OIL TREATMENT PRODUCTS FOR FRICTION & WEAR PROTECTION

4 BALL WEAR TEST

BELL PERFORMANCE

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Controlled Testing of Aftermarket Oil Additive Products for Friction and Wear Protection: Four Ball Wear Test

July 2009

Introduction

Bell Performance, Inc. is the oldest fuel additive company in the United States, founded by Robert. J. Bell in 1909 to coincide with the development of the United States' first fuel additive on record. In the 1980s, Bell Performance developed an aftermarket additive product for engine oil, called **X-tra Lube**. X-tra Lube has been sold continuously since that time, both domestically and through foreign private label agreements.

Recently, Bell Performance was given the opportunity to compare its oil additive to a pool of other aftermarket oil additive products. There are hundreds of aftermarket additive products for lubricating oil, representing hundreds of millions if not billions of dollars in annual sales. Many of these products utilize the same technologies as their competitors and make the same kinds of product claims – reduced friction, increased power and compression, viscosity improvement – as their competitors. What's more, many of these companies either utilize faulty testing or incorrectly interpret test data to "document" their claims or simply do not disclose test data at all.

Therefore, the purpose of this test is to compare and contrast the X-tra Lube product with other product samples supplied by a leading distributor of after-market oil products. The comparative product list includes names familiar to many consumers:

- Greased Lightning
- Hy-per Lube
- Lucas Oil Stabilizer
- Marvel Mystery Oil
- MotorPurr Oil Stabilizer
- NAPA Oil Treatment
- Prolong Engine Treatment
- Rislone Oil Stabilizer
- Slick 50 Engine Treatment
- STP Oil Treatment
- Torco Oil
- Z-Max Friction Reducer

From this point, the claimed functions and benefits for each product will be discussed along with available test data for each product if available testing. At this point, controlled comparative test results for the pool of test products, including X-tra Lube, will then be discussed. This will include a description of the test protocol, preparation of test samples, and a discussion of controlled test results with appropriate analysis.

Comparative Oil Products

Many of the products to be tested claim similar product functions, albeit achieved at different treat ratios. Treat ratios can be important in that they affect the cost of product use to achieve the same results as a different product. The products are listed below in order of least to most expensive cost to treat.

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Oil Product Treatment Costs and Claimed Functions										
Product	Treat Rate (additive/ oil)	Retail Cost ($$)*	Product Size (oz.)	Cost to Treat **	Reduces Friction	Oil Stabilizer	Improves Mileage	Improves Emissions	Viscosity Modifier	Increases Horsepower
STP Oil Treatment	1:10.7	$4.50	15 oz.	$4.50	X				X	
X-tra Lube	1:80	$20	8 oz.	$5.00	X		X	X		X
Marvel Mystery Oil	1:5	$21	128 oz.	$5.25	X				X	
Hy-Per Lube	1:5	$8	32 oz.	$8.00	X				X	X
Lucas Stabilizer	1:5	$12	32 oz.	$12.00	X	X			X	
NAPA	1:5	$12	32 oz.	$12.00	X				X	
Greased Lightning	1:20	$13	32 oz.	$13.00	X		X		X	
Rislone Oil Stabilizer	1:5	$13	32 oz.	$13.00	X	X			X	
Slick 50	1:5	$19	32 oz.	$19.00	X					
Prolong	1:13.3	$20	12 oz.	$20.00	X					
MotorPurr	1:8	~~$20~~	16 oz.	~~$25.00~~	X	X	X	X		X
Z-Max	1:13.3	$30	12 oz.	$30.00	X		X	X		X
Torco Oil	1:1	$8.50	32 oz.	$42.50	X		X			X

* - Average retail cost. Actual cost may vary upon location. Does not include shipping costs from internet retailers.
** - Cost to treat based upon amount used per 5 quart oil change

All of the products claimed to reduce friction. Viscosity modification was the 2nd most common benefit claimed (typically claimed as a causative effect for the further effect of reducing friction). Improvements in mileage and horsepower were claimed by five of the thirteen, while emissions improvement and oil stabilization were the least common benefits claimed.

At this juncture, it was determined that it was necessary to narrow the scope of testing to an appropriate range. Individual controlled assessments of the mileage, emissions and horsepower effects for all thirteen products would produce test cost runs well into six figures (> $100,000). However, many manufacturers of aftermarket oil products link the benefit claims of increased horsepower, mileage improvements, reduction in noise and operating temperature, and extended engine life with a base claim of friction reduction. In order to narrow the scope of testing to an appropriate and cost-effective level, it was determined to settle on a test which would best document each additive's performance at reducing friction and bearing load under increasing load conditions.

