A Study of Compressor Oils

White Paper # 7

G-1592
AMSOIL Industrial Division
June 2000

Table of Contents

Overview

Compressed air is often a critical part of manufacturing operations and therefore good, reliable compressor operation is always necessary. Compressor oil is an important part of the equation and the lubricants market for compressors is very complex with several products being available.

Compressor oil is not governed by an organization and there are no official performance standards. Therefore, responsibility for marketing a satisfactory product has been up to the individual oil companies with performance requirements determined to a varying degree by the compressor original equipment manufacturer or OEM.

Compressor OEMs help eliminate some confusion by publishing minimum oil specifications required for their units. They also frequently market their own brand of compressor oil and have often been able to tie warranty requirements to the use of this oil. Since there is not an official standard for compressor oil performance, end users find comfort in using manufacturer recommended oil. Unfortunately, in many cases the price of these oils is unnecessarily inflated and is frequently exorbitant. In addition, these oils often do not have the best performance characteristics that are available on the market.

OEM branded oils are very expensive primarily for two reasons. One reason is multiple step distribution of two to four steps before the customer receives the product. The second reason is that since warranties are often tied to the use of OEM branded lubricants, the customer must pay the price demanded by the OEM if they hope to avoid having their warranty coverage challenged. As a result of these two circumstances, pricing for OEM compressor lubricants is significantly higher than even oil company premium products.

Purpose

The purpose of this paper is to inform consumers about the performance and cost differences between OEM branded and popular aftermarket compressor oils. Critical performance criteria and retail pricing of some of the major compressor oils available in the marketplace has been evaluated.

Method

The testing by which these oils are evaluated is done in accordance with ASTM (American Society for Testing and Materials) procedures. All testing was done in duplicate and the average of the results is reported. The results of these tests can be duplicated and verified by laboratories that conduct these ASTM tests. A notarized affidavit certifying the results are correct is included in the appendix. Compressor oil pricing was determined by contacting the manufacturer or the distributor for the subject lubricant and requesting a quote on a five-gallon pail and a fifty-five gallon drum. Price quotes obtained are listed in the pricing section. A notarized affidavit attesting to the pricing obtained is included in the appendix.

Scope

This paper is focused on rotary screw type compressors and synthetic oils. Rotary screw compressors are widely used in all types of industries and synthetic compressor oils are recognized as superior to mineral based compressor oils by compressor manufacturers as well as most oil companies and consumers. Therefore, synthetic oils, with the exception of Sullair SRF 1/4000, were the only oils tested. Sullair SRF 1/4000 is a highly refined mineral oil and was included for comparison.

The testing conducted is intended to address main lubricating requirements of rotary screw compressors. While there are many tests by which oils could be measured, the information provided by the tests included in this paper gives a well-rounded view of the compressor oil's performance.

Synthetic Compressor Lubricants

The synthetic compressor oils tested are formulated using polyalphaolephins (PAO), esters and polyglycols. These synthetic oil chemistries are widely available and well accepted for use in compressor applications.

1. PAO (polyalphaolephins) synthetic compressor oils are commonly used in rotary screw compressors as well as vane and reciprocating compressors. These oils provide long life in screw compressors often exceeding 8,000 hours under normal operating conditions. PAOs have excellent water resistance and excellent thermal and oxidative stability. They can be used in wide ranging operating temperatures and they have excellent cold temperature properties. They are compatible with most seals, paints and plastics as well as petroleum and ester type compressor oils. PAOs are also available in food grade. PAOs are not compatible with polyglycol type compressor oils. PAOs are typically less expensive the polyglycols and esters.
2. Synthetic ester based compressor oils are commonly found in reciprocating compressor applications because of their low carbon forming tendencies. They are also used in rotary screw and vane compressors. Synthetic esters have a long life in rotary screw compressors, often exceeding 8,000 hours. Some synthetic ester oils are aggressive toward seals, paints and plastics and these compatibilities should be checked. Most synthetic esters used for compressors have good water resistance and excellent thermal and oxidative stability. They are compatible with PAOs and petroleum-based products. They may not be compatible with polyglycol-based compressor oils. These oils are typically more expensive than PAOs, but less expensive than polyglycols.
3. Polyglycol synthetics are commonly used in rotary screw compressors. These oils have a long life often exceeding 8,000 hours under normal operating conditions and are often used in applications that compress process gasses, as they do not readily absorb these gasses. Polyglycol oils have good thermal and oxidative stability and they have fair water resistance. They exhibit good compatibility with seals, paints, and plastics. These oils, including **Sullair Sullube 32** and **Ingersoll-Rand SSR Ultra-Coolant**, are generally **not compatible** with other oils. In addition, they are typically very expensive.

Viscosity in all lubricated equipment is an important consideration. Generally, rotary screw compressors use an ISO-46 and sometimes an ISO-32 compressor oil.

