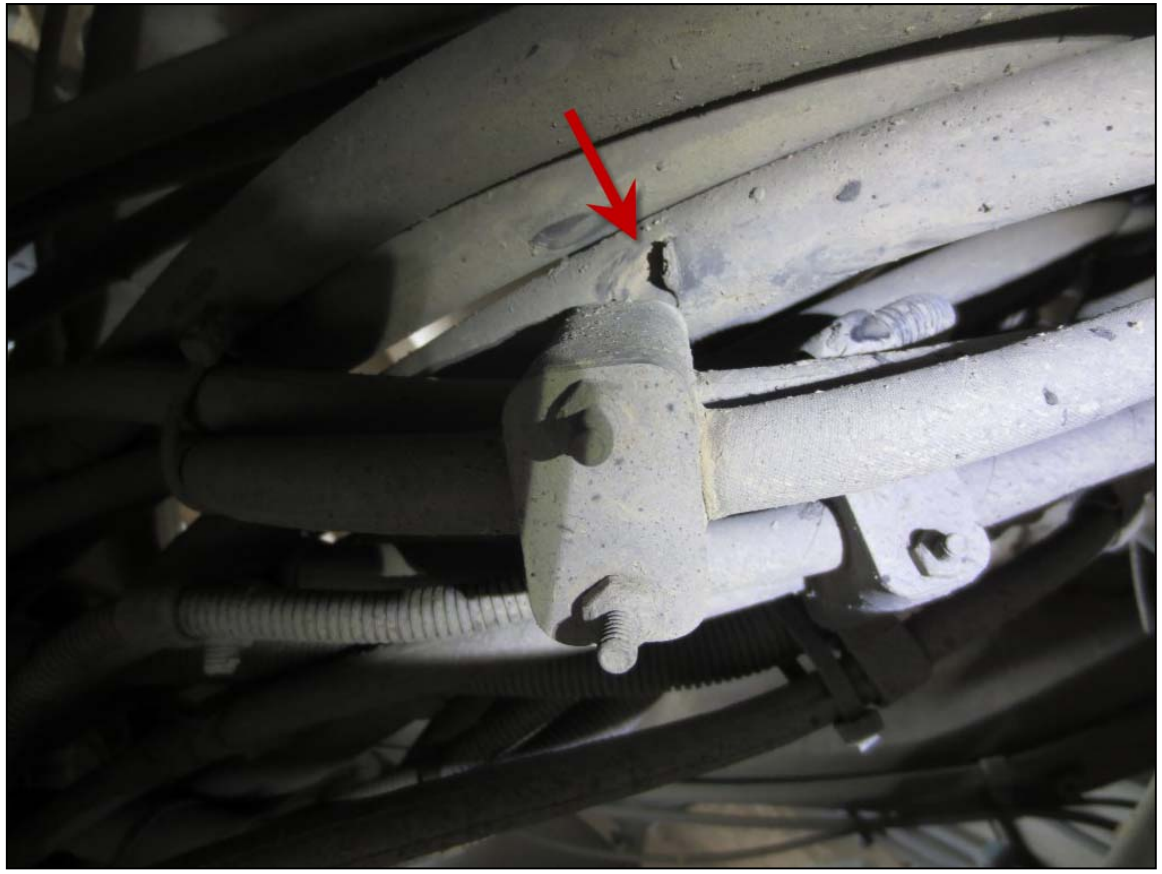
From the evidence of the arcing damage, there was current flow between Motor 1 U - 2 and most probably U -1 phase. The drive system wouldn't protect easily for this type of fault. Trip 3,800 A for 0.5 seconds.

Melting temperature for copper is 1,082C Cable 535.3MCM (American). Temperature rating is 90C 2kV rated.

Stauff clamp supported the 3,400 PSI pressurised hydraulic park brake hose which eventually failed from heat accelerating the fire. Flash point of the oil 250 – 400C.



Case Study Truck Fire



Audited truck fleets and found this cable damage

Every truck had cables and hydraulic hosing run to the axle box differently. (In Australia and the US)

There was no one common standard.