It was also determined after consideration to narrow the number of products tested from thirteen to nine (plus one baseline sample). These two decisions produced a pool of ten products (nine products plus an untreated base oil sample) to be tested with a selected load-bearing ASTM test protocol.

Products Included In Testing Pool

X-tra Lube Concentrate (manufacturer: Bell Performance, Inc.)

- ***Treat Rate per 5 Quarts: 2 oz.***
- ***Cost to Treat: $5.00***

X-tra Lube Concentrate was formulated in the early 1980s by Bell Performance, Inc., who has the longest additive-producing history of any company in the test pool. X-tra Lube is sold by Bell Performance in both a concentrate form (to be mixed with the user's preferred base oil) and a pre-mixed form (already blended into base oil and ready to be added directly to the engine).

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The technology behind the X-tra Lube product is a simple concept , utilizing micro-metallic particles which, when subjected to the normal pressure and heat present within an engine, fill in the scratches and irregularities present on any seemingly-smooth metal surface. This results in metal surfaces now made "super-slick" by the re-surfacing action of the malleable metal ingredients. This action is similar to the theory espoused by the makers of PTFE ("Teflon") additives, two of which were included in the testing pool. However, unlike Teflon particles, the metallic particle within X-tra Lube are able to change shape and fill in the wear within the metal surfaces. Makers of Slick 50 and other Teflon additives claim a similar effect, but hide the fact that the Teflon molecules cannot change shape nor bond with metal surfaces, rendering them essentially ineffective for their product claim.

X-tra Lube claimed product benefits include reduced heat and friction, extended engine life, improved ring seal and reduced oil blow-by. The product also claims increased horsepower and torque.

Bell Performance does cite some controlled test results related to some of its product claims. Dynamometer testing was conducted with the additive added to the crankcase of a V-8 engine with a Superflow 901 dynamometer. Power tests were performed over a two-week period and the following changes were noted, before and after:

- Power at 2100rpm increased from 307hp to 323hp
- Torque at 2100rpm increased from 400 lb-ft to 420 lb-ft
- Blow-by was reduced from 8 standard cubic feet per minute (SCFM) to 2.5 SCFM.

A second dynamometer test was conducted in Australia, utilizing a Holden 173 Cubic inch engine coupled to a Go Power Model DA Dynamometer with built-in instrumentation. Baseline cylinder compression pressures were established at different throttle rpm speeds, followed by the addition of 100ml of X-tra Lube Concentrate to the engine oil. The engine was run for fifteen minutes and additional readings. The engine was then run for an additional twenty hours, to allow additional plating and repairing by the metallic particle contained in the X-tra Lube formulation.

Results from this test showed a 3.5% increase in horsepower over the range of 1000-3000 rpm, an 18% increase in thermal efficiency and a 100 rpm idle speed increase.

Bell Performance's cost to treat of $5.00 per oil change was the second lowest of the nine products tested, trailing only STP. Together, STP and X-tra Lube were significantly less expensive (approx. 40%) than even the third least-expensive product (Hy-Per Lube) and well under half the cost of the median product in expense (Greased Lightning).

Z-Max Friction Reducer (manufacturer: Oil-Chem/Speedway Motorsports, Inc.)

- ***Treat Rate Per 5 Quarts: 12 oz.***
- ***Cost to Treat: $30.00***

The Z-Max product claims to be a "micro-lubricant" containing molecules that soak into metal surfaces when applied to the engine and crankcase. The product claims that this action disperses carbon and other deposits, with a subsequent positive effect on gas mileage and vehicle performance. Z-Max claims to reduce friction, though it is not clear from the description of how the product works, how this is accomplished, other than a residual lubricating effect from the micro-lubricant particles in the metal surface. Additional product claims are an increase in horsepower, ostensibly due to the same cleaning action previously mentioned.

There were no controlled test results listed on the Z-Max web site which provided any positive or negative verification of the product claims. Numerous customer testimonials and a testimonial from their sponsor, Carroll Shelby, are available on the Z-Max web site.