Desired Performance Characteristics and Results

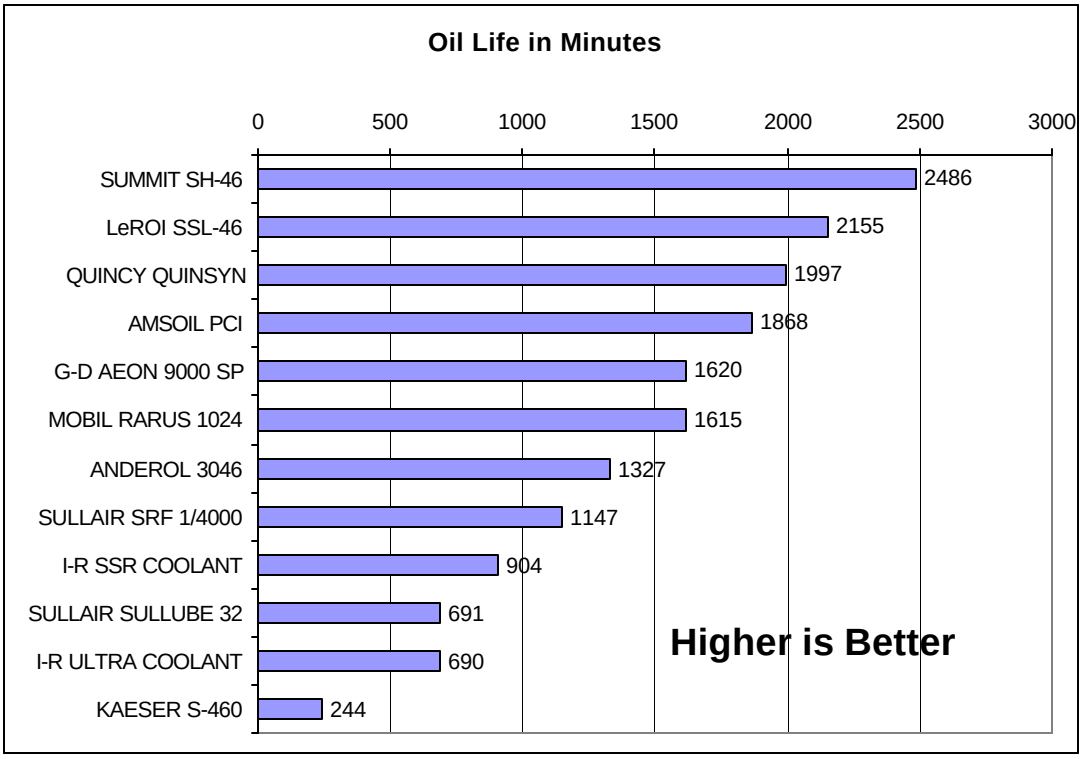
Oils used in rotary screw compressors operate in severe environments. The oil in the compression chamber is exposed to high heat as well as moisture. The oil is further exposed to high volumes of oxygen and constant churning. The oil is expected to lubricate the screws and bearings for extended periods of time (up to 8,000 hours). In view of the basic conditions in which rotary screw compressor oil operates, the oil needs to perform well in the following areas:

Oxidation Resistance

The compressor oil gets hot and is exposed to high volumes of air. This heat and air combination increases the rate of lubricant degradation through oxidation. The evaluated oils were subjected to two oxidation tests.

Rotary Bomb Oxidation Test (RBOT) ASTM D-2272

The Rotary Bomb Oxidation Test is a rapid method of comparing the oxidation life of lubricants similar formulations. The bomb is initially charged with 50 grams of test oil and 5 grams of distilled water. A copper catalyst is added, and the bomb is pressurized with oxygen to 90 PSI at room temperature and submerged into a 150º C temperature bath. The bath temperature causes this pressure to increase to approximately 200 PSI. The bomb is rotated and as oxidation occurs, the pressure drops. The usual failure point is taken as a 25 PSI drop from the maximum pressure attained at 150º C. The results are reported as the number of minutes to the 25 PSI loss.

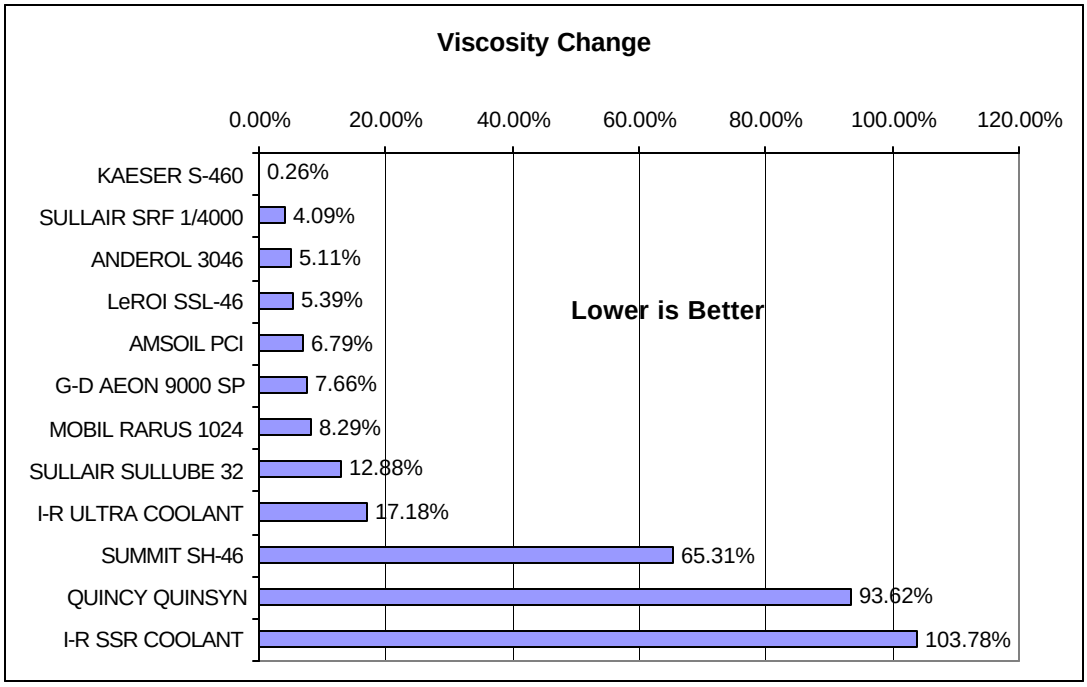


Modified Universal Oxidation/Thermal Stability Test ASTM D-4871

This universal test allows for the examination of oxidation stability under a prescribed condition. This test was conducted with a copper and iron catalyst since these components are often found in compressors. The temperature was elevated to increase the rate of oxidation and shorten the duration of the test. This oxidation test has been modified to the following conditions:

1) 192 ppm (parts per million) of an iron/copper catalyst
2) Test temperature is 160° C
3) Test time of 168 hours
4) 50 grams of oil
5) 10 liters of air per hour

As the oxidation of the oil occurs, the viscosity and acid values increase. These values are reported in the charts below.



Total Acid Values increase with oxidation. A lower change in TAN indicates less oxidation. TAN values were measured using ASTM D 664.

