External use / September 2011

A HYDRAULIC LUBRICANT FOR ALL ARCTIC SEASONS

Shell Lubricants

DESIGNED TO MEET CHALLENGES

TO HELP KEEP A KEY CUSTOMER'S GIANT EXCAVATORS OPERATING 24-HOURS-A-DAY, YEAR ROUND AT TEMPERATURES FROM -50°C TO 75°C, SHELL COMBINED PHYSICS, CHEMISTRY AND MECHANICAL ENGINEERING TO FIND THE SOLUTION. SHELL LUBRICANTS TECHNOLOGY PROJECT LEADER RICHARD DIXON EXPLAINS HOW.

AN EXTREME CHALLENGE

One of the most unusual challenges Shell Lubricants has been set was to develop a hydraulic fluid that would enable the world's largest dumper truck excavators to start at temperatures as low as -50°C. Not only that, the truck excavators needed to operate reliably around the clock through the full range of Arctic Circle conditions, which can see summer machine operating temperatures soar to 35°C and beyond.

If equipment keeps operating at very low outside temperatures, issues with lubricants do not usually occur – heat generated from the equipment operation keeps the fluid warm and enables it to circulate properly. The problem comes during start-up, when everything has cooled down to very low temperatures. Under these conditions, a conventional hydraulic fluid will solidify, so when the machine starts up, there is no fluid circulating to protect the pump and other components from extreme wear.

One solution is to heat the fluid before the machine starts, but the design of the excavators and amount of fluid involved in this case made it impractical. Another option is to use a range of different fluids with varying viscosities that can be changed quickly with the seasons. But again, in this case, seasonal oil changes were not an option. The excavators would be in continuous operation at extremely remote locations in Siberia. And with an 8,000 litre fill, a hydraulic fluid change would become a major challenge in itself. Besides, the long supply lines and the Siberian climate would make transporting and maintaining sufficient stock both problematic and expensive.

What we needed was a fluid that stayed just that – a pumpable fluid – even following an unscheduled stop in the most extreme cold. It also had to be suitable for year-round use, including the relatively hot summers typical of this location.

Clearly the wide temperature range presented a tough test. We needed a product both 'thin' enough to facilitate ultra low temperature start-up and 'thick' enough to provide long-term wear protection and stability. At first, these seemed like contradictory requirements. But the fluid we developed – Shell Tellus Arctic 32 – has the properties to do the job.

Today, it is widely used by operators of outdoor and off-road machinery, such as bulldozers, shovels, excavators and snowploughs, in extremely cold climates in situations where quick start-up is crucial and risk of equipment failure is unacceptable.

A TAILORED SOLUTION

Developing a fluid capable of performing across a wide temperature range is difficult enough. But there was a further challenge: we needed to ensure the fluid would meet the exacting viscosity specifications of our customer's equipment, which uses specific pumps. Viscosity being too high could cause catastrophic failure of the pump on start-up, while viscosity being too low would accelerate pump wearing. A tailored solution was required.

IMAGINATIVE FORMULATION

A key property of all lubricants is viscosity, which is a measure of the fluid's resistance to flow. Viscosity is extremely dependent on temperature and increases dramatically as the temperature drops. At low temperatures, particularly during start-up, high viscosities may inhibit oil flow. Conversely, once the equipment is warmed up to its normal operating temperature, high temperatures will reduce viscosity and may compromise the thickness of protective oil films.

Both possibilities are a concern to equipment manufacturers and encourage them, or their customers, to set constraints on the low and high temperature viscosities. In this case, our customer required that the cold-start viscosity did not exceed 1000 centiStokes cSt while the minimum high temperature viscosity was specified to 12cSt.

At first sight, this appears to be a huge viscosity range – a factor of almost 100 – but a conventional fluid changes in viscosity about three times as much as this. Such a stark change in behaviour required a distinct change in formulation strategy combined with the use of novel formulation components.

Conventional base fluids precipitate out large amounts of wax at very low temperatures, so the first thing we needed was a suitable base fluid with a very low wax content that would remain mobile under the coldest conditions. For such a fluid to be suitable for providing wear protection at higher temperatures, it needed to be thickened with a special additive called a viscosity modifier (VM). These are rubber-like molecules that thicken the oil at higher temperatures much more so than at lower temperatures.

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VM molecules are much larger than those of the primary base fluid and can be torn apart as they pass through tight-tolerance engineering components such as bearings and hydraulic pumps. This tearing – or shearing – is akin to stretching and breaking a rubber band. It reduces the VM's effectiveness and therefore the ability of the fluid to protect the hardware. Fluids that have degraded in this way lead to increased wear rates, higher levels of leakage and in some cases failure. Shearing is clearly undesirable and is linked with loss of reliability, productivity and operational cost.

This vulnerability of VMs to shearing required us to select molecules with a general architecture and scale that was innately robust, and then to use them at unusually high treat rates to achieve the narrow viscosity range. Typically hydraulic fluids designed for outdoor use contain about 3% VM.

This unusual specification required 20% - an astonishingly high level which required us to reverse our manufacturing procedure completely to ensure that the VM was satisfactorily blended.

Ultimately we delivered a fluid comprising a very specialised base oil with an extremely shear stable polymethacrylate VM. The fluid is Shell Tellus S4 VX. Its unique viscosity characteristics make it compatible with start-up at temperatures as low as -50°C while providing adequate protection at up to 75°C.

INNOVATION, APPLICATION AND PARTNERSHIP

What the development of this extreme lubricant highlights is the breadth and depth of Shell's technical skill and versatility in product innovation, development and application. Not only in lubricants, but also across a range of closely-related competencies, including engineering, physics and chemistry.

Shell Tellus S4 VX is a widely-mirrored example of our ability to work in close collaboration with our customers to set new boundaries for performance and technical excellence.

Demand for this product continues to grow, not only within the mining application for which it was originally designed, but also in emerging applications such as the control mechanisms of wind turbines which are also often situated in cold, exposed environments.

HARD WEARING, WITHOUT TEARING

Once we had achieved the right 'viscometrics' and shear profile, we needed to ensure our fluid also provided wear protection. Our next step was to build a unique test rig to run a range of piston pump tests under very high pressure conditions, cycling from 0 to 400 bar every second for 500 hours.

The manufacturers sent us a pump, which we tested and then returned – uninspected – for the customer's verdict. The results came back as 'excellent'. The customer concluded that the pump, its piston shoes, pistons and swash plates, showed no sign of wear. The good news was that the new Shell Tellus S4 VX was enabling the pump to greatly exceed wear requirements.

The final test was a summer/winter field trial in a remote Siberian mine in two customer excavators, each with a 5,000 litre fluid reservoir. With ambient temperatures ranging from –50°C to 35°C and oil temperatures ranging from –50°C to 75°C, the test results were outstanding.

Richard Dixon is a Product Developer for Shell Lubricants. Richard joined Shell in 1996 after completing a PhD in Physical Chemistry. He worked initially in the Lubricant Chemistry group at Shell's Thornton Research Centre learning the basics of lubricant technology. Richard then moved to the Industry group and worked on redeveloping Shell's portfolio of hydraulic fluids. After a spell as Technology Manager, Richard is currently engaged in the Passenger Car Team, with a focus on delivering increased fuel economy.

Shell is the number one global lubricants supplier for the fourth consecutive year (source: Kline & Company). This has been achieved by placing innovation, the application of our products and technology partnerships at the heart of everything we do. It enables us to develop world-class technology that helps our customers to lower operating costs, improve productivity and ultimately increase their profits. For more information about Shell Lubricants, visit www.shell.com/lubricants

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