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Rigs & Equipment

Dual-BOP systems emerge on deepwater rigs as ultra-mobile rigs carve niches in land, offshore applications

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BIOFLUIDS: Combining environmental responsibility, performance

By Diane Langley, editorial coordinator

Just as the environmentally responsible use of lubricants in daily offshore rig operations and use of zero-spill methods is an ongoing responsibility of the drilling contractor, progress in available chemistries of lubricants is an ongoing effort on the part of industry suppliers. Increased options from suppliers are helping contractors marry environmental responsibility with performance.

More than 250 types of lubricants are used in daily offshore rig operations in appreciable volumes, including engine oils, hydraulic fluids, thruster fluids, pipe dope, gear oils and greases. According to **Jon Pearce**, marine and energy lubricants product manager for **Castrol**, the newer rigs being built today have large 3,000-gal hydraulic power packs on the drill floor that sit directly above the moonpool or on the drill floor directly above the sea. The new semisubs have complex hydraulic systems that incorporate heave compensation, and derrick and hydraulic rig mains can have 10,000 gal of oil in them. "When a 6-in. hose burst on one of those, it released 5,000 gal onto the deck of the rig in 20 seconds. It's not just about system volumes, it's the huge flow rate that affects the scale of a spill."

According to lubricant suppliers, switching out the use of older lubricant technology fluids to newer alternatives can deliver comparable if not better performance. The fact that the industry has experienced disappointments with "green" lubricants makes spreading the word of chemistries suited for offshore rigs even more important.

"Historically, green lubricants existed, but they had quite a bad name because typically they didn't work well in the applications for which they were designed. That's been quite a hurdle to get over because people think that green lubricants aren't as good as a conventional product," **Susannah Linington**, environmental specialist for Castrol, said. "We found that products that were designed using vegetable oil were great environmentally but technically don't give the performance required for offshore rig applications."

There has been a huge development in the type of chemistries used during the last few years that offer both environmental and technical performance," according to Ms Linington. "A lot of the activities in which we are involved is educating people that the new types of green lubricants are designed with completely different base chemistries that give both the desired environmental performance and the technical performance that works in specific applications," she said.

Chauntelle Baughman, account manager for **Hydraquip**, agrees, noting that the greatest challenge in the acceptance of

Right: *Operator requests have led to the manufacture of more advanced and durable fluids. "Green" lubricant chemistries are emerging that hold the promise of both environmental and technical performance.*