Brand	Product	TAN Change
KAESER	S-460	0.02
AMSOIL	PCI	0.05
COMP AIR LeROI	SSL-46 PLUS	0.1
SULLAIR	SULLUBE 32	1.31
SULLAIR	SRF 1/4000	1.53
MOBIL	RARUS 1024	1.72
INGERSOLL-RAND	ULTRA COOLANT	1.81
GARDNER DENVER	AEON 9000 SP	1.90
ANDEROL	3046	1.93
QUINCY	QUINSYN	1.96
SUMMIT	SH-46	2.10
INGERSOLL-RAND	SSR COOLANT	3.58

Water Resistance

When air or process gasses are compressed, moisture from humidity condenses and collects in the oil. Therefore, the oil needs to have good hydrolytic stability, demulsibility and rust protection.

Good hydrolytic stability is important as this helps prevent the formation of acids and insures long lubricant life.

Demulsibility is the oil's ability to separate from water. This is important because it allows for water to be drained from the oil sump. Water is a poor lubricant and water mixed in with oil (emulsified) can cause thinning of the oil and premature wear. In addition, water mixed in with the oil can degrade the oil faster and shorten lubricant life.

Since water is present, rust protection is important. Oil in its neat state, without additives, does a poor job of preventing rust. The oil needs to be formulated with additives that will inhibit the formation of rust. Rust is very abrasive and once formed on bearings and critical components it will significantly shorten component life.

The candidate oils were subjected to three tests to measure hydrolytic stability, demulsibility and rust protection.

Hydrolytic Stability ASTM D-2619

This test is used to determine the stability of oils in contact with water. It depends upon the catalytic effect of copper at elevated temperatures in the presence of water to accelerate the rate of hydrolysis. This test is conducted by incorporating 75 grams of test oil along with 25 grams of water and a polished, weighed copper strip catalyst sealed in a 6 ounce pressure type beverage bottle. The bottle is rotated at 5 rpm, end over end, for 48 hours in an oven at 200° F.

At the end of the test, 6 parameters are measured. They are: acidity of water layer, TAN change of oil, insolubles present, percent change in oil viscosity, weight change of copper panel, and appearance of copper panel.

The most significant parameters are acidity of water, appearance of copper panel, and weight loss of copper panel. The other parameters importance depends on the amount of deviation from the initial measurements.

The following chart shows the amount of acid in the water. A lower amount of acid is considered better. For reference, Denison HF-O, a top tier hydraulic oil performance standard, has a maximum allowable limit of 4 mg KOH.

Acidity of Water Layer

Brand	Product	mg KOH (acid)
INGERSOLL-RAND	ULTRA COOLANT	0.02
MOBIL	MOBIL RARUS 1024	0.11
SULLAIR	SULLUBE 32	0.54
ANDEROL	ANDEROL 3046	0.76
GARDNER DENVER	AEON 9000 SP	0.88
INGERSOLL-RAND	SSR COOLANT	0.94
KAESER	S-460	1.01
AMSOIL	PCI	1.13
SULLAIR	SULLAIR SRF 1/4000	1.21
QUINCY	QUINSYN	1.48
COMP AIR LeROI	SSL-46 PLUS	2.40
SUMMIT	SUMMIT SH-46	3.25

The following chart shows the amount of acidic change in the oil following the test. A high change is undesirable. Negative acid values can be attributed to acid neutralization by the catalyst and/or acid transfer to water.

Brand	Product	TAN Change of Oil
COMP AIR LEROI	SSL-46 PLUS	-.05
QUINCY	QUINSYN	-.01
KAESER	S-460	.01
GARDNER DENVER	AEON 9000 SP	.01
SULLAIR	SULLAIR SRF 1/4000	.02
AMSOIL	PCI	.03
MOBIL	MOBIL RARUS 1024	.06
ANDEROL	ANDEROL 3046	.07
SUMMIT	SUMMIT SH-46	.07
SULLAIR	SULLUBE 32	.11
INGERSOLL-RAND	ULTRA COOLANT	.15
INGERSOLL-RAND	SSR COOLANT	1.49

The following chart shows the amount of insolubles present after the test by percentage. A lower percentage is desired.

Brand	Product	Insolubles
MOBIL	MOBIL RARUS	0.00%
SUMMIT	SUMMIT SH-46	0.00%
INGERSOLL-RAND	ULTRA COOLANT	.002%
INGERSOLL-RAND	SSR COOLANT	.003%
ANDEROL	ANDEROL 3046	0.01%
SULLAIR	SULLUBE 32	0.01%
SULLAIR	SULLAIR SRF 1/4000	0.01%
AMSOIL	PCI	0.019%
QUINCY	QUINSYN	0.02%
KAESER	S-460	0.02%
GARDNER DENVER	AEON 9000 SP	0.03%
COMP AIR LeROI	SSL-46 PLUS	0.05%

This chart shows the change in viscosity that occurred during the test. Changes in viscosity can be attributed to water solubility of either the light or heavy components of the oil. Deviation from initial viscosity is undesirable.

Brand	Product	%Change in Viscosity
INGERSOLL-RAND	SSR COOLANT	-2.34%
SUMMIT	SUMMIT SH-46	-0.65%
GARDNER DENVER	AEON 9000 SP	-0.27%
AMSOIL	PCI	-0.06%
MOBIL	MOBIL RARUS 1024	-0.03%
ANDEROL	ANDEROL 3046	0.00%
QUINCY	QUINSYN	0.02%
SULLAIR	SULLAIR SRF 1/4000	0.03%
KAESER	S-460	0.11%
COMP AIR LEROI	SSL-46 PLUS	0.12%
INGERSOLL-RAND	ULTRA COOLANT	2.79%
SULLAIR	SULLUBE 32	4.03%

Weight Change of Copper Panel

Results: **All oils did well on this test exhibiting a less than .06 mg/cm^2 weight change.**

Appearance of Copper Panel

Results: **All oils did well on this test achieving a "1b" or better rating.**

Demulsibility ASTM D-1401

This test is used to determine the ability of hydraulic oils, steam turbine oils and many similar products to separate from water.

In this test, 40 ml of distilled water and 40 ml of oil are measured into a properly cleaned 100 ml graduated cylinder and immersed in a bath at 130°F. The oil and water are mixed for 5 minutes at 1500 rpm with a special stirrer. The amounts of separated oil, water and emulsion are recorded at 5-minute intervals for up to one hour reported as ml oil/ ml water/ ml emulsion (minutes). Most specifications require separation, so that less than 3 ml of emulsion (cuff) remain after 30 minutes.