Case Study Truck Fire

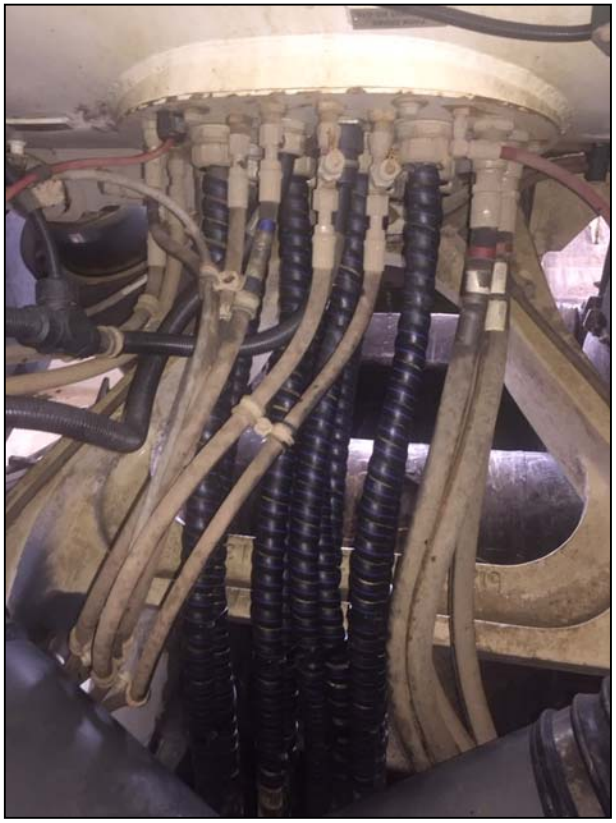
Stauff clamp supporting the high pressure hydraulic lines had moved resulting in the cable rub failure between conductors. The movement could have been during operation as a result of the movement of the axle box or by human intervention or a combination of both.

Most probably cause was human intervention from a maintenance activity.

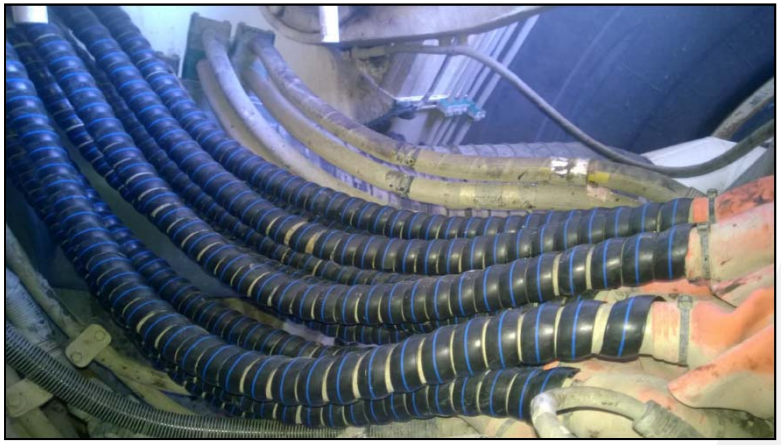
Maintenance History

08/06/2016 – Hydraulic Park line was replaced in this area
02/07/2016 – Air conditioner hydraulic pump was replaced
20/07/2016 – 3,000 hr service was completed
24/08/2016 – 500 hr service was completed
19/09/2016 – Truck Fire

Case Study Truck Fire



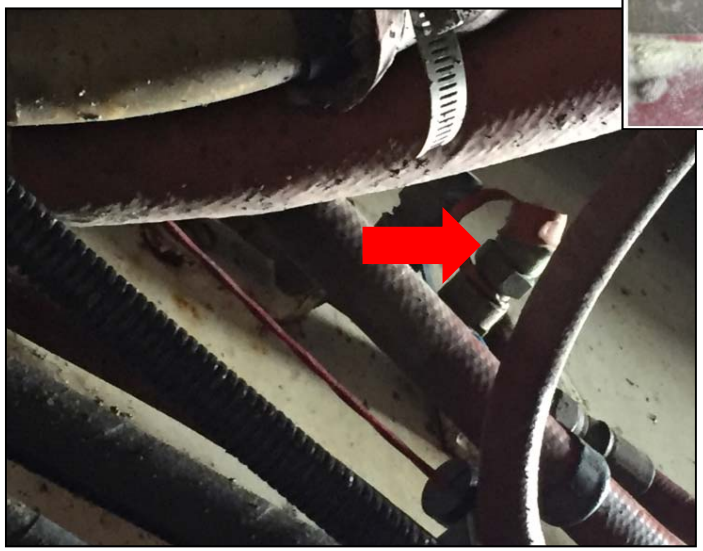
New standard



Case Study Truck Fire

Fire suppression system failed to fully discharge all nozzles.

