

Off-road and eMobility: competition or collaboration?



Claudia Agostinelli, Senior Marketing Specialist, and Bryan Rock, R&D Supervisor, Afton Chemical

Off-road lubricant specifications have typically had multifunctionality at their core, enabling one lubricant to be used in multiple systems from transmissions to hydraulics. As sustainability initiatives push Original Equipment Manufacturers (OEMs) towards electrification, how many more demands can be placed on these lubricants before balanced performance becomes impossible? Afton Chemical shares lubricant benchmarking results that highlight gaps in Off-road and Electric Vehicle (EV) lubricant performance and opportunities for developing solutions.

Off-road applications are hugely diverse, ranging from ride-on garden mowers to agricultural tractors, from compact construction equipment to enormous mining trucks. How quickly eMobility will come into play as a result of sustainability initiatives will vary by application. Light duty vehicles and equipment like mini excavators have been relatively easy to electrify, whereas other types of equipment may need longer to make the transition. The push towards off-road electrification will likely follow the journey of on-road; electric passenger cars are already commonplace whilst electric commercial vehicles are still few and far between.

In contrast to the dedicated lubricants used for the different systems in passenger cars, multifunctionality has always been a more distinctive characteristic of off-road lubricants. Despite the 'TO' standing for 'transmission oil', Universal Tractor Transmission Oil (UTTO) and TO-4 oils are designed to be used in not only transmissions but also wet brakes, axles and hydraulic systems. Multifunctionality can generate cost savings by rationalising lubricants for fleet owners and making maintenance programmes simpler, with less chance of errors.

Towering requirements

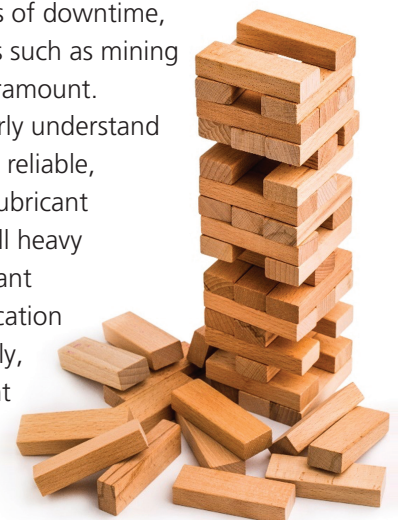
If each lubricant performance characteristic is seen as a block in a game of Jenga, off-road OEM lubricant specifications can be compared to Jenga towers – some of them now incredibly tall, with foundation blocks laid over two decades ago.

Formulators must now consider the additional demands of electrification, which brings new technologies, hardware and materials with which the lubricant must work in harmony. This will increase current performance requirements for copper compatibility and oxidative resistance while adding new considerations like electrical conductivity, which need to be balanced on top of these tall Jenga towers.

The extent to which meeting electrification needs could create gaps in other off-road fundamental performance areas – such as wear and Extreme Pressure (EP), friction control and water sensitivity – has been poorly understood until recently.

A balanced approach

The off-road market is typically risk-averse, largely due to the high initial outlay for equipment and the financial implications of downtime, particularly for industries such as mining where productivity is paramount. Although end users clearly understand the connection between reliable, efficient operation and lubricant performance, there is still heavy reliance on legacy lubricant specifications. If electrification is to be pursued optimally, the approach to lubricant development needs modernising.



Prioritisation will be key: some elements of legacy specifications may have become less relevant over time and can be scaled back or substituted with alternative performance requirements. This requires careful consideration: like deciding which Jenga block to slide out from the lower section of the tower before adding a new block on top.

Stretching functionality

The questions are endless. How well will today's Off-road lubricants perform with electrified systems and how much further can we stretch these lubricants? Could multifunctionality cease to be feasible or commercially necessary? Can EV-optimised lubricants deliver strong enough performance in crucial Off-road areas? Could lubricants become over-formulated in the attempt to adopt additional performance requirements? How much should backward compatibility take precedence over innovation for future needs?

Answering these requires an understanding of which lubricant tests remain most relevant. When formulating a new UTTO or TO-4 oil to meet global market needs, the tests easily add up to over 100. How should these myriad tests be prioritised alongside electrical needs?

Lubricant benchmarking

Afton Chemical has carried out benchmarking to identify and understand where current off-road and EV additive technologies may have performance gaps alongside opportunities for developing solutions. Samples of commercially available multigrade UTTO and monograde TO-4 style lubricants were compared

with blended oils containing either traditional off-road additives or on-road electrified transmission fluid additives. Performance was evaluated using a selection of Off-road and eMobility tests.

Traditional off-road tests included FZG low speed wear and load carrying capacity, D1748 rust, seals compatibility, water sensitivity and friction.

eMobility tests included DKA Oxidation (170°C/192 hrs) with electrical conductivity measured before and after oxidation, breakdown voltage, thermal conductivity and copper compatibility in extended D130 and Afton's in-house Printed Circuit Board (PCB) test.