Brand	Product	Demulsibility
GARDNER DENVER	AEON 9000 SP	40/40/0(5)
COMP AIR LeROI	SSL-46 PLUS	40/40/0(5)
QUINCY	QUINSYN	40/40/0(5)
INGERSOLL-RAND	SSR COOLANT	40/40/0(5)
ANDEROL	ANDEROL 3046	40/40/0(10)
SUMMIT	SUMMIT SH-46	40/40/0(10)
AMSOIL	PCI	40/40/0(15)
KAESER	S-460	40/40/0(15)
MOBIL	MOBIL RARUS 1024	40/40/0(15)
SULLAIR	SULLUBE 32	40/40/0(20)
SULLAIR	SULLAIR SRF 1/4000	40/40/0(45)
INGERSOLL-RAND	ULTRA COOLANT	0/30/50(65)

Rust Prevention in Synthetic Sea Water ASTM D-665B

This test is designed to measure the ability of industrial oils to prevent rusting under conditions of water contamination. The test consists of stirring a mixture of 300 ml of water, either distilled or seawater, at 140° F for 24 hours. A special cylindrical steel test specimen made from #1028 cold finished carbon steel is polished and then completely immersed in the test fluid. At the conclusion of the 24-hour period the specimen is removed, washed with solvent and rated for rust. In order to pass the ASTM D-665 Rust Test, the specimen must be completely free from visible rust when examined without magnification under normal light.

This test conducted in synthetic seawater is more severe than in distilled water. It helps identify the oils with superior rust protection.

Brand	Product	Rust Prevention Procedure B
AMSOIL	PCI	PASS
COMP AIR LeROI	SSL-46 PLUS	PASS
SULLAIR	SULLAIR SRF 1/4000	PASS
SUMMIT	SUMMIT SH-46	PASS
MOBIL	MOBIL RARUS 1024	PASS
ANDEROL	ANDEROL 3046	FAIL
INGERSOLL-RAND	ULTRA COOLANT	FAIL
INGERSOLL-RAND	SSR COOLANT	FAIL
QUINCY	QUINSYN	FAIL
SULLAIR	SULLUBE 32	FAIL
GARDNER DENVER	AEON 9000 SP	FAIL
KAESER	S-460	FAIL

Foam Stability ASTM D-892

The oil in flooded rotary screw compressors experiences severe churning and foaming of the oil is likely to occur. Foam causes increased oxidation by exposing more of the surface area of the oil to oxygen. Foam also increases heat by acting like a blanket and not allowing the oil to dissipate the heat. Foam reduces the lubricating qualities of oil because the bubbles collapse and reduce the oil film in critical areas. The test oils were subjected to one test.

This test method is used to evaluate oils operating in systems with high-speed gearing, high-speed bearings, high-volume pumping and splash lubrication.

This test consists of a 1000 ml graduated cylinder, 200 ml of oil and an air inlet tube which is fastened to a gas diffuser placed at the bottom. Air at a rate of 94 ml/min flows through the diffuser. The test is conducted in three sequences.

Sequence I is conducted at 75° F, Sequence II is conducted at 200° F, and Sequence III is conducted at 75° F. The foam results are reported in ml of foam at test end and after 10 minutes of settling.

Brand	Product	Foam Tendency*
AMSOIL	PCI	0/0/0
ANDEROL	ANDEROL 3046	0/0/0
INGERSOLL-RAND	SSR COOLANT	0/0/0
COMP AIR LeROI	SSL-46 PLUS	0/0/0
QUINCY	QUINSYN	0/0/0
SULLAIR	SULLUBE 32	0/0/0
INGERSOLL-RAND	ULTRA COOLANT	0/0/0
SULLAIR	SULLAIR SRF 1/4000	0/10/0
SUMMIT	SUMMIT SH-46	0/25/0
GARDNER DENVER	AEON 9000 SP	150/10/110
MOBIL	MOBIL RARUS 1024	160/30/70
KAESER	S-460	280/30/155

*After 10 minutes of settling, all test subjects registered 0/0/0.

Anti-wear

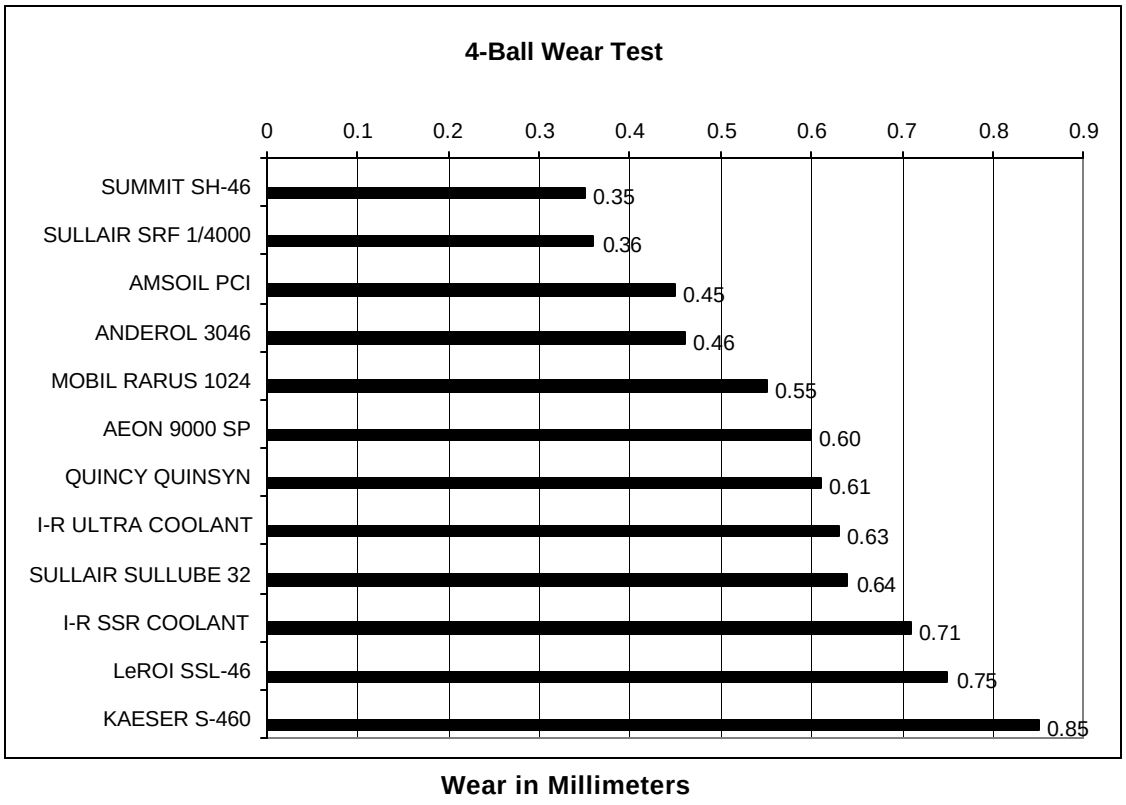
Anti-wear chemistries are not always used in compressor oils. It is speculated that this is done because the high-speed operation of flooded rotary compressors allows the bearings and components to ride on top of the oil film and therefore anti-wear additives are not needed. It is also speculated that anti-wear additives can inhibit other performance parameters of the oil such as oxidation stability.

