FIRE SAFETY
- BUS BARS AND A CASE STUDY -

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POOR ELECTRICAL CONNECTIONS ARE A MAJOR CAUSE OF FIRES IN EQUIPMENT. IT'S IMPORTANT TO FOLLOW THESE SAFETY GUIDELINES IN THIS REPORT.

BACKGROUND

- High current and low voltage versus low current and high voltage, which is safer?
- The same power can be delivered with various combinations of voltages and currents. Power (Watts) is what is required, so how do you choose system voltage?
- For most power applications engineers select current as the main driving factor for safety and efficiency. Voltage is a secondary factor with equipment and component requirements.
- There are good reasons why electric cars operate in the range of 200 Vdc to 600 Vdc and Trucks up to 1,200 Vdc, to increase efficiency and lower operating currents.

HIGH CURRENTS ARE THE ENEMY OF ANY ELECTRICAL CIRCUIT

- Larger copper cables, add considerable weight and cost.
- Voltage drops create heat causing elevated temperatures.
- Increasing current reduces motor, motor controller, and inverter efficiencies.
- Connectors, terminals, fuses, circuit breakers, switches, relays / contactors increase in cost.

LOW VOLTAGE SYSTEMS

- Typically require more batteries in parallel, which is not optimum for charging.
- Inverters, motors, power supplies are less efficient
- Require increased current for a given load and power demand.

TOO HIGH OF A VOLTAGE

- Increases component and hardware cost due to additional safety requirements.
- Fewer system component options

HOW TO SAFELY MANAGE CURRENT IN A CIRCUIT TO PREVENT FIRE OR EXPLOSION

- Bus bars should be tin or nickel plated. In marine installations plating must be mandatory for safety.
- Compression lugs should have 2 holes in connecting 30+ amps.
- Oxygen barrier grease should be used for preventing corrosion / oxidation in the connection.
- Verify your circuit connections by measuring voltage drops and temperatures at full operating currents.

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CASE STUDY

Pictured is a failed bus bar that could have caused a fire on a telecom site or a yacht. This bus bar was .125” thick, 1” wide, and 4.5” long, carrying a max of 200 amps.

- This was part of a 500 amp load bank (an expensive one!) used in testing generators at Polar’s facility in Los Angeles. This was not a marine or tropical environment.
- There was strong air circulation around the component.
  The type of load was resistive, meaning that as the resistance increased the voltage and current will drop.
- The melted hardware was a 5/16 stainless bolt and nut, the melting point is 1420°C.
  At this temperature most nonmetal materials would catch on fire from the drips of molten stainless steel (notice the drip in the picture).

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CASE STUDY

There were multiple causes leading to the failure of this part.

1. It all started with slow oxidation creeping between the mating surfaces as seen around the hole on the left. On the right hole, the oxidation has reduced the mating contacts to a very small area, driving up the electrical resistance (milli-ohms). Bus bar resistance around the center hole is so high that the current was carried by the stainless bolt. The resistance on stainless steel is high so heat generated raised the temperature to over 1420^{o}C.
2. As the resistance increases during beginning stages of oxidation, the temperature increased driving up the rate of oxidation. The temperature and oxidation spiral out of control, until the metal melts or burns. The high degree of oxidation on this bus bar is a result of high temperatures.
3. In a dry environment, without marine or tropical conditions this process took 3 to 4 years to fail. In a marine or tropical environment this process can happen within months.

SOLUTIONS TO SAFELY MANAGE BUS BAR CIRCUIT TO PREVENT FIRE OR EXPLOSION:

- Bus bars should be tin or nickel plated, as these are the most practical materials for creating a low resistance (ohms) surface. Nickel plating is the best choice, but very expensive. In marine installations plating must be mandatory for safety. A quality plating job prevents the copper from oxidizing.
- Compression lugs should have 2 holes in connecting 30+ amps circuits. The large surface area lowers the contact resistance lowering the heat produced. The lugs must be also plated. See photo.
- Oxygen barrier grease should be used for preventing corrosion / oxidation in the connection
- Split washers or serrated conical / Belview washers are recommended to keep the bolt from loosening.
- Stainless steel 18-8 bolt and nuts are an excellent choice for securing the connection. Using a very small portion of oxygen barrier grease is recommended to also keep the stainless nut and bolt from galling.
- Always make sure the lugs are in direct contact with the copper bus bar, DO NOT use steel, brass, aluminum or stainless washers, spacers, or nuts between the lug and the bus bar. See Photo.
- Verify your circuit connections by measuring voltage drops and terminal temperatures at full operating currents.

