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Recommendations Regarding Multi-Voltage Vehicle Electrical Systems

Developed by the Technology & Maintenance Council's (TMC)
Future Electrical/Electronic Systems Task Force

ABSTRACT
With the rising demand for improvements in efficiency and power availability, efforts are underway to incorporate higher voltages into the electrical systems of heavy-duty commercial motor vehicles. Throughout this effort, it is important that safety, reliability, and compatibility with equipment currently in use, be maintained. This paper, developed by TMC's Electrical/Electronic Systems Task Force, under the auspices of the Council's Future Truck Committee, serves to further outline these expectations.

INTRODUCTION
There are many compelling reasons driving the industry toward the adoption of multi-voltage electrical architectures. Federal emissions regulations are the main driving force behind the pace of this change. Therefore, it is important that benefits to the industry such as improved power availability and increased fuel efficiency are not outweighed by greater complexity, cost, or hazards while seeking to meet these emissions benchmarks. The potential advantages of including higher voltages on the vehicle are substantial and include efficiency gains through the electrification of vehicle systems and the potential for inclusion of energy harvesting systems to tap into currently unused heat, vibration, solar, and mechanical energy sources. In addition, future technologies such as automated driving and the rising driver demand for increased "hotel loads" steadily outpace the load capacity offered by current vehicles. These load capacity issues can be more easily resolved with the introduction of higher voltages and their increased efficiency. However, the need will remain for lower voltages to coexist on the

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vehicle alongside higher voltages. These lower voltages would serve to power in cab accessories such as driver mobile devices at five volts, trailers at 12 volts, and other accessory systems of various voltages.

Significant challenges arise as the voltage of an electrical system increases. The two key concerns are an increased risk of arcing and rate of electrolytic corrosion. Additional measures will be needed in order to protect higher voltage wiring, connectors, and components. Connectors must be designed to minimize the chance of significant fretting corrosion caused by micro-arc oxidation, and must be safeguarded against moisture penetration which would result in rapid electrolytic corrosion.

With higher voltages, more power is able to be transmitted through a given size of wire. This would allow for the use of smaller diameter wire to carry a similar electrical load. Smaller diameter wire is more easily damaged and is also acted on more quickly by corrosive effects, so it is imperative that protective measures are taken. Electrical components such as switches and relays operating at higher voltages can be damaged or degrade with time due to arcing within. Proper component and material selection will be critical to maintain reliability.

Currently, there exists a wide variety of differing heavy-duty commercial motor vehicle electrical architectures internationally. With the introduction of multi-voltage trucks, there is the opportunity for increased supply chain efficiency by allowing for interoperability and promoting the convergence of the many different worldwide designs.

SUMMARY OF EXPECTATIONS AND REQUESTED ACTIONS

The following is a summary of actions TMC believes the trucking industry should take and expectations the industry has, pertaining to the introduction of multi-voltage trucks.

1. Multi-voltage trucks should benefit from increased electrical load capacity to facilitate the use of future technologies and meet rising power demands.
2. Multi-voltage trucks should maintain compatibility with trailers in current use, having no need for the modification of either vehicle.
3. The singular electrical interface between the multi-voltage truck and trailer should conform to the SAE J560, *Primary and Auxiliary Seven Conductor Electrical Connector for Truck-Trailer Jumper Cable* standard or any updates thereof.
4. Multi-voltage trucks should maintain compatibility with existing accessory systems such as trailer lift gates, trailer lighting, telematics systems, etc.
5. Multi-voltage trucks should benefit from somewhat reduced emissions and increased fuel economy.
6. The starting cycle of multi-voltage trucks should improve in speed and efficiency when compared to current generation trucks.
7. The charging cycle of multi-voltage trucks should improve in speed and efficiency when compared to current generation trucks.
8. The procedure for jump starting a multi-voltage truck should be consistent across all vehicles and be achievable using commonly available 12-volt equipment.
9. A voltage limitation of 60 volts should be maintained throughout the multi-voltage truck for personnel safety.
10. All wiring, batteries, and components bearing unique voltages should be unambiguously and consistently marked and labeled across all suppliers.
11. The battery box design of multi-voltage trucks should provide containment sufficient to isolate the batteries and/or capacitors in order to reduce the likelihood of fire or electrical shock, but must preserve ease of maintenance.

12. In the segments of the electrical system with increased voltage, components such as switches, relays, connectors, etc. should be able to withstand or (preferably) avoid damage due to arcing.
13. Steps should be taken to adequately protect smaller diameter wiring from damage, as higher voltages greatly increase the rate of electrolytic corrosion and arcing fire hazard.
14. Where ever possible, multi-voltage vehicles should utilize common parts with trucks of prior electrical architecture in order to reduce the number of inventoried parts required for fleet maintenance.
15. Extensive training material and support should be made available to both owner and third party technicians to facilitate on-the-road repair. As well, emergency responders may also require additional training especially involving any labeling standards regarding higher voltage exposure points.
16. Multi-voltage trucks should operate with similar or improved/extended maintenance practices/service intervals when compared to vehicles currently in service.
17. With a common range of voltages to be supplied within all multi-voltage trucks, efforts should be made to end regional disparity of electrical architecture (e.g. North America at 12 volts, Europe at 24 volts, etc.).
18. SAE vehicle wiring safety testing standards should be utilized on all technologies requiring wiring on CMVs. ❑