Since the choice to use anti-wear chemistries is left to the oil manufacturers, and many have chosen to incorporate it, the anti-wear performance of each oil was measured. Test oils were evaluated for these criteria as follows:

Wear Preventive Characteristics of Lubricating Fluid ASTM D 4172 (4-Ball Method)

This test method is used to determine the anti-wear properties of a fluid. It is conducted with 3 steel balls clamped together and covered with the lubricant to be evaluated. The fourth ball is pressed with force into the cavity formed by the 3 balls clamped together. The temperature of the test lubricant is regulated and the fourth ball is rotated. Using the average size of the wear scars worn on the 3 lower clamped balls is how is wear is measured. The test conditions that the candidates were subjected to are 75° C, 1200 RPM and 40 kg of force.

The diameters of the wear scars are measured in millimeters. Lower values represent better anti-wear performance.



Copper Corrosion ASTM D-130

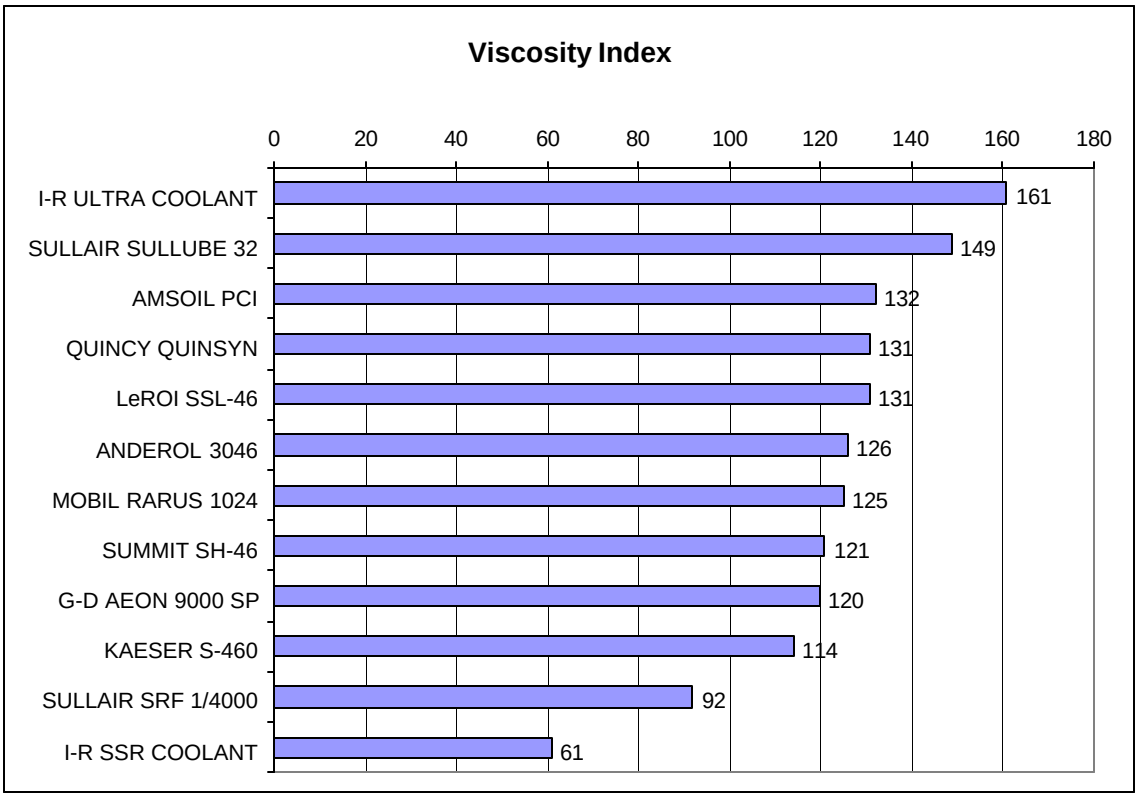
Corrosion resistance is an important consideration in compressor oils. Copper corrosion characteristics were measured using the ASTM D-130 test. This test operates for 3 hours at 100° C with a copper strip submerged in the candidate oil. **All oils tested were non-corrosive and achieved a perfect score 1a.**

Physical Data

Other data has been accumulated to describe the properties of the various oils. This is physical data and does provide an indication of performance in certain areas such as cold temperature operation. Three data points are presented:

Viscosity Index ASTM D-2270

Viscosity Index indicates the degree of change in viscosity of an oil within a given temperature range. A high VI signifies a relatively small change in viscosity, whereas a low VI reflects a larger change in viscosity. Generally high a viscosity index is more desirable.



