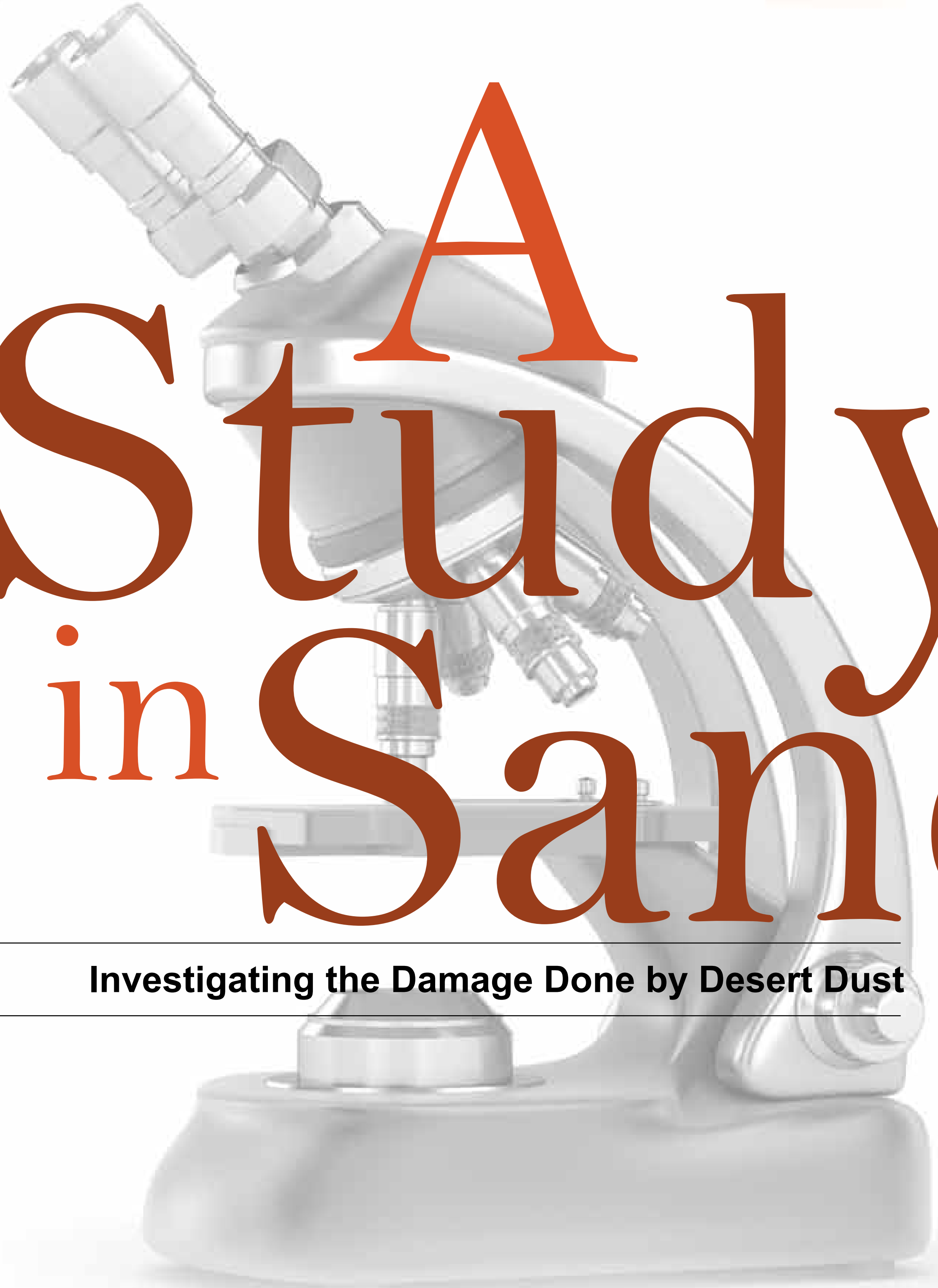

A Study in Sand

Investigating the Damage Done by Desert Dust

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BY MARK TOWNSEND

As much as 20 percent of the world's land mass is classified as desert, a landscape that poses considerable challenges to lubricant performance. The main consequence for engines or machinery operating in arid environments is dealing with the negative effects of dust ingress and the potential for accelerated engine wear.

Historically, to minimize problems, original equipment manufacturers have recommended increasing the frequency of drain intervals to slow wear under these conditions. This has been a traditional rule of thumb, but there has been no recent testing to verify whether it is still valid. Recently, one company set out to test this assumption and to establish whether it still holds true for today's lubricant technology.

