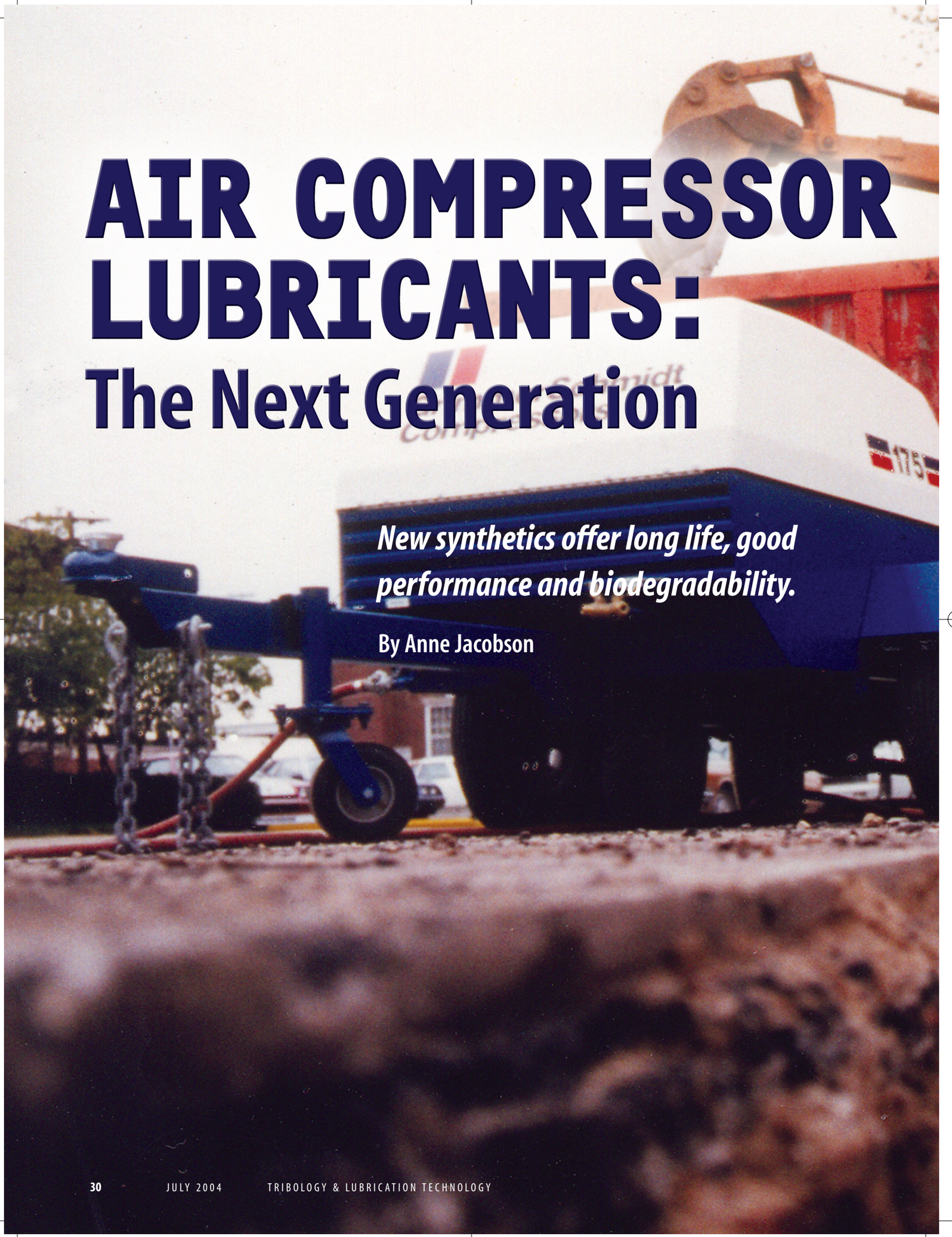


AIR COMPRESSOR LUBRICANTS: The Next Generation

New synthetics offer long life, good performance and biodegradability.

By Anne Jacobson

CONTINUED ON PAGE 32

CONTINUED FROM PAGE 31

Few lubrication challenges are more difficult than creating an ideal oil for air compressors,

Compressors consume about 12 percent of the industrial power generated in the United States.

particularly for the rotary screw air compressor. Inside the compressor the lubricant is forced to mix with the air being compressed. The oxygen in the air, the high pressure, the high temperatures and the moisture that condenses out of the compressed air—together these elements create a hostile environment that can break down even the toughest lubricant.