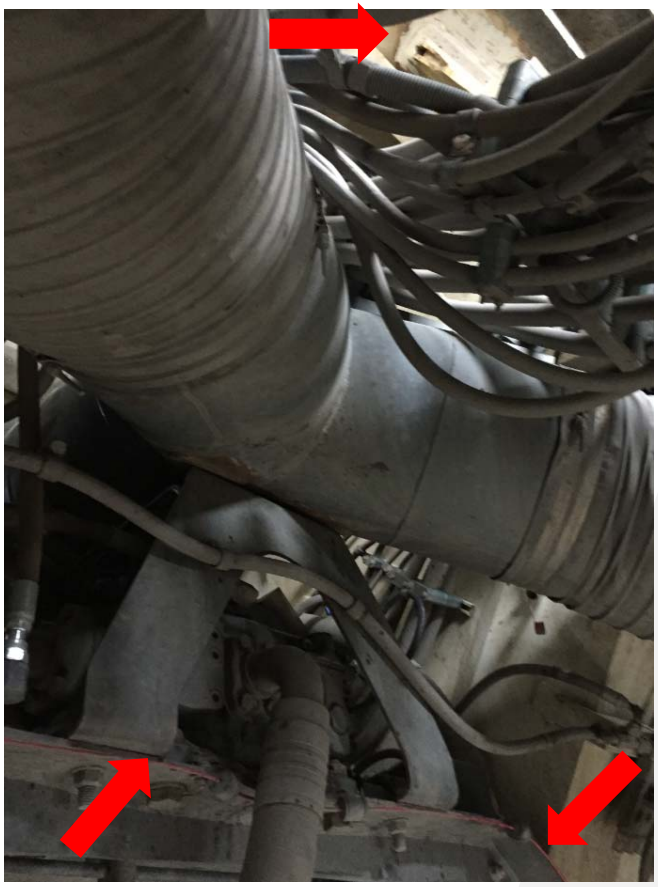
Filler lid was found loose on the Ansul chemical bottle. The system discharged through the fill cap on this Ansul bottle.



Case Study Truck Fire

Fire wire for auto activation of the fire suppression system is located below the cable ignition risk by > 1 metre.

No heat or ignition sources below the “Y” ducting, only hydraulic pumps and hoses



Case Study Truck Fire

Corrective Actions

- Improve cable / hose routing and standardised with the OEM

AS/NZ 4871.6 Electrical equipment for mines and quarries – Part 6 Diesel powered machinery and ancillary equipment

Section 2.2.4 Protection of cables and cable harnesses
(a) (iii) Not in direct contact with any hot surfaces, fuel lines, brake lines, pneumatic lines, hydraulic lines or the like.
NOTE: Where wiring is in close proximity, additional protection, spacing, restraint or fixing should be utilized.

- Separate high pressure fluids further, a technical request sent to OEM
- Ansul fire chemical tank, installation of mechanical security to the filler cap
- Fire wire was repositioned to improve the activation time
- *Education program and improvements with the inspection program, interactions between trades (Mechanical / Electrical)*

Case Study Truck Fire

Learning's

- Educating maintainers with the risks of cable / hydraulic hose rubbing
- Sticking to the OEM installation and engaging with them for product improvement
- Managing Mechanical / Electrical interfaces with cable and high pressure fluid management needs an increased risk focus
- Fire risk management, don't be a passenger, we as maintenance and engineering leaders need to become more active with the suppliers. Share the learning's to improve equipment for the future.

Case Study Truck Fire

It is not enough to do your best; you must know what to do, and then do your best.

William E. Deming

Thank you