Viscosity at 40° C ASTM D-445

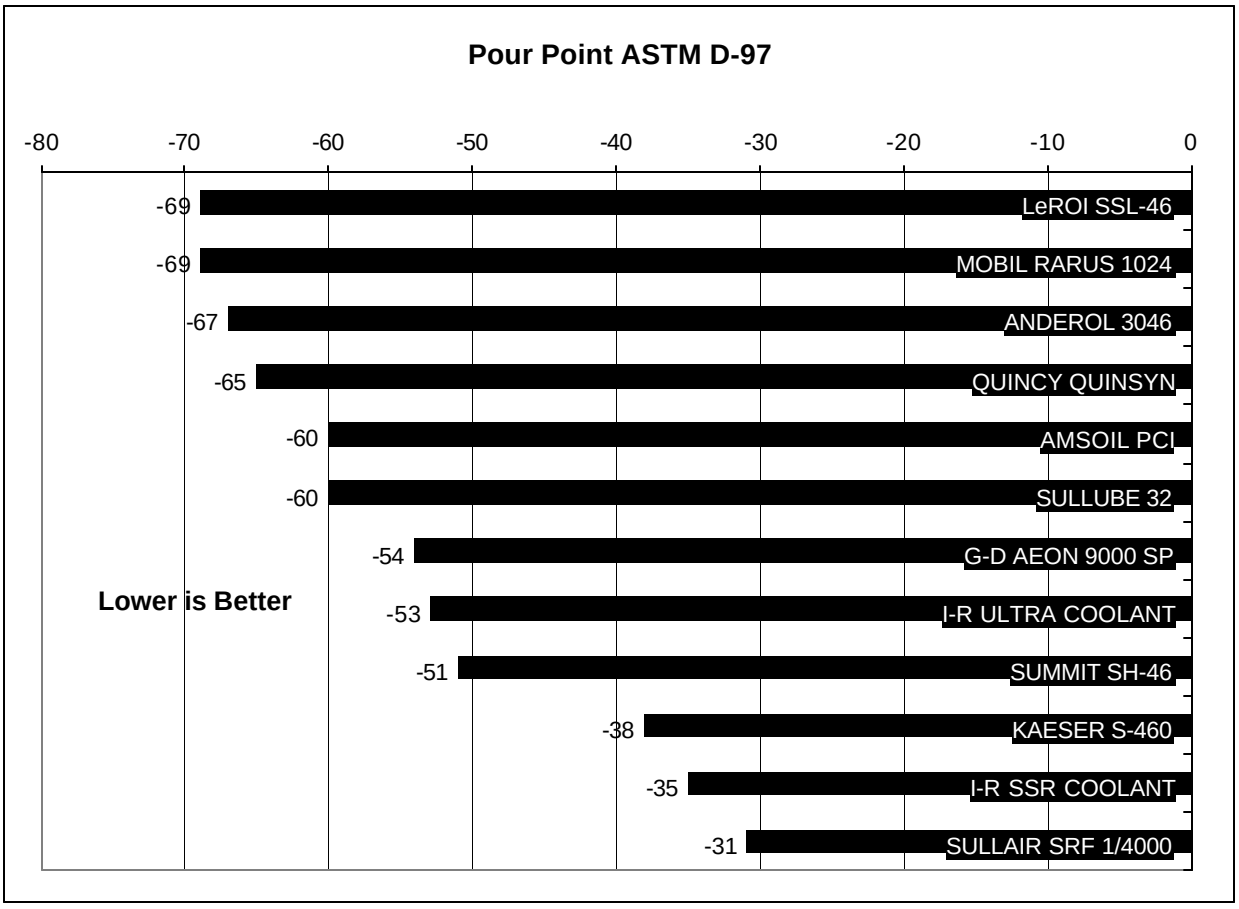
This is the temperature at which an oil's viscosity is measured for ISO viscosity grading.

Brand	Product	Viscosity at 40° C
AMSOIL	PCI	47.24
ANDEROL	ANDEROL 3046	44.99
INGERSOLL-RAND	ULTRA COOLANT	49.35
INGERSOLL-RAND	SSR COOLANT	65.95
COMP AIR LeROI	SSL-46 PLUS	33.79***
QUINCY	QUINSYN	44.63
SULLAIR	SULLUBE 32	39.18
SULLAIR	SULLAIR SRF 1/4000	39.09
GARDNER DENVER	AEON 9000 SP	30.03
SUMMIT	SUMMIT SH-46	44.31
KAESER	S-460	45.62
MOBIL	MOBIL RARUS 1024	32.22

******* Note that according to the International Standards Organization, the acceptable viscosity range for an ISO-46 oil is 41.4 cSt. to 50.6 cSt. The oil noted, while marketed as ISO-46 oil, is out of range and would be classified in the ISO-32 grade.

Pour Point ASTM D-97

This is a physical measurement of the oil's ability to flow at cold temperatures. This test gives an indication of an oil's limiting factors when cold temperatures are involved. A good safety margin for compressor start up is 20° F above the pour point. Oil starvation could occur at colder temperatures and result in equipment damage.



*** Note: In general, lower viscosity oils have lower pour points. Mobil Rarus and Gardner Denver AEON 9000 SP are ISO 32 viscosity oils as labeled. Comp Air LeROI SSL-46 Plus is advertised as an ISO-46 oil but was tested and found to be in the ISO-32 range. Ingersoll-Rand SSR Coolant is an ISO-68.

Pricing

There is a wide variety of pricing in the industry with OEM lubricants averaging 60% higher than oil company products. The average price of four oil company synthetic lubricants was $132.41 per pail while the average for seven OEM products was $217.98. Since it is not classified as a synthetic, the Sullair 1/4000 is not included in these calculations. The AMSOIL PCI product, which is a synthetic oil based on a combination of PAOs and esters, is priced lower than all of the other oils tested. Prices for pails and drums are included in the following charts.