Courtesy of Panolin

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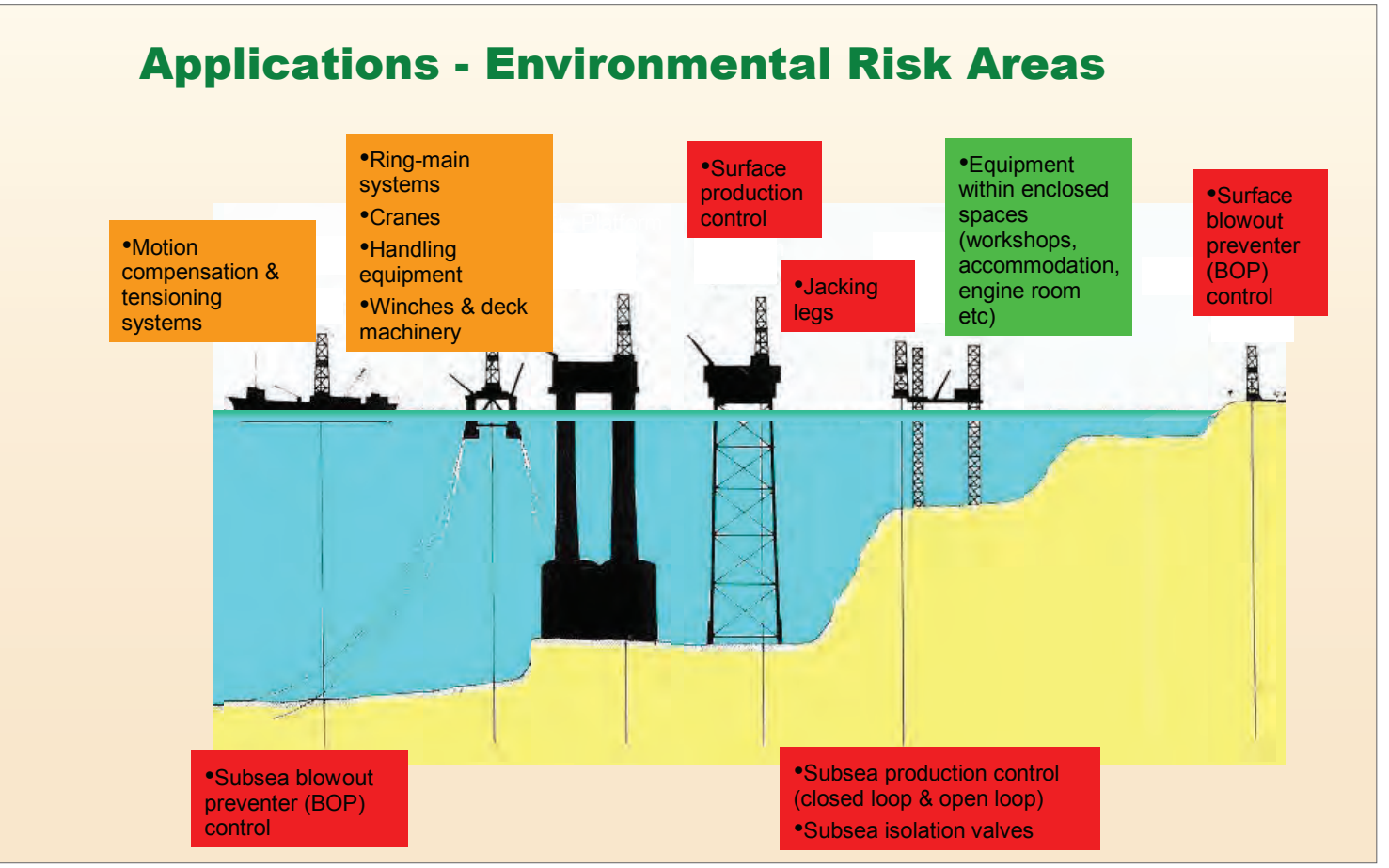

Several environmental risk areas exist onboard an offshore drilling rig. Systems that result in high levels of discharge or a high probability of entry into the sea (red) are considered to be high risk. Applications that contain relatively small lubricant volumes and from which, under fault conditions, the lubricant could not enter the sea are considered to be very low risk (green). Between these extremes are those systems that present significant risk, as anything spilled or leaked directly enters the sea (orange).

biofluids has been an overall lack of education on the subject and that every effort should be made to promote education on biofluids through the energy industry. "Knowledge of basic fluid properties and their toxicity will position contractors and operators to make environmentally considerate decisions," she said. "While companies are aware that biofluids are available and becoming increasingly mandated, there is still much confusion about terms such as biodegradability and toxicity and how standards are defined." Hydraquip is a distributor of hydraulic components and a line of Panolin biodegradable lubricants.

Environmental regulations have been the primary driver behind the use of biofluids. Operator requests have led to the manufacture of more advanced and durable fluids. The use of environmentally friendly fluids overall has largely been the result of governmental regulations restricting and reducing environmental impact, according to Ms Baughman.

In addition to meeting various environmental regulations around the world, advantages to using the green lubricants include fire resistance, rust prevention, longer lubricant life, better system performance over time, and stability in high-heat applications.

BIOFLUID DEVELOPMENT

According to Mr Pearce, about 20 years ago the industry started working on hydraulic oils based on vegetable oils as an environmentally friendly alternative to mineral oil, and the equipment in which they were used had to be designed around the oil because of their performance limitations. There was never widespread adoption, and the fluids were used only where needed.

"Hydraulic systems were the first systems for which the industry required green solutions," Mr Pearce commented. "But it became apparent that other equipment (specifically items sitting below the water line on floating rigs, such as thrusters) have leakage because they are deliberately pressurized to keep water out. As a result, there is more focus on what can be called operational discharges as opposed to big spills. As this need surfaced, the solution called for a whole range of green products."

