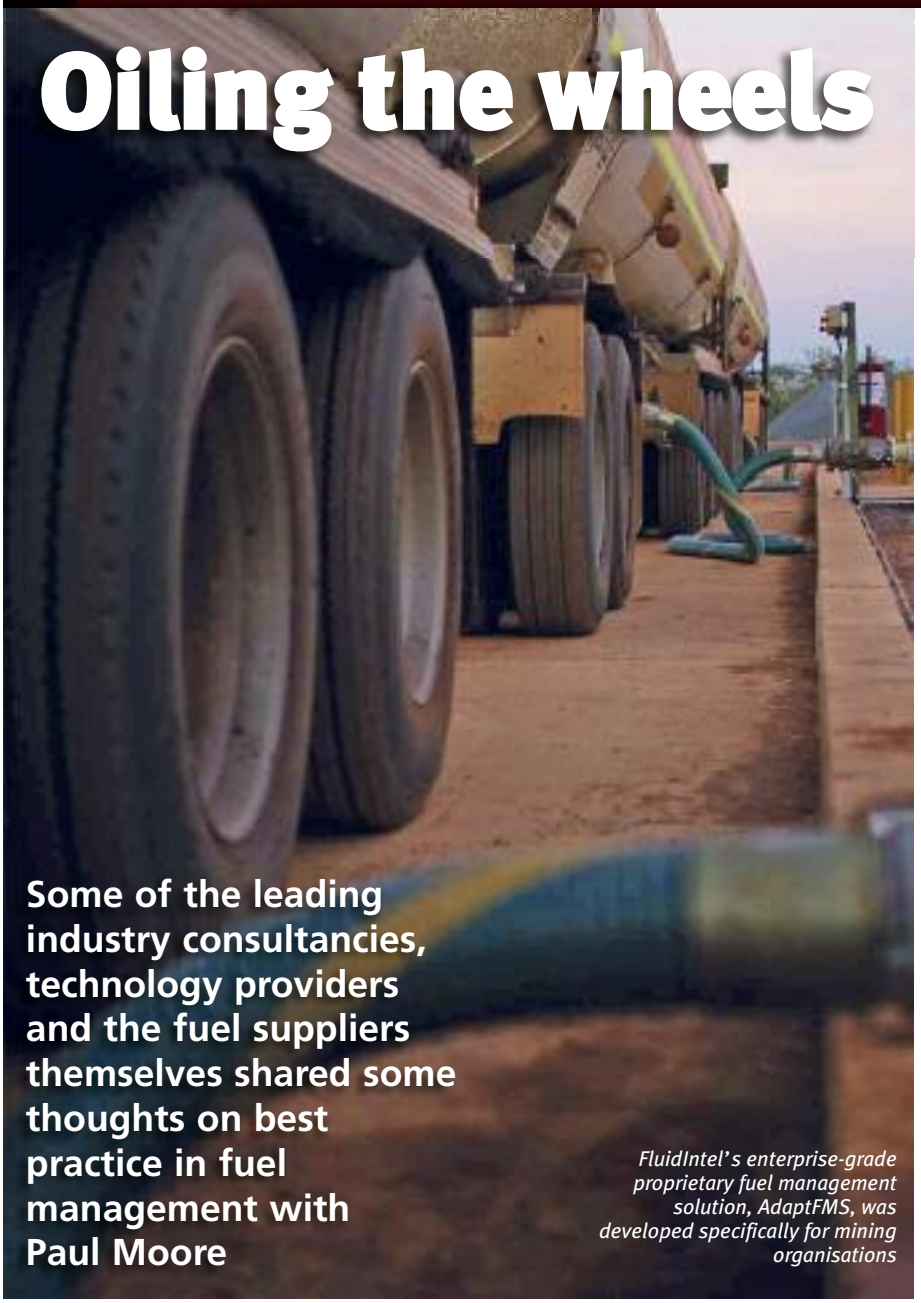
Oiling the wheels



Some of the leading industry consultancies, technology providers and the fuel suppliers themselves shared some thoughts on best practice in fuel management with Paul Moore

FluidIntel's enterprise-grade proprietary fuel management solution, AdaptFMS, was developed specifically for mining organisations

For nearly twenty years, **FluidIntel** has been helping the mining sector understand and optimise its hydrocarbon use. Its enterprise-grade proprietary fuel management solution, AdaptFMS, was developed specifically for mining organisations. It provides on-site hydrocarbon control and monitoring, and manages billions of litres of fuel across mine sites owned by seven of the world's ten largest mining companies. In preparing its new Best Practice Guide for Fuel Management in Mining, the company told ***IM*** it has leveraged its extensive experience in deploying and operating Adapt FMS in over 50 large scale mines, all over the world.

On the basics, Fluidintel states: "Establishing and maintaining a high performing Fuel Management System (FMS) requires careful consideration. While there are numerous technology options available, and various different ways to measure and manage your fuel usage, it's important to ensure you are investing in a solution that will deliver the best possible returns over its lifecycle." The company believes that when selecting a Fuel Management System, it's important to focus on three key principles:

- Integration: Does your FMS provide seamless integration between its hardware and software component to ensure you receive data effectively?
- Scalability and adaptability: Can your FMS adapt and scale to suit your specific needs and the size of your mine site(s)?
- Built for purpose: Is your FMS equipment specifically designed for the rugged nature of a mine site to ensure value and longevity?