Mark Wilkes, engine oils technology and product manager at Lubrizol Corp., participated on a team that designed a benchmark study to investigate the impact of dust on engine performance and durability. Speaking in October at the 8th ICIS Middle Eastern Base Oils and Lubricants conference in Dubai, he noted that the study specifically wanted to assess if the problem of dust ingress remains real and significant. The team used a number of criteria to ensure that meaningful conclusions could be drawn despite the wide number of variables involved. Key objectives of the study were to define what is present in dust in arid environments, whether it actually gets into the engine and, if so, how.

Additionally, the characteristics of the particles entering the engine compartment were identified and the impact on engine wear was assessed. The test results could then be used to determine if there are any implications for engine lubricant life and oil drain intervals.

Looking for Dust

The study was carried out in the United Arab Emirates, a country known for its arid environment and difficult operating conditions. Roadside samples were taken to determine what sand and dust particles were present in the ambient environment. In addition, dust deposits at higher elevations were examined to determine what was being blown about by the wind. These measurements were taken because particles of airborne sand and dust vary in size, shape and abrasive properties.

Vehicle deposits – particles found in engines – were tested to identify what gets into the engine, and the air filter was examined to determine what it collects and removes. The inlet tract was also checked to measure what size contaminants get past the air filter, and a used oil drain sample was evaluated to find what stays in the oil. An oil sludge sample helped ascertain the particles that drop out of the oil, and a used oil filter provided information about those removed from the oil.

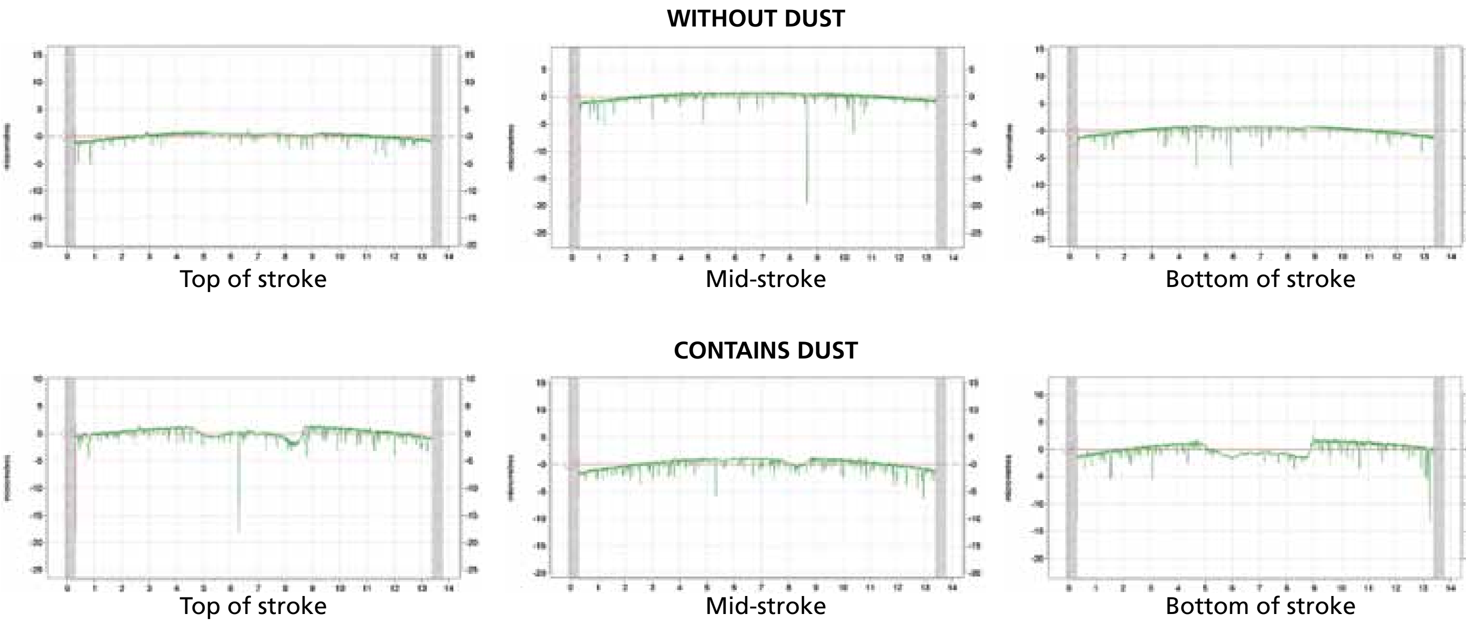
As a precursor to the findings, the team defined particle sizes most detrimental to engine wear. Typically, the most damaging particles are in the 1 to 125-micron range on the Krumbien phi scale, a scale commonly used to classify particle size distributions. For reference, clay is associated with a particle size of up to 3.9 microns, silt with the 31.25 to 62.5-micron range and very fine sand with the 62.5 to 125-micron range. These particles can pass between piston, rings and cylinder wall and eventually become suspended in the lubricating oil.