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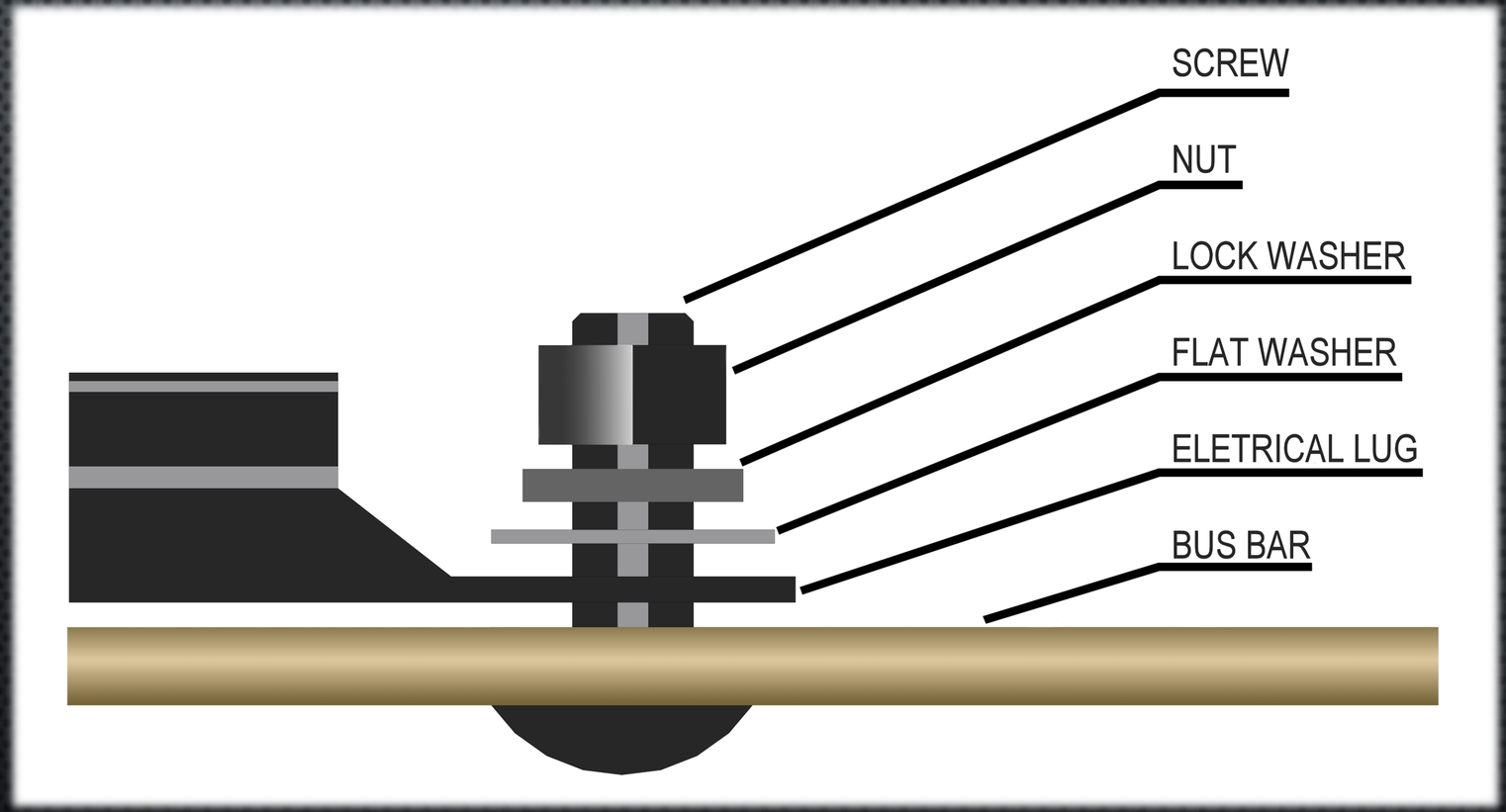
CASE STUDY

Very bad idea to use compression lug with spacers between other lugs and the bus bar.



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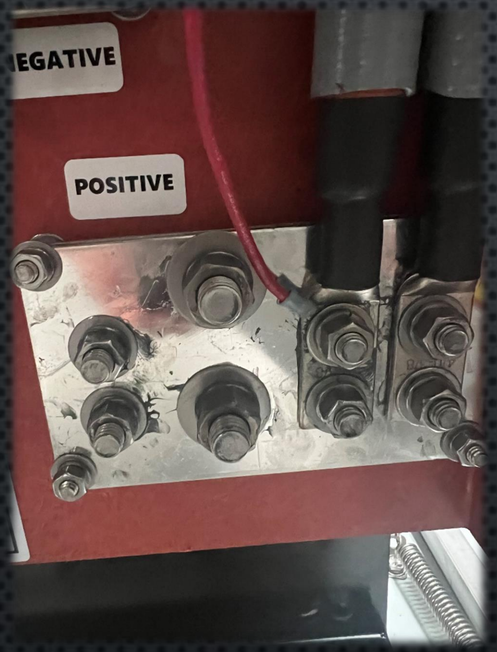
CASE STUDY

Here is a bus bar from a Polar DC Generator:



1. Copper is tin plated
2. Compression lug is plated with 2 holes for securing to the bus bar
3. Using BURNDY® Penetrox™ P8A Corrosion Protection
4. Stainless 18-8 bolts and nuts with split washers.

CASE STUDY: IN CONCLUSION

This bus bar was installed in a small steel metal box with 6 fans blowing air over all surfaces. Being a resistive load bank, as the voltage drops due to resistance in the connection, so does the current.

An inductive or capacitance type load, for example electric motors, battery chargers, inverters, DC/DC power supplies, as the voltage drops the current can increase, placing the failed bus bar in a more dangerous condition.

When purchasing equipment make sure the electrical circuits have met safe practices and remember cheaper products tend to take shortcuts.

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Thank You

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