An effective FMS (also known as a Hydrocarbon Management System) monitors fuels, lubricants, coolants and grease, or any other liquid that needs to be monitored and controlled. As such, effective fuel or hydrocarbon management requires seamless integration between its various hardware and software components. These components can include field instrumentation including level gauges and flow meters to monitor current inventory levels and the flow of inventory in and out of storage tanks.

It can also include vehicle identification devices fitted to vehicles to enable automatic identification. Some tags are available which also monitor operating and idle time between refuelling. Identification data is transmitted to the enterprise application to confirm dispense authorisations.

An HMI/controller provides a user interface for field operators to deliver, transfer and dispense fuel and lubricants. The controller also executes business logic such as authorisation rules based on equipment and user credentials, and aggregates and buffers data before synchronisation with a centralised application.

Enterprise application software allows data analytics and reporting while providing administration of permissions, authorisations, and reconciliation. The centralised application can also be used by external parties such as suppliers for Vendor Managed Inventory (VMI) if web enabled or operating as a SaaS solution.

The report adds, however: "To deliver unique and relevant insights, an effective FMS must be scalable and able to adapt to suit your particular mine site and supply chain. Your FMS may, for instance, simply monitor a small number of discrete fixed tanks and dispensing points. Or, it might manage a complete supply chain spaning bulk fuel deliveries from ships to large terminals, the scheduling and monitoring of fuel distribution via road or rail to sites, transfers within sites and the ultimate distribution to fuel-consuming assets from fixed locations or service trucks. If you operate a large, global enterprise, your FMS may even need to cover multiple sites and monitor your fuel use across a particular country, continent or the globe." To achieve maximum scalability and adaptability, Fluidintel says your FMS should:

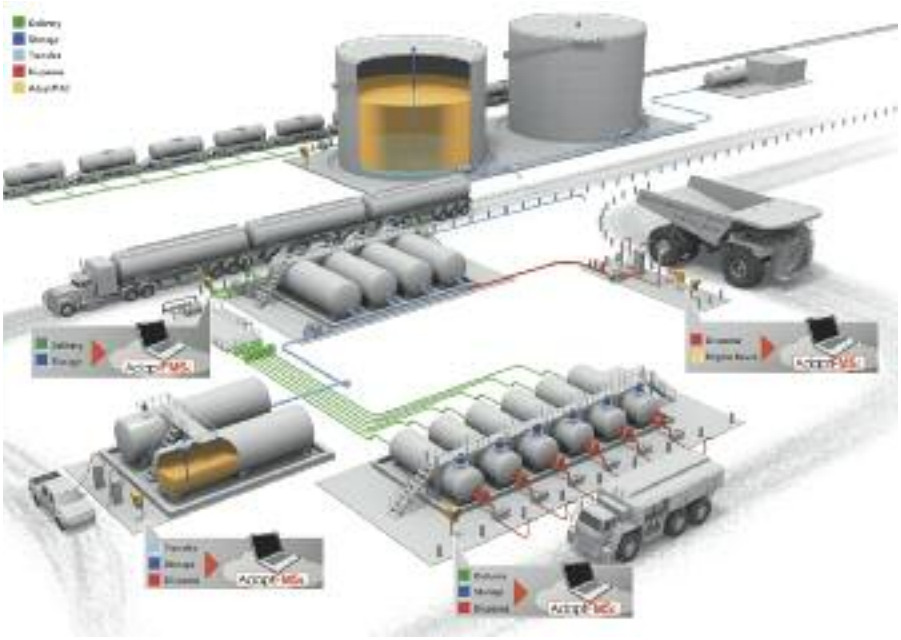
- Provide comprehensive fuel and oil management by monitoring and controlling deliveries, distribution, dispensing, transfers and storage from a central application.
- Utilise field measurement instruments and control hardware to capture transaction and inventory level data and push this to a central software application.
- Only dispense fuel and oils to authorised equipment items which are identified by a PIN or RFID tag (an additional layer of accountability could be added by requiring user authorisation at the dispensing or delivery point which is reported as part of the transaction record).
- Utilise a controller to authorise and record

transactions as products are delivered to storage tanks and dispensed to equipment. The controller should identify and authorise the equipment and may also capture engine hours or kilometres. It should be able to manage multiple metres from which volume data is received and perform multiple simultaneous delivery and dispensing transactions. The controller should also be able to interface with level gauges to provide tank volume and level

- data in the field and capture and record data.
- Be capable of monitoring lubricants and coolant products which, when effectively and accurately monitored, can provide equipment maintenance and performance insights.
- Be able to support several delivery/dispensing points across a site (note: a controller and a collection of metres connected to tanks is called a delivery/dispensing point). Service (or lube) trucks are both tanks and dispensing points with their own controller monitoring all meters on the truck. All transactions should be sent to the enterprise software and monitoring application, which can collect, aggregate, export and display the data in a variety of ways to the user, and provide alerts and alarms as required.
- Provide all of this information via an interface for operators in the field, including delivery drivers, operators, or service technicians. This interface should support workflows and procedures that ensure safety, good environmental stewardship and accurate data collection. It should also ensure the correct products go to the equipment, load plans and deliveries as scheduled, with minimal errors and omissions.

However, the report also has a note of caution on meeting the uniquely harsh minesite conditions in terms of hardware. “Regretfully, too many mines have implemented an FMS adapted from, say, air transport, only to find that the equipment has a very short life in harsh mine site conditions. Ensuring all hardware deployed is fit for purpose for mining is essential to ensure value and longevity. It’s important to remember that creating hardware that is rugged enough for the mining industry does add additional costs. However, it also means reduced servicing and downtime. If your equipment is offline, you will be losing valuable data and the effectiveness of your FMS could be compromised.