These oils were less toxic and did not create as much of a sheen but were not truly biodegradable, **Mark Miller**, chief executive officer for fluids manufacturer **Terresolve Technologies**, said. "This was a first step in environmental improvements; it was a better technology for environmental

Activity	Standard lubricant description	Typical vol/no. of systems/consumption	Potential for spill
Jacking gears	Jacking grease	100 kg per rig move	No potential-discharged
Surface BOP control (jackups)	Hydraulic fluid	5000 liter closed system	High
Subsurface BOP control (semisub & drillship)	BOP hydraulic fluid	5000 liter open system	No potential-discharged
Drilling system hydraulics (rig floor)	Mineral hydraulic oil	3 - 10,000 liter	Low
Deck machinery (mainly winches and cranes)	Mineral gear & hydraulic oils	25 - 3000 liters each	Low
Thrusters (semisub)	Mineral gear oil	2 - 5000 liters each, up to 8 per rig	Continual low-level leakage
Pipe & casing dopes	Grease/paste	Continual consumption during drilling	Lubricant in well
Motion compensation / riser tensioner systems	Water glycol hydraulic fluid	80,000 liters per system	Low

Numerous rig systems require the use of lubricants and oils. Each system carries its own level of risk, and fluid volumes vary.

performance but was a step down in equipment performance."

In the late 1990s and early 2000s, readily biodegradable oils surfaced on the market. "I would not say that there was a wholesale shift, but a lot of the pioneers looked to find an environmental alternative for applications in the offshore rig arena," he continued. "Then along came the perfect storm."

This was the coincidence of three elements. First, the technology was evolving to where it was suitable for use on drilling rigs. Second, drilling contractors and service companies were looking for further improvements in the environmental arena. Finally, there was a groundswell of US and international agencies pushing for the industry to go greener, according to Mr Miller.

Until recently, most biodegradable hydraulic fluids, gear oils and greases were based on vegetable-oil technology. These technologies are useful in certain applications but typically are poor for use on offshore drilling rigs because 1) rig equipment runs very hot, and vegetable oils cannot take extreme temperatures, 2) there is a good possibility that the lubricants will get wet as the rig and equipment operate in a humid environment, and 3) the change-out interval is very lengthy, according to Mr Miller.

People moved away from the vegetable oil-based fluids in two directions: synthetic ester and biopolyolefin technologies. Terresolve went forward with biopolyolefin technology because it is biodegradable, non-toxic, non-sheening and can take heat, cold and contamination from water and old oil. Hydraquip and Castrol went with synthetic esters. Hydraquip's synthetic fluid is made from saturated esters and is readily biodegradable, non-toxic, and zinc-free. Castrol also has a suite of synthetic-based hydraulic fluids and lubricants that includes a topside hydraulic fluid and a thruster-specific fluid.

A HINDRANCE TO MASS USE OF BIOFLUIDS

"Some suppliers don't get the industry all that well, and products that fail give us all a black eye," Mr Miller noted. "We have to explain that there are fluids out there with different characteristics. Some of them are very good and durable, and some of them fall apart when they get wet. When you've got a billion-dollar piece of machinery that's making $300,000, $400,000 or $500,000 a day, you can't risk downtime," he said.

Ms Baughman agreed. "Not all biofluids are created equal. There are some that react poorly to high temperatures, some that are unstable in certain environments, and some that have poor performance characteristics. There have been performance reliability issues in the past because there is a general lack of education regarding the different types of biofluids and which of those fluids are best suited to specific applications."

Advantages of "green" lubricants vary depending on the type of biofluid being used. "We look at the weaknesses of certain biofluids, but we never stop and say why it is worth it," Mr Miller said. "Green lubricants typically have better lubricity that equates to reduced wear and reduces operating temperatures, which can prolong equipment life. These lubricants also have a higher viscosity index (how the thickness of oil changes with regard to temperature), so the fluid will stay within the designed thickness and viscosity over a broader temperature range."

UNDERSTANDING THE TERMINOLOGY

"I think it's fair to say that the majority of the industry associates environmental performance with biodegradability. To state that something is inherently biodegradable is getting accepted, when in fact, any oil-based product is inherently biodegradable. It just takes a long time to degrade," Mr Pearce noted. "The level of awareness needs to be raised about what is and isn't environmentally responsible."