Results

Results were as expected in that overall, off-road and eMobility lubricants share some similar requirements, but their key priorities may conflict.

Performance areas where similarities exist are gear protection, elastomer compatibility and low severity copper compatibility, whereas with friction, electrical conductivity and copper protection, their core priorities often conflict.

Friction remains the most complex challenge, with EV lubricants unable to deliver the right balance of durability and static/dynamic performance across different applications. One of the main differentiations between UTTO and TO-4 is friction performance. Avoiding Noise, Vibration, and Harshness (NVH) is critical for UTTO applications, while TO-4 applications tend to favour higher torque

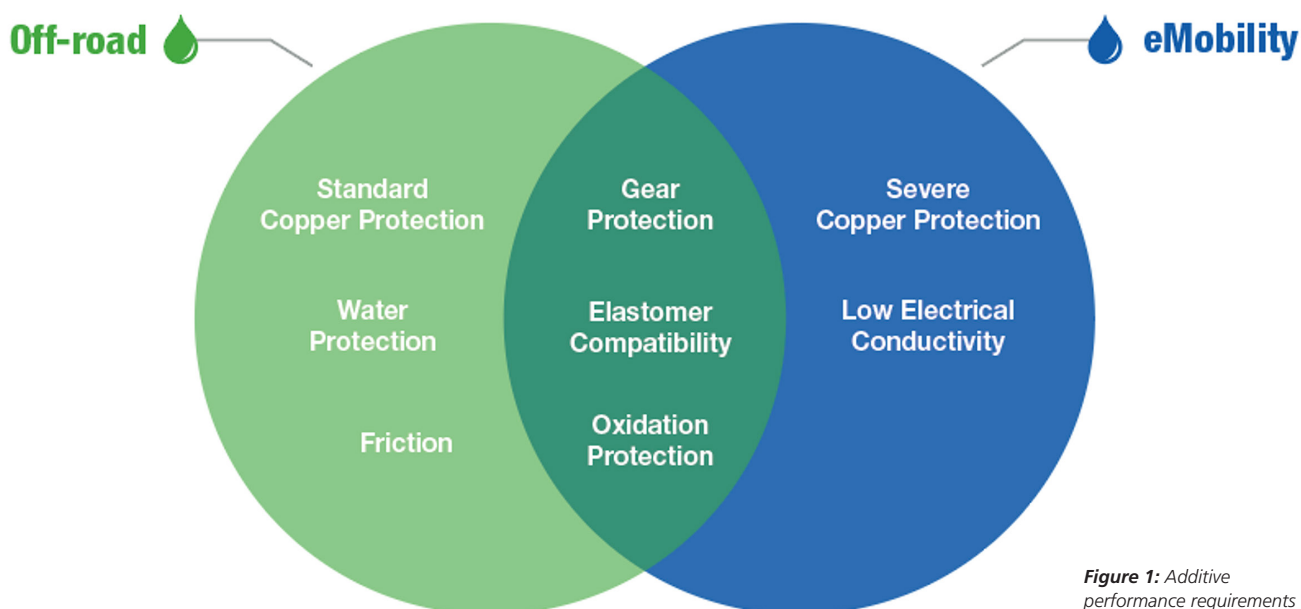


Figure 1: Additive performance requirements

capacity and responsiveness. The consequence is that UTTO lubricants have relatively lower static friction compared to TO-4.

When EV lubricants were tested in friction rigs, dynamic friction was typically not an issue and matched somewhat closely with Off-road lubricants. However, static friction was a different story. In the case of UTTO, EV tests had to be terminated early because the amount of shaking was too violent. For TO-4, the static friction was not high enough for the application's demands – either from the start or after significant friction material degradation.

Based on the commercially available lubricants assessed, Afton demonstrated that not one solution exists that can meet the needs of traditional multifunctional and electrified drivetrains. To bridge these differences in performance requirements with one technology, it would need a dedicated reformulation with extensive validation testing.

Collaborative solutions

So, how can these insights start to shape tomorrow's off-road lubricants? The most productive approach is

a collaboration between an OEM, their new hardware and their oil and additive suppliers.

Multifunctionality may be easy to keep demanding, but it may only be possible to build that Jenga tower to a certain height. It's important to understand what the equipment needs most and how this could be delivered by a lubricant solution. OEM priorities will vary thanks to their unique approaches to electrification.

Creating one lubricant with a healthy balance between all performance aspects may be the ideal, but if the demands of electrification coupled with legacy specification requirements prove too great, the multifunctional Jenga tower could topple.

Access to insights from relevant and robust testing will help OEMs to build appropriate connections and develop solutions that can support reliability for a lifetime spent Off-road.

aftonchemical.com

ELID



The Directory for the Global Lubricants Industry

a LUBE Media publication
Published by United Kingdom Lubricants Association
www.lube-media.com/elid

© United Kingdom Lubricants Association