Considerations for suitable hardware include temperature as to operate effectively, the FMS should have an operating temperature range of -40 to +70°C. “Be mindful that, in many cases, the conditions that the internal components will be subjected to will be far higher than ambient.”



A Fluidintel FMS can operate across an entire mining network or site

Water ingress is also a risk, particularly on controllers mounted on service trucks. “Look for devices that exceed IP66 which tests with strong jets of water. Note that a higher IP rating does not necessary mean better protection. For example, IP67 tests for submersion can in some instances be less relevant than water jet tests, and not as applicable in the mining and rail environments as IP66.

Service trucks can be subject to high levels of vibration, particularly as they may travel on haul roads that are far harsher than the highway conditions some controllers are designed for. “Additionally, there are often additional pumps and sources of vibration on the equipment which can contribute to the challenge. Look for MIL spec 810G or similar.”

On vehicle installations, electrical robustness can be notoriously difficult. “Ensure the hardware you choose is specifically designed to allow for this. In fixed locations, challenges can also exist with unreliable power, generators, and solar systems. Is your controller designed for these conditions, or would it be better suited to a service station environment? Do you have effective backup power to ensure data validity and safety?”

There are new controllers coming to market with touchscreens to take advantage of the more sophisticated user interface that can be provided. Many are not rugged enough for the mining environment. “For example, resistive touchscreens can be damaged easily, many touch screens are not damage resistant, and screens are commonly not bright enough for effective daylight use. A screen should have 1,000 nits of brightness – yet 350-400 nits is common amongst poorer quality equipment. Look for rugged touchscreens that can withstand impacts.”

Serviceability is also key. “In a mining environment, failures can occur and it is critical to get back online quickly. An effective FMS will have a modular design that allows speedy rectification and replacement when faults are identified.

Banlaw’s take on predictive maintenance

João Silveirinha is **Banlaw’s** Group Engineering & Development Manager, and recently gave a paper covering predictive maintenance and optimising the life of assets through Unified Fuel Management.

In it he states: “Scheduled hydrocarbon fluid sampling provides the insight to stay ahead of problems. Laboratory analysis, data interpretation, and then quickly taking action are the most critical part. Interpretation of contaminants and fluid composition can give us up-front information on wear rate of the equipment. Condition monitoring of filters and auxiliary equipment further reduces the vectors where contamination is introduced.”

Real time data acquisition methods are of extreme importance, and software reporting of abnormal equipment fuel consumption. The idea is identification and action based on symptoms rather than problems, and these are some of the tools that we use to help our customers. With regards to preventative maintenance, this process becomes an additional layer of asset protection. Advice is often provided by the OEM as well, to support planning for a specific machine type.

Banlaw's João Silveirinha, Group Engineering & Development Manager

"Executing a preventative maintenance plan can be a complex task, requiring a multi-skilled workforce. Some of the key aspects are having a strategy in place; monitoring the process for continuous improvement purposes; real-time and reliable data acquisition and availability; scheduled maintenance which leads to safe operation of your assets (such as a haul truck, or a complex process area like a fuel farm for example); and limitation of the risks you accept (skipping routine predictive and preventative activities can lead to warranty claims, which may not be covered by OEMs or your insurances."

Silveirinha describes the Unified Fuel Management philosophy as a powerful tool. This method provides guidance and helps companies set key requirements and have full control in the asset life-cycle; including the hydrocarbons involved, from buy to burn.

First, overfill protection systems can be used in multiple markets like rail or mining heavy equipment, as well as bulk storages. These systems help maintain the integrity of the equipment by preventing over pressurisation of fuel tanks, preventing spills (and contamination from overfill events), and increasing refuelling efficiency as well. There are electrical and hydraulic powered versions available. The hydraulically powered version from Banlaw offers flowrates of up to 1,000 lpm (264 gpm), and the electrically powered version has no limitations with regards to flowrate.

By optimising the achievable flowrate when refuelling plant and equipment, you will increase the productivity of equipment and utilisation of refuelling infrastructure. This can be achieved at fixed refuelling facilities and also with mobile service vehicles.

Contamination continues to be one of the most serious issues in fuel consuming industries such as mining and rail. "Unfortunately, it's not sufficient to simply invest in your fuel filtration infrastructure at incoming or dispensing points in the fuel farm. Having a full operational analysis done of your fluid management equipment and processes will help maintenance and operations to increase asset reliability."

He adds: "We try to prevent these contaminants from reaching the fuel injectors on the machines. It can become very expensive to fix a breakdown which has been due to water in the diesel supply." Contamination can take multiple machines offline in rapid succession. Some examples of contamination control techniques include:

- Installation of filtration systems
- Flush faced and colour-coded fluid couplings with a single fluid type assigned to each colour (this will prevent contamination and cross contamination).
- Water detection in bulk tanks by use of tank level monitoring systems
- Filtered breathers on tanks, bulk storages as well as the reservoirs on vehicles for fuels and other fluids as a mine site can be an extremely dusty environment

Fuel security is also important. Leveraging a fuel management system can ensure that only the correct fluid is dispensed to the correct vehicle, in the correct amount. The fact that only authorised machines receive fluids, can enable fluid reconciliation rates in excess of 99.5%. This level of control satisfies tax office requirements and also the levels of environmental compliance required of modern heavy industries. Appropriate fuel management helps ensure contamination control and responsible operations practices.

On environmental accountability, having a reporting system enables companies to issue hydrocarbon accountability reports. ERP accountability means the integration of information across multiple departments, and it can also be one of the most challenging tasks. "When we are talking about a company which may have many hundreds of people working across multiple sites, this becomes a real key enabler of the business if successfully achieved."