"People seize on just one statement like saying that something is biodegradable," Ms Linington said. "Food grade is a misconception. Many say, 'oh, it will be fine' when confronted with food grade as an option. But humans are very different organisms than algae. What can be perfectly safe for a human to eat can be very toxic to an algae or a smaller organism living in the plankton. That's why it's important to test the product in seawater."

"There is no scientific definition of what environmental responsibility is," she continued. "People have different conceptions of what is considered environmentally responsible. It's important to say that this product is going into the marine environment, and therefore, the marine environmental impact will be at the point that it goes into the sea. Biodegradation, toxicity and bioaccumulation need to be considered and they need to be measured in seawater, not fresh water or soil, which are quite easy tests to pass."

"It's important that contractors ask lubricant suppliers the right questions," Ms Linington continued.

First, what is biodegradation? "It seems like a simple question that should have a simple answer," Ms Baughman commented. Actually, there are two standards for biodegradability: inherently biodegradable and readily biodegradable. "While some fluids are biodegradable, that does not necessarily indicate that they are non-toxic. According to the US Army Corps of Engineers standard, a hydraulic fluid is considered to be non-toxic if a specific ratio of the hydraulic fluid to water is used and less than 50% of the test organisms die within 96 hrs," she said.

"Ideally, you want 60% of any of the chemicals within a formulation to have broken down naturally when they go into the sea," Ms Linington said.

"Inherently biodegradable" means that the product has the propensity to biodegrade; no specific time frame or degree is given for the breakdown. Petroleum-based lubricants may be inherently biodegradable; however, they persist in the environment for years and require long-term remediation.

"Readily biodegradable" fluids break down rapidly when they enter the environment. Four types of readily biodegradable fluids are conventional vegetable-based fluids, synthetic esters, polyalkylene glycol and polyolefin.

Vegetable-based fluids are readily biodegradable, but, when exposed to heat, begin to break down to the point of destruction; they can only withstand operating temperatures under 160°F and they become unstable when exposed to water or moist environments.

Synthetic esters are also readily biodegradable and non-toxic and are available in two categories: saturated and unsaturated. Unsaturated ester products tend to oxidize quickly, while saturated ester products resist oxidation. Some synthetic fluids may form acids as a result of exposure to moisture, but all acids created are not the same. Hydrolysis of esters does not always lead to corrosive acids; sometimes acids formed can improve anticorrosion capabilities, according to Ms Baughman.

Polyalkylene glycol exists in both biodegradable and non-biodegradable form. It is intolerant of conventional petroleum oils and vegetable oils, is very soluble and is typically incompatible with seals and filters used in marine equipment.

Biopolyolefin is biodegradable, non-toxic and tolerant of water and contaminants. It is stable in all temperature ranges, climates and seal compatibilities. It is also compatible with conventional petroleum and most other biodegradable products.

The second important question relates to toxicity. Toxicity is the degree to which a substance can damage an organism. It can refer to the effect on a whole organism, such as an animal, bacterium or plant, as well as the effect on a substructure of the organism.

Mineral oil is quite toxic, especially in combination with conventionally used additives, Ms Linington said.

"We test all components in our formulations on four different species across the food chain. It's important that you test all levels from algae to fish at the top of the food chain," Ms Linington commented. "The last thing we look at is bioaccumulation potential, the potential for a chemical to build up in the fatty tissue of an organism and gradually over time have toxic effects. This can go right up the food chain into humans … bioaccumulation is something that people tend to ignore; they focus on biodegradation."

REGULATIONS REGARDING LUBRICANTS

Environmental legislation related to lubricants surfaced in the 1990s, according to Ms Linington. Today, regulatory guidelines specifically related to hydraulic fluids and lubricants have been issued in the northeast Atlantic region, the Gulf of Mexico, Norway, and Canada. Also, any pollution in international waters is covered by the International Convention for the Prevention of Pollution from Ships (MARPOL).

