Fuel costs, base oil costs, labor costs and equipment costs are squeezing profits in every commercial and industrial corner of the United States. Short term and long term solutions are unclear but one outcome is certain, those organizations able to improve efficiency of their operation will do better than those organizations that are not. Improving efficiency in the off-highway and mining sector can be particularly challenging when equipment is continually bombarded with dirt, moisture and extremes of temperature. Lubricant formulators are challenged to ensure that the lubricant enables improved efficiency and does not become the Achilles heel of the operation!

What Constitutes a Robust and Quality Lubricant?
Pressures are rising, loads are increasing and temperatures are rising while the equipment footprint generally is not. How can we ensure that the capacity of the lubricant selected is also increasing? Over the past 12 months we have visited numerous equipment builders who serve the off-highway market to find out what the critical lubricant issues are from the OEM’s perspective. In addition, we have spoken with maintenance personnel who are charged with ensuring that the equipment runs efficiently. Contamination is by far the highest cause of concern. This contamination is often dirt or water or more usually both. Some OEMs have even initiated programs to assist in fluid management training and proper lubrication in order to reduce maintenance problems arising due to contamination. Dirt can be very abrasive leading to wear of critical parts such as bearings and seals. Oils offering improved wear protection and oils with cleanliness properties may be particularly suited to these harsh environments.

Dealing with Harsh Environments
There are several tests available in the industry which may be used to measure the wear and extreme pressure protection of lubricants. One convenient test which is available throughout the industry is the FZG load stage test. Spur gears are driven under successively increasing load to see how much protection is afforded by the lubricant. After each load stage the teeth of the gears are inspected for scoring and wear. Typically the industry measures oils up to a load stage 12 level. If the gear teeth looked acceptable even after the highest load was...
applied to them, the lubricant is said to offer load stage 12 pass protection. If substantial degradation of the gears are noted after stage 9 loads, the lubricant is said to offer load stage 9 failing FZG performance. This test has been used in gear, transmission and hydraulic oil evaluation for many years.

We have used this FZG test to compare the performance of a variety of tractor lubricants. The results, which are summarized in Figure 1, clearly show a wide disparity of performance across the oils. It is perhaps not surprising that the oils used in very severe environments such as mining show higher wear/EP protection than oils used in agriculture applications. It is also of interest that even among those fluids used in the mining field, there is a disparity in FZG performance of up to 5 load stages.

**Keeping the System Clean**

Abrasive deposit build up on shafts and other surfaces can lead to physical erosion of the seals. This in turn leads to lubricant leakage which puts more strain on the reduced amount of remaining lubricant. Low lubricant levels are the cause of a multitude of problems which have been widely published. Premium oils are formulated to protect these critical surfaces from deposit build up even after oil oxidation. A test that has been used for several years and forms part of the industry API GL-5 specification is the L-60-1. This test runs at 163°C in a small motored transmission. To make the system severe, air is bubbled through the oil during the test, and copper catalysts are present which tend to promote the oxidation process. At the end of the testing period, the gears are removed from the transmission and inspected. Clean gears after this test are highly desirable and signify that the oil is able to resist the formation of deposits. Examples of these clean gears run on off-highway fluids are shown in Figure 2.

**Resisting the Effects of Contaminant Water**

There is universal agreement in the off-highway industry that contaminant water is something to be avoided. Water is really a poor lubricant which freezes at low temperatures and evaporates at high temperatures. It causes corrosion and provides almost no lubricant film strength under the mildest of conditions. It is also universally
accepted that water will be present at most times in most if not all off-highway equipment. Unlike many industrial applications where contaminant water may be periodically drained from the system, this rarely occurs in the mobile sector. While there are some exceptions, generally industrial fluids are formulated so that water readily separates from the oil and mobile fluids are formulated so that any water remains emulsified into the oil. Mobile systems are going to contain some water – better that it is emulsified than left to separate and do real damage. There are many water separation tests in the industry, some as simple as mixing the fluid with water and shaking to see how fast or slowly it separates. Examples are shown in Figure 3.

Corrosion protection is also a measure of the ability of lubricants to cope with contaminant water. Figure 4 shows the corrosion protection results obtained when tractor hydraulic fluids were subject to a corrosion test. The variation in results reflects the different abilities of the formulated oils to protect equipment under prolonged wet conditions. Some agriculture equipment may be left standing inactive over winter months waiting for the spring thaw. This type of service would benefit from strong corrosion protection seen with the premium fluids.

Friction Retention/Wear Control

Resisting contamination is only half the story. Other performance aspects are just as critical to efficient operation of the equipment. One such aspect is the frictional characteristics of the fluid as seen in the clutches and in the brakes. Obtaining good torque transmission through the driveline but with the correct friction to accommodate braking is a fine balance. This balance is often compromised as the lubricant ages. This is seen in Figure 5 below where the frictional characteristics of two tractor fluids are compared. Oils containing the premium technology demonstrate consistent friction performance, with friction durability needed in the modern tractor. The frictional characteristics of the premium fluid are significantly more stable than the characteristics seen with standard technology.

Conclusion

Efficiency in industry is driving productivity. There is nothing more inefficient than equipment that does not work. Down time is simply unacceptable in the 21st century. More and more equipment design is advancing to do more work. Lubricants are being reformed to keep up with the changes. The off-highway sectors are under even more pressure due to the environment. Robust performance is measured in terms of fluid stability, and the fluids ability to withstand contamination. This paper has illustrated some ways that the lubricant marketer may choose to demonstrate that the fluid has embraced this challenge.