Onsite Asset Management is the end goal, and how to implement a safe operation. The first aspect of this is performing a requirements review. What are the requirements? Regulatory and regional standards exist to provide direction on how to increase asset lifetime.

Some examples of techniques and methods applied to fuel farm design and operation that help increase asset life are:

- Proper requirements analysis
- Performance of HAZOPS (to identify risk to equipment and people)
- Planning with contribution from maintenance and operations
- Implementation of safety instrumented systems for emergency stop circuits and overfill protection
- Leveraging standards like the Australian Standard 61511 (functional safety)

The Banlaw Unified Fuel Management concept

- Design of systems to meet requirements under AS 60079 (explosive atmospheres)

Having the right expert support is important for operations. "Nobody can have a local specialist in every related field on the payroll. Organisations such as Banlaw are often valued the most for their design support, helpdesk, system health checks, site audits, software integration...all that specialist expertise, that when you need it, you need the advice to be right. Access to specialised support keeps an operation moving forward, finding improvements, and innovating year after year."

The author gave a quick example from one organisation Banlaw works with. "They have a significant fleet of haul trucks and diggers. Together we chose to zero-in on fuel usage exception reporting at a machine level to improve fleet management. The report compares fuel consumption of vehicles which have been classified into the same class, and identifies which vehicles are consuming fuels at above predefined thresholds. This predictive maintenance trigger leads to preventative maintenance activities in a very targeted way. This international mining group has been able to achieve very significant reductions in their cost per wet tonne (cwt) of product, through targeting outlier machines identified with predictive reporting approaches, then taking appropriate action before a problem occurs."

Silveirinha concludes: "At the end of the day it is up to management to define strategies and policies which will set the framework for Maintenance Management Systems. If management provides the right support to maintenance and operations teams; then they will achieve the incremental improvements, which distance innovative organisations from their peers." Banlaw's Predictive Maintenance and Preventative Maintenance checklist in summary format is as follows:

- Maintenance Management System
- Establish requirements and OEM Specifications
- Accuracy of data captured
- Asset Life Cycle Management
- Use leading planning and 'real time' monitoring tools for predictive maintenance
- Apply preventive maintenance measures to help maintain requirements
- Perform condition monitoring and rapidly take action if required
- Avoid delays and be flexible
- Fuel and Fluids Management
- Evaluate implemented systems and perform continuous improvement activities on the Maintenance Management System itself
- Controlled Maintenance plans leads to increased efficiency, productivity and reduction of downtime

TOTAL Excellium diesel fuel does not increase the combustion efficiency of the fuel during the combustion process but rather prevents (and even reduces) the formation of carbonaceous deposits at the injector nozzle tip which in turn helps optimise the combustion process

Total practical tips for oils and fuels on-site

Total's mining specialists put together six practical tips for mining companies to make savings on mine sites for oils and five ways to reduce fuel costs at a mine site. Total Mining Solutions supplies fuel, lubricants and associated services to over 200 mining sites in over 40 countries.

"A core fundamental of oil management is to rationalise the number of lubricants and lubricant packaging. The Total mining team has observed that this can result in savings up to 17% of your total oil cost. This is done through savings in physical inventories, costs associated with handling, spoilage, theft, storage space and stock obsolescence. Quite often we find two or three oils covering similar applications, with slightly different specifications or pack sizes. One way in which Total can help is to go through your oil range at site and select the most appropriate product to cover as many applications as possible. For example, Total has developed the TP Star Max lubricant which is suitable for engine, hydraulic and transmission systems thus reducing the need to store three different oils on site whilst still meeting the required OEM specifications."

Another way is to standardise oil packaging wherever possible. "Do you really need the same product in pails, drums, Intermediate Bulk Containers (IBCs) and bulk? Too many options can result in increased costs and duplication of effort. A thorough look at where and how each pack size is being used and dispensed will allow you to reduce the number of disposable packs. Not only will you simplify your ordering processes, but you will also free up valuable storage space and reduce your cost of working capital."

Total argues that contamination control is often overlooked when considering why premature failure occurred or why oil life has been diminished. The two primary contaminants in oil are dirt (environmental dust) and moisture. When oil is contaminated, it accelerates wear which can result in early breakdown, thus leading to significant increase of the operating cost. Thus, maintaining clean oil is a key investment initiative for mining companies. Total suggests using contamination control techniques such as desiccant breathers on bulk and intermediate containers as well as filtration on bulk fluid dispensing. The use of filtration on fluid dispensing on IBC and drums can also be applied. The benefits of sound contamination control in lubricants will extend the life of lubricated equipment and reduce overall maintenance costs.

Oil analysis is an increasingly used tool. "The aim of oil analysis is to get a snap shot of the condition of both the lubricant and the equipment at a point in time. Used over a period of time, used oil analysis allows predictive maintenance which helps you to know when to plan your maintenance operations at the optimal moment. It also allows you to optimize your oil change frequency, to avoid costly emergency repairs, and to increase lifespan of your machines." For example TOTAL ANAC Laboratories perform over 200,000 diagnostics each year for mining companies and other automotive and industrial customers. All that is required is to collect the oil sample at regular intervals (without having to stop the machine) and send it to Total's oil analysis laboratory using the ANAC analysis kit. ANAC automatically sends a full comprehensive report via email with the analysis of the sample. This report can also be viewed over the internet.