"Really you've got three situations, two of which are covered by regulations (blowout preventer control fluids and oil spills into the sea)," Mr Pearce said. "Small-scale oil releases (such as from thrusters and hydraulic line leaks) fall in between existing regulations."

FINDING FORMULATIONS THAT WORK

While "green" lubricants have been available for some time, significant advances have been made in their chemical composition, according to Ms Baughman. When selecting a biodegradable fluid that meets the needs of the offshore drilling industry, things to look out for include the fact that synthetic esters are often grouped together despite the significant performance and longevity differences between saturated and unsaturated.

Whether the product is saturated is determined by chemical bonds within the fluid itself. Unsaturated esters have multiple open bonds that interact with oxygen quickly, leading to oxidation (aging) of the fluid. Aging is the cause of extreme thickening and gumming of the fluid, along with deposits of shellac, which lead to catastrophic system failures, according to Ms Baughman.

"Ask the fluid manufacturer for the Iodine Number," she said. "It identifies the number of open bonds available, so the higher the Iodine Number, the greater the number of bonds that can interact and oxidize. Generally speaking, a saturated ester product has an Iodine Number of less than 15."

Another thing to determine is whether the fluid will be compatible with seals in existing equipment. The biofluid supplier should be able to provide testing documentation and manufacturer approvals, Ms Baughman said.

Also, hydrolytic stability should be considered when selecting a biofluid, she continued. Hydrolytic stability is the ability of a fluid to resist decomposition in the presence of water. To measure the degree of hydrolysis in a biodegradable ester, for instance, the total acid number (TAN) should be reviewed. When oils are mixed with water and heat, they are cleaved, or bonded, and new chemicals are formed as a result of this reaction. These chemicals can include glycols and fatty acids. When looking at TAN results, a high number indicates that a large number of ester molecules have cleaved, meaning that the chemical composition of the fluid has changed.

In the case of mineral-oil-based lubricants, the TAN should not exceed 2 mgKOH/g (milligrams of potassium hydroxide per gram) but the TAN values of biodegradable alternatives may increase up to 5 mgKOH/g without leading to any problems, Ms Baughman said.

"It is important to note that before hydrolysis of synthetic products will cause any issues in a hydraulic system, the amount of water needed for that hydrolytic process to take place will cause major cavitation, corrosion and other catastrophic issues before the fluid even begins to react.... In principle water is a harmful contaminant, reducing the life of the hydraulic fluid and the mechanical components," she said.

COST VERSUS PERFORMANCE

"The reality is that a good-quality biodegradable fluid is going to cost more than a good-quality petroleum oil," Ms Baughman said. "But you're going to get a lot of benefits from the biofluid like improved performance, potentially longer change-out intervals and better operation at reduced environmental risk. So, in the long term there is actually a cost savings."

MAKING THE EFFORT

Most operators and contractors would agree that it's better to stay ahead of the curve when it comes to understanding environmental properties of chemicals used in daily operations, discerning levels of discharge and probability of spills, selecting the best chemical options based on the level of environmental compliance and equipment performance, and maintaining zero-spill solutions.

"I think the industry overall is doing a phenomenal job from the environmental perspective. I firmly believe that the industry has not given itself enough credit for all of the environmental initiatives that it has taken and accomplished," Mr Miller remarked.

A CONTRACTOR IN SEARCH OF ALTERNATIVES

While some "green" chemistries have not performed as expected, there are environmentally safe rig fluid alternatives that do work. According to Mr Miller, **Noble Drilling** had been looking for a non-toxic hydraulic fluid for use in the exposed areas on its rigs; several products were tried, but in the end, they did not meet Noble's needs because they broke down quickly in the harsh offshore environment.

"Despite the fact that they experienced a significant failure, Noble was still willing to try it again," Mr Miller said. "They did a limited program with us which was a sweeping success. Now they are starting to do some change-outs across their fleet."

"I like to say that today's chemistries are not your daddy's biofluids," Mr Miller quipped. "There were no doubt problems with earlier versions of the green fluids. The lubricants industry has realized that the needs of a drill rig are different than some of the other applications. We have to be smarter and make our fluids more durable... Some of us have taken that challenge, gone back to the lab and made the fluids work better."