Pail Pricing

Brand	Product	5 Gallon Pail
AMSOIL	PCI	$109.75
SULLAIR	SRF 1/4000	$119.50
MOBIL	RARUS 1024	$133.20
SUMMIT	SH-46	$134.20
ANDEROL	3046	$152.50
QUINCY	QUINSYN	$185.00
KAESER	S-460	$191.00
COMP AIR LeROI	SSL-46 PLUS	$193.00
GARDNER DENVER	AEON 9000 SP	$218.00
INGERSOLL-RAND	SSR COOLANT	$219.70
SULLAIR	SULLUBE 32	$235.50
INGERSOLL-RAND	ULTRA COOLANT	$283.70

Drum Pricing

Brand	Product	55 Gallon Drum
AMSOIL	PCI	$990.00
SULLAIR	SRF 1/4000	$1,286.50
SUMMIT	SH46	$1,366.20
MOBIL	RARUS	$1,370.40
ANDEROL	3046	$1,512.50
KAESER	S-460	$1,804.00
QUINCY	QUINSYN	$1,850.00
COMP AIR LeROI	SSL-46 PLUS	$1,971.00
INGERSOLL-RAND	SSR COOLANT	$2,210.90
GARDNER DENVER	AEON 9000 SP	$2,219.00
SULLAIR	SULLUBE 32	$2,552.50
INGERSOLL-RAND	ULTRA COOLANT	$2,785.80

Test Results Summary

The chart on the following page ranks the performance and price for each oil. Oils that ranked the best in the test were ranked with a one (1), second best with a two (2), and so forth. Oils that performed the same received the same rank. The lowest score represents the best overall product and price. All tests were weighted equally for purposes of developing this "golf" score.

Tests that are not included in this summary are the Hydrolytic Stability Percent Change in Viscosity and Change in the TAN of the Oil. Test results showed both increases and decreases in viscosity and TAN of the oil. There is no set rule for determining if an increase or decrease in viscosity or TAN makes an oil better or worse. In view of this fact and considering that the test results were very low, these tests were omitted.

Ranking the rust test pass/fail was simply done by assigning a one (1) for a pass and a two (2) for a fail. Proper rust protection is very important and may carry more weight than is reflected in the scoring. However, the scoring criteria were maintained for purposes of consistency.

The price ranking was done on the 5 gallon pail price. It should be noted that the price and ranking for drums is slightly different. However, this difference would have no impact on the overall product ranking in the following table.

	AMSOIL PCI	MOBIL RARUS 1024	ANDEROL 3046	COMP AIR LeROI SSL 46 PLUS	SUMMIT SH-46	SULLAIR SRF 1/4000	SULLAIR SULLUBE 32	QUINCY QUINSYN	I-R ULTRA COOLANT	GARDNER DENVER AEON 9000 SP	KAESER S-460	I-R SSR COOLANT
PHYSICAL TESTS												
VI	3	6	5	4	7	10	2	4	1	8	9	11
Pour Point °C (°F)	4	1	2	1	7	10	4	3	6	5	8	9
ANTIWEAR TESTS												
4-Ball Para 1	3	5	4	11	1	2	9	7	8	6	12	10
HYDROLYTIC STABILITY TESTS												
Appearance of Copper Panel	2	2	2	2	2	2	2	2	2	2	1	2
Acidity of Water Layer mg KOH	8	2	4	11	12	9	3	10	1	5	7	6
% Insolubles	5	1	4	8	1	4	4	6	2	7	6	3
OXIDATION TESTS												
Rotating Bomb Oxidation 150°C (minutes)	4	6	7	2	1	8	10	3	11	5	12	9
ASTM D 4871 MODIFIED UNIVERSAL OXIDATION STABILITY TEST												
(Vk40 %Viscosity Change)	5	7	3	4	10	2	8	11	9	6	1	12
TAN Change	2	6	9	3	11	5	4	10	7	8	1	12
MISCELLANOUS												
Foam Tendency	1	5	1	1	3	2	1	1	1	4	6	1
Copper Corrosion (3 hr, 100°C)	1	1	1	1	1	1	1	1	1	1	1	1
Demulsibility	3	3	2	1	2	5	4	1	6	1	3	1
Rust Prevention Procedure	1	1	2	1	1	1	2	2	2	2	2	2
PRICE												
PRICE (Per Pail)	**1**	**3**	**5**	**8**	**4**	**2**	**11**	**6**	**12**	**9**	**7**	**10**
TOTAL SCORE (LOWER IS BETTER)	**43**	**49**	**51**	**58**	**63**	**63**	**65**	**67**	**69**	**69**	**76**	**89**

Discussion

Compressor oils need to be able to perform many functions. These include oxidation stability, water stability, rust protection, foam resistance, copper corrosion resistance and anti-wear performance. There was not one oil that did perfectly in all categories. This is because as different chemistries are introduced to achieve a particular performance parameter, sacrifices are often times made in other areas. For example, chemistry that is good for rust protection may cause foaming, and chemistry that is good for anti-wear may not be good for oxidation resistance.

It is important to have a well-balanced product that will give good performance in all areas needed by compressors. And while AMSOIL PCI Synthetic Compressor Oil did not do the best in every category, it did perform well in all categories. AMSOIL produced PCI to be a well-balanced oil that delivers consistent, dependable performance in one of the most critical pieces of equipment in a manufacturing environment.

After seeing the data, one would expect the price of AMSOIL PCI Synthetic Compressor Oil to be higher than the other oils tested. However, this is not the case because AMSOIL specializes in synthetic oil manufacturing and does this job very efficiently. Another reason for the low cost is that AMSOIL sells factory direct. This eliminates the multiple steps of distribution that unnecessarily inflate the oil's price.

There are a large number of compressor oils on the market with a wide variance in performance and price. Without established performance standards for consumers to refer to, after market compressor oil performance is left to each individual oil manufacturer.

Without an official standard, compressor OEMs market their own brand of oil to insure that the oil used in their compressors meets the lubrication needs. Compressor OEMs in turn may tie warranty requirements to the use of their oil. This means that the consumer pays a high price for oil of a known quality by the OEM.

The AMSOIL prices posted in this study are the maximum suggested retail price to keep an "apples to apples" comparison. In actuality, AMSOIL offers a much lower commercial price with purchase discounts and freight allowances to many industrial end users of the product.

For more information and pricing of AMSOIL PCI Synthetic Compressor Oil, contact your AMSOIL Dealer or contact the AMSOIL Industrial Division at 1-715-392-7101.

The results in this report indicate that to get superior performance, you do not have to pay the inflated price of compressor OEM branded lubricants.