When a 205 litre container or a 1,000 litre container (IBC) has reached the end of its product shelf life, its use can have detrimental effects on mining equipment. "The product should be discarded which comes with increased cost. This can be attributed to the term obsolescence cost and it occurs when proper storage practices are not in place. Total suggests a First-In-First-Out (FIFO) approach to storage of oils on mining sites. Improving overall warehouse management of stored products as well as a FIFO approach to product storage will help reduce these obsolescence costs. Total's site facility audit can help identify areas of improvement."

Finally, Total employs oil specialists to assist Total's clients in identifying areas of improvement that contribute to cost saving initiatives. For example, replacing just one lubricant with another can contribute to the reduction of many different types of costs. These may include purchasing cost, maintenance cost, energy cost, fuel cost, and waste oil cost.

Moving on to fuels, Total states: "the most obvious way to cut costs on fuel is to look for price reductions, but with the competitive nature of supplying to mines there is most probably very little margin left to squeeze out of the suppliers. There have also been some exciting technological advances in recent years with fuel economy improvements being realized through improved engine design, turbo chargers, Electronic Fuel Injection etc. Assuming that you have the best price you can get from the suppliers and the most economical equipment for your site, there are few other areas you can look at to reduce fuel costs and fuel consumption in your mining operations."

The development and shift to lighter grade SAE 10w30, and SAE 5w30 oils in favour of SAE 15w40 grade engines oils plays a significant role in reducing fuel consumption. The lower viscosity oil effectively means reduced friction under hydrodynamic conditions within the engine. Less friction means less fuel consumption.

"TOTAL's range of FE lubricants play an essential role in reducing the operating fuel costs for mining companies by utilising specific viscosity grades and specially enhanced additives designed to minimise the friction responsible for 10-15% of energy loss within an engine and drive train compartments."

High quality, high Viscosity Index (VI), multi-grade hydraulic fluids work by reducing hydraulic leakage of the hydraulic pump through the broader operating temperature range. This means that at higher operating temperatures the viscosity of the lubricant is not as thin when compared to a lower VI mono grade hydraulic oil of similar viscosity. This equates to less engine power needed, (and less fuel), to deliver the required fluid power to the working parts of the hydraulic system under operating conditions. Following similar principles, higher equipment productivity is also realised.

Shell Lubricants states that achieving extended oil drain intervals, for example, is one way that customers can realise cost savings almost as soon as they upgrade their lubrication

Particulate contamination of diesel fuel due to in-efficient housekeeping practices has the propensity to reduce filter life, diminish fuel life and cause component failures. "The unwanted particulates in diesel fuel can serve to increase fuel pump wear. In addition, due to the high fuel pressures, these particulates can act as a projectile within the fuel system leading to increased injector nozzle wear and reduced combustion efficiency, which in turn results in increased fuel consumption. Improvements in fuel cleanliness will also improve fuel pump and injector life (reduced maintenance costs)."

Many diesel fuel researchers conclude that there is benefit from the use of chemical related supplementary fuel additives. "TOTAL Excellium diesel fuel does not increase the combustion efficiency of the fuel during the combustion process but rather prevents (and even reduces) the formation of carbonaceous deposits at the injector nozzle tip which in turn helps optimise the combustion process. This is where fuel savings are then realised. TOTAL Excellium diesel fuel enables optimum performance of the combustion process within the engine to be sustained."

There are other energy and cost reduction projects to consider the likes of which include but not limited to:

- Periodic bench mark testing or requests for tenders from fuel suppliers
- Lubricant rationalisation programs and consideration to reducing inventory levels
- Use of a Fuel Management System to help identify in-appropriate use of diesel fuel on site
- As your supplier to perform oil drains extention programmes
- Use energy efficient lubricants

Shell's view on lubricants Total Cost of Ownership

Mining companies are significantly undervaluing the potential savings from effective lubrication, according to a recent study by **Shell Lubricants**. While 60% of companies recognise they could reduce costs by 5% or more, fewer than 10% realise that the impact of lubricants could be up to six times greater. For the mining industry in North America alone, this could mean potential savings in excess of $29.1 million.

The Shell Lubricants sponsored research found that 96% of mining companies report experiencing unplanned equipment shutdowns in the last three years, with over half (56%) acknowledging this is due to their incorrect selection or management of lubricants. This is having a direct financial impact, at a time when cost competitiveness is a priority for mining companies.

The international study of mining companies across Asia, Europe and the Americas commissioned by Shell Lubricants reveals that many businesses do not realise that some of their critical operational factors can be significantly influenced by how lubricants are managed. For example, less than half realise that lubrication can influence unplanned down time, and 64% are not clear about how extended oil drain intervals can generate cost savings.

Renée Power, the Shell Global Sector Manager for Mining, said; "40% of the companies we surveyed estimated that they had incurred costs of at least $250,000 over the last three years from breakdowns due to ineffective lubrication. This shows potential for companies to achieve a significant boost to profits by working closely with a supplier like Shell Lubricants to improve equipment lubrication practices."

However, with maintenance managers facing budget and time constraints, and only 34% of businesses making use of regular visits from their lubricant supplier's technical staff, most are not well equipped to take action. The study revealed that only 41% of companies have all the recommended procedures in place to manage lubricants effectively and 59% recognise they don't conduct staff training on lubricants as regularly as they should. Misconceptions about lubricants are also evident, with 44% believing

that all lubricants and greases provide the same level of performance.

Power commented; "The impact of lubrication on Total Cost of Ownership is too often underestimated. Almost half of companies surveyed wouldn't expect to see a reduction in maintenance costs resulting from lubrication, but we have helped deliver over $44 million in savings to mining companies over the last five years. Longstanding experience in the mining sector enables Shell Lubricants to identify potential opportunities for lubrication to deliver significant business value. We work closely with customers to help them reduce operating costs and enhance equipment productivity by looking after the lubrication needs of their machinery – not just selecting the right product, but providing guidance so that it can be properly managed."

