Cross Company

# Intro to Thermal Management for Electric Vehicles

When electrifying your mobile equipment, thermal management is an important consideration. The thermal management needs of electric vehicles (EV) are significantly different from those of internal combustion engines (ICE) and must be considered when planning for electrification.

Why are they so different? There are two primary reasons. First, ICE vehicles are significantly less efficient (~30-40%) meaning a significant amount of excess energy goes to generating noise and heat compared to EVs which operate with 85-90% efficiency. Second, batteries operate within a much more narrow temperature range. ICE can run much hotter (up to around 212° F) and still operate when it is very cold. In contrast, batteries only properly discharge when they are within a tighter range. Batteries can operate between 32° F and 90° F, but much like humans, they operate best around 68-80° F. In order to maintain this temperature, a more robust thermal management system is required.

## Passive Thermal Management

Passive thermal management systems work only when the ambient temperature is cooler than that of the system. Passive systems typically use a fluid-to-air heat exchanger like an automobile to reject excess heat into the environment. If operating in a cold environment, the power being drawn from the pack will need to be limited until the heat generated by the system is able to warm up the battery pack enough to support higher discharge rates. This is why active systems are recommended for high-voltage battery systems, as an active system will get the battery to operating temperature quicker than a passive system and will maintain ideal thermal conditions.

## Active Thermal Management

In situations where ambient temperatures are significantly above or below the ideal range for batteries, active thermal management is needed. The high temperatures of ICE systems relative to their ambient environment (200-230° F vs 70-80° F) drive enough heat transfer for passive systems to work. In contrast, Battery systems operate at temperatures that are close to, if not at the same temperature as ambient conditions. In order to transfer heat, energy must be used to “pump” the heat out of or into the system.

These systems usually still have a passive cooling loop consisting of a radiator, water pump, and expansion tank, however, they add an active cooling/heating loop. The active loop consists of a high-voltage coolant heater (to heat the system in cold environments) and an AC Compressor/Heat Pump (used to pump heated or cooled refrigerant), electronic expansion valves, and a fluid-fluid heat exchanger to exchange energy between the passive coolant filled loop and the active refrigerant filled loop). These systems work together to keep the battery and other sensitive components, like the motor and motor controller, within the optimal temperature range so the system performs at its best. Operating at optimal temperatures also helps to prevent battery degradation which will help improve the value of your equipment over time.