The roadside samples had a broad particle distribution of 100 to 1,000 microns. Conversely, wind-blown particles from higher elevations showed a tighter concentration of smaller particles, predominately in the 100-micron range. Tests also showed that an air filter effectively blocks particles larger than 100 microns. This is borne out by the fact that particles smaller than 100 microns were observed in the engine inlet tract. The roadside sample source had a mean particle size of 253 microns, higher elevation deposits 113 microns and vehicle deposits 136 microns. From these measurements, the team established that vehicle deposits are a combination of wind-blown and roadside particles.

The team concluded that dust does enter the engine compartment and that it is combination of lighter, windborne material and a fraction of roadside material thrown up by preceding vehicles. Further examination of the dust in the inlet tract, using optical and electron microscopy,

GAUGING EFFECTS OF DUST

Results of profilometry tests on engine oil with and without dust. Test measured profile of contact surface at both ends of apparatus motion and mid-stroke. Prolonged deviation from base line indicates wear.



Source: Lubrizol

indicated the presence of particles smaller than 100 microns, confirming earlier analysis that the air filter is less effective in preventing the ingress of smaller particles.

Furthermore, elemental analysis revealed the presence of high-hardness minerals in the dust, including traces of calcium carbonate, calcium oxide, calcium magnesium silicate, iron silicate and silica. These particles significantly increase the chances of engine wear. Ferrographic images made from sludge indicated the presence of sand in the range of 10 to 110 microns. Additional images of drain oil and filter oil samples found dust contaminants of 60 microns. Lubrizol says that dust particles in the 1- to 125-micron range are potentially the most detrimental, particularly when combined with the effects of the hardness of minerals found in the investigation.

Wearing on Engines

Having established that dust enters the engine compartment and beyond, the Lubrizol team sought to evaluate the wear impact through wear test profilometry and a reciprocating wear test. Profilometry test results in the absence of dust showed no significant wear. The surface profile was measured at ring reversal points and mid-stroke after two test runs. Conversely, profilometry results with dust present using similar parameters indicated significant wear.