Power adds: "We are very aware that companies are under pressure to limit costs and often looking for immediate results. Achieving extended oil drain intervals, for example, is one way that customers can realise cost savings almost as soon as they upgrade their lubrication. As the oil or grease lasts longer, less frequent re-greasing or oil changes are required, helping reduce overall cost of lubrication."

Shell Lubricants has released a whitepaper to address some of these issues, and set out how profits can be gained by effective lubrication practices, firstly by selecting the right lubricant or grease for each application and, secondly, effectively managing the on-going use and application of the lubricant. Looking at mining engines, for example, the report states: "Effective engine lubrication is critical to protect high-cost equipment, and minimise downtime due to frequent oil changes, maintenance or

even component failures." For example, viscosity control in extreme conditions is important. "Engine wear as a result of metal-to-metal contact can occur at low speeds, high loads, or cold starts. The lubricant helps keep moving parts separated to avoid wear. At engine start-up, particularly in cold climates, the oil must remain thin enough to circulate quickly to protect critical components. Once the engine is operating under full load, the oil needs to remain thick enough and provide the necessary protection to help prevent abrasive wear."

Accumulation of soot in the engine can lead to oil thickening and abrasive wear. This is a particular challenge in underground mines, at high altitude, and when exhaust gas recirculation (EGR) is applied as an after-treatment system. Extended periods operating at idle load makes an engine particularly susceptible to higher rates of soot generation. The use of API CJ-4 lubricants has been found to help

reduce the impact of soot accumulation. Further performance increases are expected with the implementation of API CK-4 engine oils.

Gases and acids are generated as a natural by-product of the combustion process. The lubricant neutralises these acids to help avoid corrosion. This is particularly important in engines with Babbit-based plain bearings, which can be very susceptible to acid attack.

Lastly, oxidation, soot accumulation and oil thickening, and the build-up of acids in the lubricant all contribute to oil aging. "High quality synthetic engine oils with the right base oil and additive technology, including anti-oxidant additives can maintain performance characteristics for longer in the presence of contaminants and by-products."

Shell Spirax S6 CXME 5W-30 is recommended for use in heavy duty off-highway equipment. It is designed for long oil life with excellent oxidation stability. It is formulated with a premium synthetic base oil, contains inhibitors to reduce oxidation and deposit formation, and is designed to protect against corrosion. "All other factors remaining equal, longer oil life would extend oil drain intervals, helping reduce equipment downtime and, therefore, cost of maintenance."

Petro-Canada lubricant developments

Petro-Canada Lubricants earlier this year introduced its DURON™ next generation line of heavy duty diesel engine oils to the European market, delivering a 'next level' of durability and performance in the commercial lubricants sector. The product line is sold in three performance tiers: DURON HP (High Performance); DURON SHP (Super High Performance); and DURON UHP (Ultra High Performance). Formulated using leading-edge lubricant technology to combine the best additives with some of the purest base oils, DURON next generation has been engineered to maximise fuel economy without sacrificing engine protection, even in the harshest environments. "Petro-Canada Lubricants prides itself on delivering on its commitment to 'toughness' and has set a new bar of excellence for itself in developing DURON™ next generation," said Tony Weatherill, Global Marketing Director, Automotive and Transportation, Petro-Canada Lubricants. "The product line is our toughest yet; rigorous testing has put it through its paces to ensure that it is not only meeting the strictest global regulations, but also meets our customers' needs for better fuel economy, extended drainage intervals and reduced vehicle downtime. Utilising the very best of our world-class technology, DURON™ next generation delivers all this without compromising on durability, strength or efficiency,".

A big change in the industrial oils market has been the launch by the American Petroleum Institute (API) of two new diesel specifications in 2016. Both specifications aim to provide very good engine protection for heavy duty engines and help them meet the American environmental regulations starting from 2017. API CK-4 effectively replaces API CJ-4 and is backward compatible with most applications where currently an API CJ-4 oil is recommended. It requires more from the oils in terms of shear stabilty, oxidation resistance and aeration control than its predecessor. Brian Humphrey, OEM Technical Liaison at Petro-Canada Lubricants told ***IM***: "The heavy loads experienced by mining equipment on a daily basis put engines under strains that can stress conventional lubricants; leading not only to engine wear, but even failure. In any mining operation, downtime costs are destructive, so using a quality lubricant to protect your engines is crucial. In comparison to their predecessors, API CK-4 oils are more robust and resistant to oxidation. This has become necessary in recent years as newer engines are designed to run at a higher temperature, in order to improve operating efficiency. Higher temperatures accelerate the rate of oxidation and oil thickening, increasing oil viscosity and can lead to deposit formation. The result is that the oil degrades and its ability to flow is reduced, thus decreasing engine protection and negatively impacting engine fuel efficiency. The new category oils are of particular relevance to mining fleet operators, as they are designed to improve resistance to aeration and increased shear stability. The importance of improved aeration control in off-road engines cannot be overstated, where a high-level of air entrainment is dangerous, particularly at the bearings where maintaining a suitable oil film is critical to protect them. To summarise, the new and improved design of API CK-4 oils provides enhanced performance and offers greater hardware protection."