Furthermore, some of the lubricant, mixed with the air, is discharged from the compressor with the air stream. However, unlike the exhaust from an engine, the air from a compressor must be relatively free of oil. Therefore the lubricant must be taken out of the air stream. Usually this lubricant is recovered and recycled back into the compressor—where it is once again subject to a hostile environment. This cycle is repeated over and over.

The perfect lubricant for these conditions—still out of reach—would be highly stable in the presence of air and water (properties known as oxidative stability and hydrolytic stability). It would provide excellent rust protection, separate easily from air and water and be biodegradable for easy disposal.

To perform well in the environment of a rotary screw compressor, the perfect lubricant also would have a long operating life and would be liquid over a wide range of temperatures; its viscosity at high temperatures would be sufficient to provide adequate lubrication, and its viscosity at low

CONTINUED ON PAGE 34

Inside a Rotary Screw Compressor

To better understand the challenges involved in lubricating and cooling compressors, it is important to understand how one of the most common positive displacement compressors, the rotary screw type air compressor, works.

In a typical rotary screw compressor, the turning rotors draw air into the intake filter. This air enters the airend, which consists of the two precision-ground helical rotors fitted inside an outer housing or stator. In the airend, the air, which is trapped between the rotors and the airend housing, is mixed with lubricating oil. The air is then compressed and moved along the airend as the rotors turn. Compression raises the temperature considerably and causes water to condense out of the air.

The air/oil mixture exits the airend and flows into the oil separator tank. This tank, which houses the air/oil separator element, acts as a reservoir for the oil and allows for the primary separation of the air from the oil. The oil is separated from the compressed air, cooled, filtered and returned to the injection point. The compressed air then passes through an aftercooler to reduce its temperature. This cooled air then enters a moisture separator, which removes the condensed water from the air. Finally, compressed air exits the compressor ready for application. <<

CONTINUED FROM PAGE 32

temperatures would be enough to allow the compressor to start up on its own at subzero temperatures.

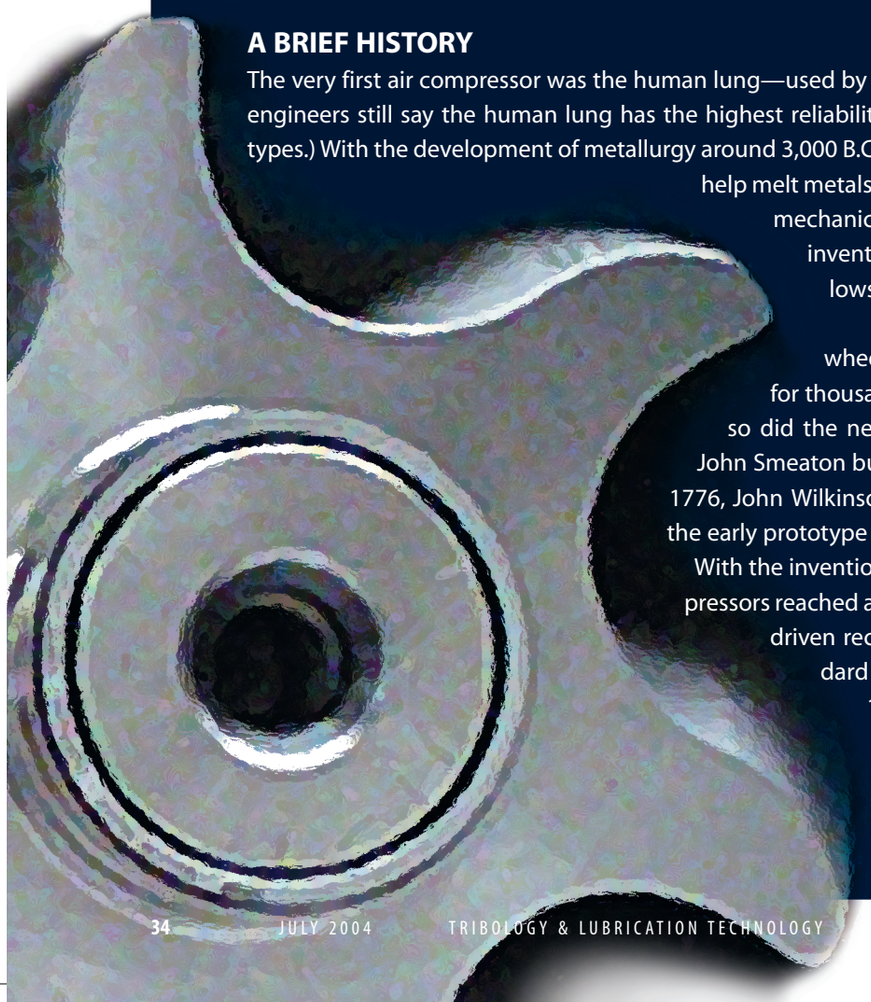
Lastly, the perfect lubricant would be, of course, widely available and relatively inexpensive.