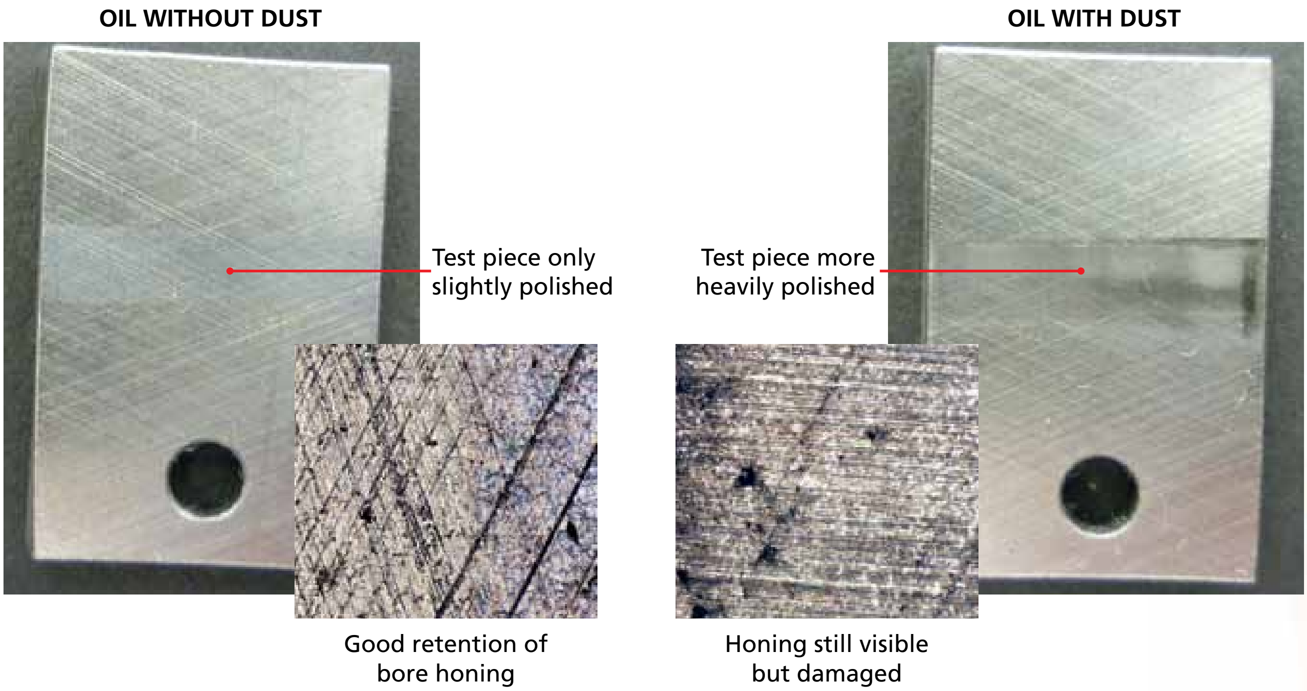
Lubrizol conducted an experiment using sections of cylinder liners from an industry test, CEC-L-101-08 OM501LA, which is part of the European Association of Automobile Manufacturers ACEA 2010 E engine oil sequences. The sections were placed on a rig with an oscillating arm and lubricated with a 15W-40 heavy-duty oil with and without the addition of silica to replicate the dust found in the field samples. Subsequent examination of the bore established that with no dust present, a slight polishing of the test piece was evident with good retention of the bore honing pattern. However, tests with dust present showed heavier polishing, a damaged though still visible honing pattern and still visible vertical scanning.

The tests conducted by Lubrizol confirm that dust ingestion increases wear, and excessive dust will likely lead to increased oil consumption, power loss and ultimately to engine failure. In arid desert conditions such as those found in the Middle East, dust will often get through the filter and into the engine. Air filters trap most of the particles that enter the engine, but inevitably some get through and into the oil.

Particle size measurements taken in bench tests confirm the presence of particles in the range known to cause engine wear. The hardness of the minerals present is also likely to cause a significant increase in wear potential. Lubrizol says the findings reinforce the recommendation that a good quality engine oil with

THE LOOK OF WEAR

In bore-liner test, a lubricated metal arm rubs back and forth across liner surface, which is then examined for wear.



Source: Lubrizol

enhanced wear protection is essential in desert conditions, and regular oil changes will minimize dust accumulation.

According to Wilkes, the study has clear implications for drain intervals. "The findings indicate that dust ingress is still a real issue in the Middle East and, likely, other desert climates." he said. "This is a separate issue from lubricant performance, which is specified by hardware manufacturers to meet the needs of the equipment and after-treatment systems".

"Ultimately, the issue of dust ingress may continue to limit oil drain extension in desert climate regions. This is true even for modern hardware that may have longer drain intervals with the same specification oils in less severe operating environments."

The Middle East has historically been dominated by engine oils made with API Group I base stocks, but advances in lubricant technology are edging the market toward higher quality Group II/III lubricants. This move has been prompted by OEM recommendations for the passenger car motor oil segment and faster replacement in the heavy-duty motor oil market as a result of a sustained regional economic boom. Regardless of oil quality improvements that are driven by the performance needs of modern vehicle hardware, Wilkes said, the study indicates that dust ingress remains a significant issue and so remains an important factor in the evolution of drain interval strategy. It must be considered by both OEMs and fleets operating under high dust conditions.

In fleet or industrial situations, several lubricant companies recommend oil testing as an effective safeguard to determine the origin of dust ingestion. They point out that in some cases the silicon in the lubricant may not be damaging because it can originate from seals or from the lubricant additive package, both of which they describe as harmless. Yet decreasing drain intervals poses something of a dilemma for larger operators because it carries major cost implications as they struggle to balance performance and maintenance considerations.

No Easy Solution

The findings of the Lubrizol study underline what many lubricant manufacturers have cautioned for some time – that arid conditions present a unique set of challenges for engine performance and durability. For now, the emphasis is on preventative maintenance as the best way to prevent engine wear. And the orthodoxy of shorter drain intervals is still valid. However, the question remains as to whether larger operators will implement these recommendations in the face of current base oil prices.

One thing is clear. The problem is not likely to diminish anytime soon. □