ExxonMobil helps gold mine achieve savings

In a practical example of the impact of lubricant strategies, ExxonMobil has helped a gold mine in the US save more than $1.1 million by switching to its premium hydraulic oil, Mobil DTE 10 Excel™ 46. The lubricant helped optimise the performance of two 250 t capacity Terex O&K (now part of Caterpillar) excavators, helping to boost productivity, save fuel and enhance safety.

The mine operator previously used a conventional hydraulic oil on the two Terex O&K RH340 hydraulic excavators. But frequent failures due to cavitation damage and the effects caused by seasonal temperature swings meant the company had to replace 52 main hydraulic pumps at $54,000 each over a 40-month period.

ExxonMobil field engineers partnered with the mine in California to identify a lubrication solution capable of mitigating equipment failure

The containerised system and in use at a minesite

and cutting costs. The team recommended transitioning to Mobil DTE 10 Excel™ 46 premium hydraulic oil.

Formulated with a proprietary additive system, the oil's high viscosity index and strong shear stability means it offers wide temperature range performance and can help optimise machinery operating in the toughest of conditions. The mine operator reported that Mobil DTE 10 Excel™ 46 helped eliminate oil-related hydraulic pump failure. This helped improve productivity, while enhancing safety as 160 hours of human-machine interaction were eliminated as a result. Additionally, the lubricant helped reduce fuel consumption by 21,450 gallons, lowering CO_2 emissions by 216 t. These improvements helped generate a company estimated annual cost saving of more than $1.1 million.

"This is a great example of how a relatively small investment in a high performance lubricant can deliver significant productivity and financial gains," said Mohamed Mourad, Industrial Marketing Advisor at ExxonMobil. "It's also important to recognise the safety benefits – a top priority for all mine site operators. We're delighted that our field engineers could help our customer optimise the performance of their machinery and improve their bottom line."

Reducing contamination in oils

In trials, and commercial installations, **Hy-Pro Filtration** elements have proven to last longer and be more efficient at removing particulate contamination. Today's oil suppliers are often required to provide fluid at or below a specified ISO Cleanliness Code to the mining industry. One such supplier was experiencing short filter element life (15 days) on the system (7 element multi-round housing) used to achieve the required ISO Cleanliness Code of 18/16/13 in a single pass as 15W-40 oil is transferred from their bulk storage tanks to tanker trucks for delivery. A Hy-Pro DFE rated G8 Dualglass element lasted six times longer (90 days) than the Brand X element (15 days). The Brand X element cleaned the fluid to the required code of 18/16/13 but the Hy-Pro element exceeded requirements by dropping the ISO code to 12/10/7.

In May 2017, Hy-Pro Filtration was acquired by Donaldson Company, bringing together two global leaders in the filtration industry. "Hy-Pro and Donaldson have been on similar trajectories in the hydraulic, lube and fuel industries, providing innovative contamination control solutions and making industry more efficient, both operationally and environmentally, through improved reliability. Hy-Pro will continue to operate independently under the Hy-Pro Filtration brand and leadership of Aaron Hoeg, as its General Manager. "We are excited to support Hy-Pro's dedicated team and valued customers," said Tom Scalf, Donaldson's Senior Vice President of Engine Products. "Hy-Pro's application expertise and filtration products improve the reliability and cost-effectiveness of their customers' systems, often by extending the life of critical equipment and expensive fluids. Hy-Pro will continue to grow its well-known brand of stationary hydraulic and lubrication systems by leveraging Donaldson's filtration technology, global support and strength in mobile hydraulics."

Latest on robotic refuelling

The Robofuel system from **Scott Automation & Robotics** uses a robotic arm to enable safe automated refuelling of mining equipment whist improving asset utilisation and reducing mine-site operating costs.

Steve Russell, Global Business Development – Mining told ***IM***: "For truck, excavator and other heavy vehicle fleets, assets currently need to be taken offline for refuelling activities. Significant time may be attributable to driving vehicles to maintenance workshops or fuel farms for periodic replenishment, and as mining operations evolve the off-circuit travel distances typically increase. Refuel facilities are either manned by at least one technician at all times or may utilise the driver for filling activities at smaller operations. As there is no manning required for an automated solution, refuelling stations are able to be placed on-circuit or even in-pit so fleet productivity can be significantly enhanced. The time and administrative controls required to safely isolate and interact with the stationary truck are optimised, and the driver receives complete feedback of the filling progress from the safety of the vehicle cabin."

The Robofuel system uses a state-of-the-art vision sensing and detection system, allowing the robot to locate the precise position and orientation of the truck's fuel tank. Fuel spillages are minimised through controlled coupling, pumping and monitoring mitigating the risk of environmental contamination.

Russell says that Robofuel has been successfully deployed across several sites, including the world's first in-pit automated refuel system in Australia in 2016, and retrofitting into several existing fuel bays and fuel farms. Ongoing development of the Robofuel technology is increasing the range of applications beyond mining truck fleets. As sites embrace Autonomous Haulage Systems the benefits in safety and productivity are even further enhanced.

HULK has mining potential

Australia's **FES TANKS** in its search for a better fuel distribution solution for remote sites, including early stage mining projects, as part of a collaboration, has developed the Hydraulic Un-Loading Kit (HULK), an optional self-loading system grafted onto a bulk self bunded tank. It offers a complete self-sufficient relocatable bulk fuel storage solution. Mining and construction sites in outback Australia present certain challenges, like a distinct lack of infrastructure and logistics that other locations take for granted. It was this challenge that prompted Diamantina Shire Council in Queensland to come up with the concept of a self-loading fuel storage system that would improve logistics, reduce costs and streamline the council's remote refuelling operations. They appointed Cairns based Nqpetro, a specialist fuel fit-out company to help bring their concept to life and Nqpetro appointed FES TANKS.