While we wait for the perfect lubricant, those of us searching for the best product for a particular application in today's marketplace still have an array of fine options. Choosing the right one is important. "The most significant thing you can do to improve the operation of a compressor is use the right oil," says Joe D'Ambrosio, pres-

AIR COMPRESSORS: Providing the Fourth Utility

Used in everything from bottle blowing plants to fish farms to the braking systems on freight trains, air compressors are one of the most widely employed industrial devices. In fact, compressed air is often called "the fourth utility"—along with gas, electricity and water—and it is necessary to almost every modern industrial and commercial operation.

Broadly speaking, air compressors come in two varieties. Dynamic air compressors use rotating impellers to impart velocity to air, which is then converted to pressure. Positive displacement compressors increase pressure by "squeezing" the air—in other words reducing the amount of space it occupies. Positive displacement compressors come in two types: Reciprocating compressors use a piston and cylinder to squeeze the air, and rotary compressors use mating helical rotors or other rotating elements to trap and compress the air.



A BRIEF HISTORY

The very first air compressor was the human lung—used by primitive man to breathe life into fires. (Some engineers still say the human lung has the highest reliability and lowest maintenance of all compressor types.) With the development of metallurgy around 3,000 B.C., a more powerful compressor was needed to help melt metals such as gold, copper, tin and lead, and the first mechanical compressor, a hand-operated bellows, was invented. In 1,500 B.C., the more efficient foot bellows was created.

Bellows driven by the hand, foot or waterwheel provided mankind's compressed air needs for thousands of years. But as blast furnaces developed, so did the need for more powerful compressors. In 1762, John Smeaton built a waterwheel-driven "blowing cylinder." In 1776, John Wilkinson introduced a "blasting machine" that was the early prototype for all mechanical compressors.

With the invention of steam turbines in the late 1800s, air compressors reached a new level of power and efficiency. The steam-driven reciprocating compressor was an industry standard for more than 100 years. In the 1930s and 1940s, centrifugal and axial compressors appeared. In the 1960s and early 1970s, rotary vane and screw compressors came into use. Rotary screw compressors are still one of the most common types used today. <<

ident of Air Power of New England, an Atlas-Copco air compressor distributor.

The options range from traditional mineral oils to synthetic lubricants to, more recently, a new type of synthetic based on polyol esters that offers long operating life, many desirable performance qualities and biodegradability, according to its proponents.

MINERAL OILS

Some oil-free compressors are available, but most require lubrication. In a rotary screw compressor, for example, this fluid must lubricate bearings, seal the rotors and compression chamber to prevent air leakage and remove the excess heat generated during the compression process. (This last function is especially important. With a properly functioning fluid, the temperature of discharged air from a typical rotary compressor is about 200 F. Without lubricant, the discharge temperature would rise in excess of 700 F.)

Before synthetic lubricants became available, mineral oils were used in compressors. Although they are still used for some applications, the properties of mineral oils tend to make them too thin at high temperatures and too thick at low temperatures. Even mineral oils containing additives to improve viscosity and lower their pour point—the lowest temperature at which they will flow—are not completely satisfactory because mineral oil lubricants are highly volatile, have poor thermal and oxidative stabilities and tend to form carbon and sludge deposits.

In addition, mineral oils tend to break down and require changing after only about 1,000 hours of use. "That is like having to change the oil in your car once a week," D'Ambrosio says "Most people won't tolerate that."