Affidavit of Test Results

Affidavit

I hereby affirm that to the best of my knowledge all of the test results reported in the document entitled " A study of Compressor Oils" also known as Whitepaper # 7 prepared for the Amsoil Industrial Division in June of 2000 are correct. I further affirm that the tests requested followed procedures approved by the American Society of Testing and Materials (ASTM) or other recognized procedures that are referenced in the paper. Written documentation of test results are on file at Amsoil, Inc.

David E. Leitten

STATE OF Wisconsin
COUNTY OF Douglas

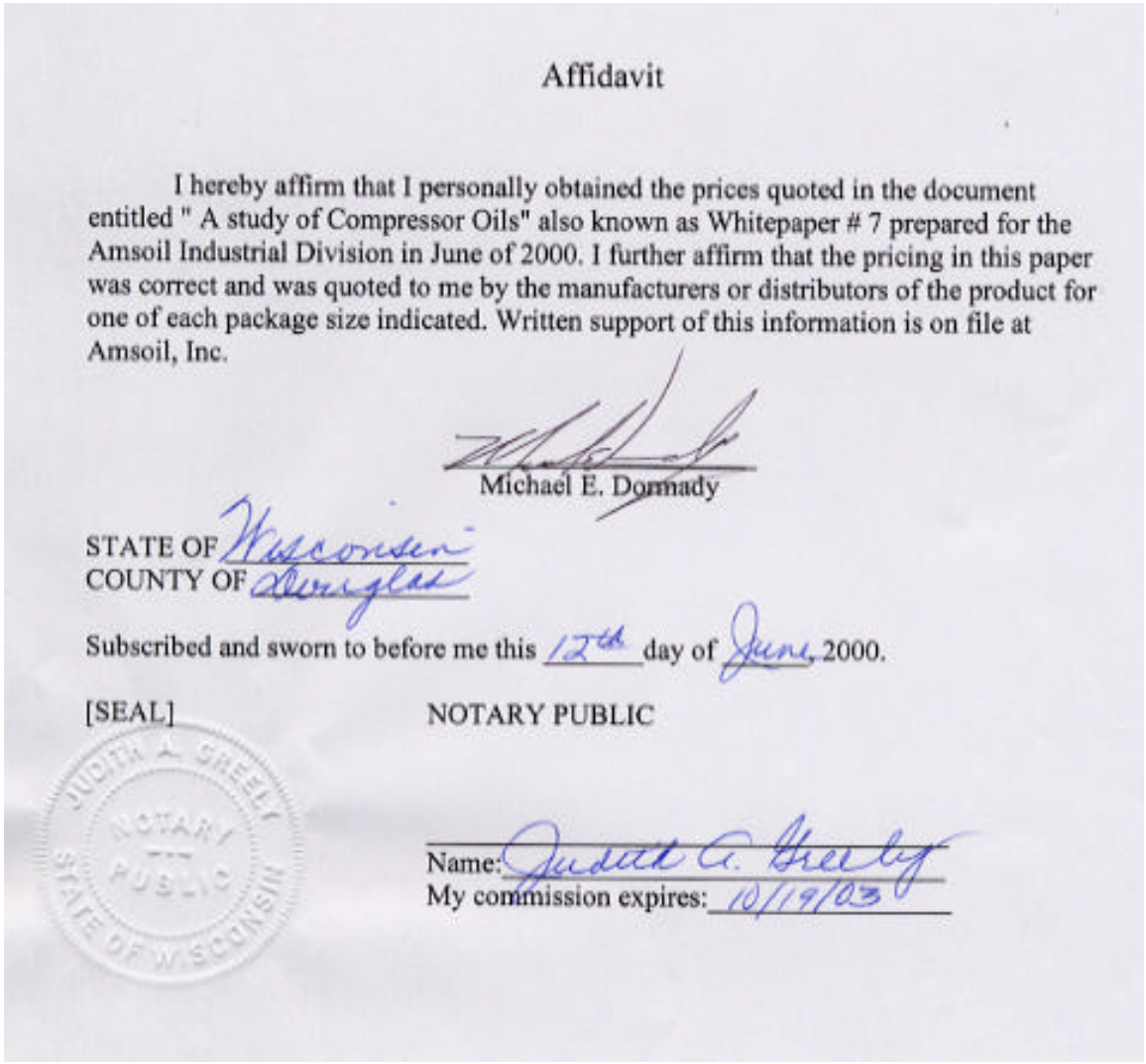
Subscribed and sworn to before me this 12th day of June 2000.

[SEAL] NOTARY PUBLIC

JUDITH A. GREELY NOTARY PUBLIC STATE OF WISCONSIN

Name: Judith A. Greely
My commission expires: 10/19/03

Affidavit of Pricing



Affidavit

I hereby affirm that I personally obtained the prices quoted in the document entitled " A study of Compressor Oils" also known as Whitepaper # 7 prepared for the Amsoil Industrial Division in June of 2000. I further affirm that the pricing in this paper was correct and was quoted to me by the manufacturers or distributors of the product for one of each package size indicated. Written support of this information is on file at Amsoil, Inc.

Michael E. Dormady

STATE OF Wisconsin
COUNTY OF Douglas

Subscribed and sworn to before me this 12th day of June, 2000.

[SEAL] NOTARY PUBLIC

JUDITH A. GREELY NOTARY PUBLIC STATE OF WISCONSIN

Name: Judith A. Greely
My commission expires: 10/19/03

Batch Numbers of Compressor Oils Tested

Brand	Product	Batch Number
AMSOIL	PCI	6091 AND ABOVE
ANDEROL	ANDEROL 3046	04037406
INGERSOLL-RAND	ULTRA COOLANT	----------
INGERSOLL-RAND	SSR COOLANT	99-1
COMP AIR LeROI	SSL-46 PLUS	988780
QUINCY	QUINSYN	991075
SULLAIR	SULLUBE 32	----------
SULLAIR	SULLAIR SRF 1/4000	----------
GARDNER-DENVER	AEON 9000 SP	989360
SUMMIT	SUMMIT SH-46	B-90206
KAESER	S-460	B-01903
MOBIL	MOBIL RARUS 1024	L04798

Reference:

Industrial Lubricants Tests, The Lubrizol Corporation, Cleveland, 1993.

Annual Book of ASTM Standards, ASTM, Philadelphia, 1998.