"They were using older style portable above-ground tanks and were continually having to move them, which posed a threat to the integrity of the tanks and a potential environmental and safety risk," FES Business Development Manager Daniel Porter says. "They sometimes had three tanks on the back of a semi-trailer, chained to the tray. Theft was a problem too, because there were only certain ways you could lock the tanks. The previous fuel distribution systems were also very basic with no filtration and a 240V pump that was hooked up to extension leads. Anyone

The FES TANKS team came up with a self-bunded, high quality 28,000 litre FES Grande tank on hydraulic legs

wanting to steal fuel could rock up after hours, plug in their power source and take as much as they wanted."

The FES team came up with a self-bunded, high quality 28,000 litre FES Grande tank. With its in-built hydraulic legs engaged it allows the truck to simply drive away while the tank lowers itself into position. The system makes it easy to position and relocate tanks at remote sites without the cost or logistical issues associated with a crane lift. It means the council, and potential mining customers, can more securely and safely carry high volumes in a single self-bunded tank, virtually eliminating the risk of fuel leaks due to structural breaches.

The HULK also dramatically reduces opportunities for theft, with the pump contained inside a lockable door, with a separate lockable isolation switch. The pump has 24V and 12V options so it can be battery powered in case of power failures. "Basically, it means they can go easily to more remote sites with a bigger volume of fuel storage and enhanced safety, portability and efficiency," Porter explains. "As part of the engineering process we built in additional capacity too, so if they wanted to we could use the system on even our Grande 68,000 litre tanks."

FES TANKS specialises in self-bunded tanks: "Self-bunded tanks are an increasingly popular solution that eliminates the need for expensive and inflexible external bunding work and dramatically improves the probability of being able to recover your fuel in a useable condition. Checking and maintaining tanks regularly can also save you big dollars in the long run.

When the bottom line is critical, every drop counts, which is why many mines have achieved major savings through measures as simple as reducing idling time and unnecessary stopping. The condition of haulage routes is another a key factor in fuel consumption, with dry and hard-packed roads offering the best fuel economy. Research shows for a mining operation moving 20 Mt over a set haulage path, wet conditions will increase diesel use by 820,000 litres. Tracking fuel consumption and finding out early about any discrepancies or fuel theft can save huge potential losses."

Ground Force raising the bar on mobile fuel and lube solutions

Ground Force Worldwide is well known for its fuel and lube truck solutions for mining as one of only a few global specialists in this area. The company had already supplied the world's largest fuel and lube truck, which is based on a Cat 789 chassis with options up to 70,000+ gallon capacity. Variants on different 789 trucks, including B, C and D chassis have been delivered to a number of sites including Newmont's Carlin gold operations and the Arch Coal Black Thunder coal mine. These machines however have now been supplanted by two 793 chassis-based fuel and lube trucks that have just been completed for a major Brazilian mining company. Aside from these record breakers, there is a lot of business is in smaller rigid trucks, such as 777, 785 and other Cat models, with the capability to also retrofit Komatsu and other chassis. These fuel and lube trucks service not only haul trucks but also wheel loaders, excavators and other equipment; but in general the size of the main haul trucks in the fleet dictate the mobile fuel truck size needed.

Moving down the capacity scale, Ground Force articulated fuel and lube trucks are engineered for increased manoeuverability in rugged off-road terrain and again have been built on a variety of ADT capacity and brand chassis. "We offer many configurations and custom features as well as heated and enclosed fuel and lube trucks for extreme and cold weather applications. Designed with a low centre of gravity and safety features such as roll-over protection, the Ground Force articulated fuel and lube trucks are proven in the most extreme terrain. Ground Force Worldwide is the world leader in articulated fuel and lube trucks, with over 250 trucks in mines across the world today."

The increasing popularity of mobile fuel and lube trucks, and especially larger models, in today's market, is based on the industry trend of utilising existing assets as far as possible. In some cases, mines have parked older trucks for a long time, and it is more economic to convert one of them to a fuel and lube hauler than to leave it as an un-utilised standard haul truck. Also, there are situations where mines have bought a new truck fleet and are able to use older and otherwise wasted trucks in this way. Mobile fuel and lube trucks also offer greater flexibility for mines that cover a large area with multiple pits, and as the industry is focussed on expanding existing mines rather than opening new ones, again these mobile fuel options come into play. Ground Force also supplies customised truck bodies, and says there are cases where its truck bodies have increased productivity to the extent where a standard truck can be taken out of the fleet and converted to a fuel hauler.

Each mobile fuel and lube truck is highly customised to the individual mine with filtration systems for mines that have to cope with fuel quality variation; open or closed options for tanks depending on climate, with enclosed

The Ground Force 789 FLT shown here has now been surpassed in size by two 793 FLTs bound for Brazil

versions widely used in Arctic mines. Lube options can include special engine oils, greases, antifreeze and other products. Operators can access everything they need at ground level, including the computer system to start the flow of fluids, as well as all the hoses and pumps.

The other major news at the company is its first dual LNG and diesel fuel truck solution for a mining customer in Florida. This is based on a standard off the road truck but rigid and ADT designs are already in place. With the increasing use of LNG/diesel hybrid retrofit solutions on haul trucks, and the fact that the big rigid truck OEMs are working on designs for new LNG or LNG-diesel hybrid-based haulers, corresponding demand for LNG supply trucks to fuel them in the pit is also set to increase. For the Florida example, Ground Force worked closely with the LNG vendor, Chart Industries. ***IM***