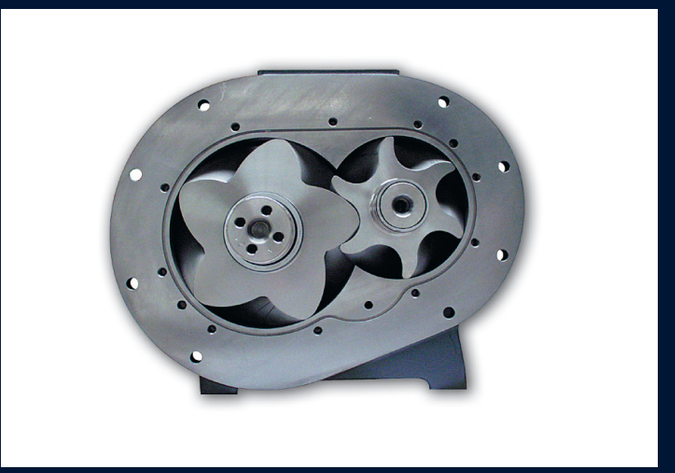
SYNTHETIC LUBRICANTS

Synthetic lubricants, which have longer operating lives, have been available for about 35 years. Based on diesters, poly alpha olefins (PAOs), polyalkylene glycols (PAGs), silicones and other compounds, synthetic lubricants offer many advantages over mineral oils, including superior lubrication properties, a high viscosity index over a wide range of temperatures and operating lives of anywhere from 2,000 to 10,000 hours.

"While synthetic lubricants are an improvement over mineral oils, they are not capable of providing all of the desired performance and physical properties for modern rotary screw compressors," says Michael McHenry, vice president of technology and marketing at Anderol Inc.

According to Henry, improving one property of a synthetic lubricant often comes at the expense of another. For example, certain diester-based oils may have a wide operating temperature range but a dangerously low flash point (the temperature at which they vaporize and become ignitable) and poor hydrolytic stability. PAG-based lubricants may perform well at high temperatures but have poor demulsibility (the abili-

CONTINUED ON PAGE 36



Photos courtesy of Kaeser Compressors, Inc.

Cutaway views of a rotary screw compressor airend show the mating helical rotors that trap and compress the air.

CONTINUED FROM PAGE 35

ty to separate from water). And silicones, while tough, are not easily biodegradable.

POLYOL ESTER-BASED, BIODEGRADABLE LUBRICANTS

McHenry has developed a new polyol ester (POE) based biodegradable compressor lubricant. He and other proponents of this next generation of lubricant claim that, compared to the other choices, this one offers superior performance properties, a long operating life and one additional benefit—biodegradability, as defined by the most current industry standards.

"Compared to other oils out there, we have gotten incredible performance with this one," says D'Ambrosio. "We use this oil in about a thousand air compressors now, and it is working very well. We have seen this oil go as long as 16,000 hours and still be in good shape."

Described in U.S. patent number 5,895,778, this preparation is based on a polyol ester base stock and additives that include antioxidants, yellow metal pacifiers, rust inhibitors and a hydrolytic stability improver. This formula achieves "all the desired performance properties, particularly the combination of extended life, low pour point, high flash point, good demulsibility and reduced odor," the patent states, adding that the preparation is particularly well suited for rotary screw air compressors.

This oil also meets the current biodegradability requirements set forth by the American Society for Testing and Materials (ASTM). In the context of compressor lubricants, "biodegradable" is defined by a test that measures how much of the material breaks down into carbon dioxide and water after a certain number of days. Early lubricants were tested and rated by the Commission for Environmental Cooperation L-33-T-82 test. More recently, tougher tests such as the ASTM D5864-00, which require 60 to 80 percent of the lubricant to degrade within 28 days, have become the industry standard.

THE (SLIM) BENEFITS OF BIODEGRADABILITY

Biodegradable synthetics have been available for about 25 years, but experts agree that the benefits of biodegradability—in and of itself—are relatively minor. They advise that biodegradability should not outweigh performance when choosing a lubricant. "Nobody in the industry is going to buy an oil because it is biodegradable," D'Ambrosio says. "They buy an oil because it performs well."

"In the United States there are few economic benefits to biodegradable lubricants, because the cost is much higher compared with mineral and most synthetic lubricants," explains John Zaimis, applications engineering manager at Kaeser Compressors, Inc. However, Zaimis adds that there are benefits to using biodegradable synthetics over traditional pure-petroleum lubricants

CONTINUED ON PAGE 38

Photos courtesy of Kaeser Compressors, Inc.

When a lubricant breaks down, carbon and sludge deposits such as these can form, which can impede efficiency and damage the compressor.

CONTINUED FROM PAGE 36

in some applications because of their high lubricity properties and the stable viscosity over a wide temperature range.

Even with these desirable properties, biodegradable lubricants for the most part do not offer a performance advantage over other synthetics in compressed air systems, the experts say. "The real benefit to the use of true eco-sensitive fluids is their impact on the environment in the event of a release," explains McHenry. "In the event of a release of an environmentally friendly fluid, some regulations allow for reduced remediation actions as compared to many conventional fluids."

Finally, experts caution that "biodegradable" does not equal "environmentally safe." Tim Last, a compressor specialist with Atlas Copco explains, "A biodegradable oil can be highly toxic and harmful to the environment. In addition, even if the oil was totally biodegradable and environmentally friendly when new, once it has been used inside a compressor for thousands of hours it may come out in a totally different state and may no longer be either biodegradable or environmentally friendly."

While synthetic lubricants are an improvement over mineral oils, they are not capable of providing all of the desired performance and physical properties for modern rotary screw compressors.

THE BIODEGRADABLE POE: COSTS VS. SAVINGS

One of the chief factors when selecting a lubricant is cost, and biodegradables tend to cost more. The higher price is usually due to the additives that are mixed with the lubricant to reduce oxidation and improve its properties, Zaimis explains. Without oxidation inhibitors, for example (vegetable-based), biodegradables tend to harden, he says.

Proponents of the new POE synthetic biodegradable argue that the higher price of this oil is offset by the savings that result from its better performance, including reduced lubricant consumption, reduced disposal costs, reduced maintenance and—most important—reduced energy costs of operating the compressor.

Compressors consume about 12 percent of the industrial power generated in the United States, says D'Ambrosio. "They are a huge energy consumer. If you can shave a few percentage points off the national average, that is a considerable savings."

A properly formulated synthetic will provide energy savings ranging from 1 percent to 6 percent, McHenry says, adding, "In a few severe applications Anderol has documented greater than 15 percent energy savings."

Advocates say that the new POE lubricant has proven itself in the field over the last six years and is gaining wider acceptance. "Other companies have begun selling it as well, and in the past year it has really started to catch on," says D'Ambrosio. "In fact, two of the largest compressor manufacturers in the world have switched to this oil, not because it is biodegradable but because it runs well." **<<**

Anne Jacobson is a science and medical writer based in Silver Spring, Md. She also contributes to Computing in Science and Engineering, CBS HealthWatch *and* WebMD. *She can be reached at* **ajacobson@nasw.org**.

For Further Reading

E-compressed air. *Introduction to Air Compressors*. Available online at **http://www.ecompressedair.com/library/air-compressors.shtml#intro**.

McHenry, M. A. et. al. United States patent number 5,895,778. Poly (*neopentyl polyol*) *ester based coolants and improved additive package*. April 20, 1999.

Carswell, R. et. al. United States patent number 4,302,438. *Rotary screw compressor lubricants*. November 24, 1981.

Timony, P. E. et. al. United States patent number 4,175,045. *Compressor lubrication*. November 20, 1979.

Ingersoll-Rand Co. *Ultra Coolant: The Leading Air Compressor Coolant*. (2003) Available online at **http://www.ultra-coolant.com**.

Kaeser Compressors. *Getting the Most for your Money: How to Select and Protect Your Air Compressor Environment*. (2000) Available online at **http://www.maintenanceresources.com/ReferenceLibrary/AirCompressors/kaeserpage1.htm**.

Gardener Denver. *Compressed Air Applications*. (2002) Available online at **http://www.gardnerdenver.com/GDCorp-Portal/RouteRequest?route=to&id=1774**.

Anderol Inc. *Anderol Rotary Compressor Lubricants*. (2001) Available online at **www.anderol.com/protcom.htm**.