In 2001, the manufacturers of the Z-Max product were the subject of legal action by the Federal Trade Commission (FTC) over unproved product claims and false representation of the meaning of certain test results. In the legal action, the FTC alleged the Z-Max manufacturers to have both fabricated test results and misrepresented the results of a CRC L38 test protocol (which measures bearing corrosion resistance) to "prove" the fuel mileage improvement claims of the product. The FTC alleged that test results for the protocol conducted for Oil-Chem and Speedway Motorsports showed the Z-Max product actually produced twice as much bearing corrosion as normal untreated motor oil. The complaint alleged that the manufacturer falsified one test report and altered another report from the laboratory to remove all negative test results, and subsequently used the altered report as documentation for a variety of unsupported product claims. The manufacturers for Z-Max reached an out-of-court settlement with the FTC without any formal admission of guilt.

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Z-Max's cost to treat of $30.00 per oil change made it the 2nd most expensive of all products and the single most expensive product tested in the testing pool.

Slick 50 Engine Treatment

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $19.00***

Slick 50 was first marketed in the 1970s through "multi-level marketing" netwroking before branching out in the 1980s into major retail outlets. Slick 50's major marketing ploy was the use of Teflon (PTFE) non-stick technology in it's "Slick 50 Protection Chemistry". Using the designation "the slipperiest substance on earth", Slick 50 claims that adding Teflon to engine oil would virtually eliminate friction and wear inside the engine by causing the Teflon to bond to metal surfaces.

Thus, Slick 50's product claims revolve around protecting against friction and heat within the engine. There are no controlled test results on Slick 50's web site documenting these claims, nor are there any customer testimonials to this effect.

In 1997, subsidiaries of Slick 50's then-manufacturer Quaker State (the rights to the product were subsequently sold to a different company) were the subject of legal action by the Federal Trade Commission over undocumented product claims. The action centered on the product's claims about the nature of engine lubrication during cold engine start-up and the Slick 50 product's claimed effects on fuel mileage, reduction in engine wear, horsepower, emissions and engine temperatures. The legal action was settled by the subsidiaries with a settlement for $10 million to be used for consumer redress.

Slick 50's cost to treat of $19.00 per oil change ranked 6th out of nine products tested.

STP Oil Treatment

- ***Treat Rate Per 5 Quarts: 15 oz.***
- ***Cost to Treat: $4.50***

STP is a name well-known within the industry through its association with Richard Petty and its wide network of retail sales.

The STP Oil Treatment product claims to be a high-viscosity formula which fights metal-to-metal friction by providing a thicker cushion (of lubricant) between moving engine parts. In other words, STP Oil Treatment is primarily a viscosity modifier, as opposed to containing some kind of particles or molecules which treat metal surfaces.

STP Oil Treatment product claims include protection against engine wear (hence, reduction of friction) and reduction of oil consumption. There are no controlled test results or relevant customer testimonials on the STP web site to document these product claims.

In 1978 STP Corporation and its then-parent company, First Brand Corporation, settled a legal action from the FTC over misrepresenting the role and benefits of motor oil additives in reducing wear inside engines. STP paid an $888,000 judgment, the third largest sum ever obtained by the FTC for a consumer protection violation.

STP's cost to treat of $4.50 per oil change was the least expensive of all products tested.

MotorPurr Oil Stabilizer (manufacturer: MotorPurr, Inc.)

- ***Treat Rate Per 5 Quarts: 20 oz.***
- ***Cost to Treat: ~~$25.00~~***

MotorPurr Oil Stabilizer is one of a full line of products made by its parent company, including a fuel injector cleaner, stop leak product and an automatic transmission product. The manufacturer claims to have been manufacturing products since 1967. The Oil Stabilizer product claims to reduce engine friction through the leaving of a protective oil film on metal surfaces throughout the engine (or wherever lubricating oil normally reaches). The manufacturer claims

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this action reduces friction, increases engine life, reduces engine oil consumption, reduces exhaust emissions and increases gas mileage. Unfortunately, there is no explanation of how this action contributes to some of these benefits. Furthermore, there are no controlled test results or customer testimonials on the product web site to support these general claims.

MotorPurr's cost to treat of $~~25.00~~ per oil change was the second highest of the nine products tested, and at least five times as expensive as the STP and X-tra Lube products.

Lucas Oil Stabilizer (manufacturer: Lucas Oil)

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $12.00***

Lucas Oil maintains a consistent and heavy presence in the aftermarket automotive market through its variety of oil and fuel treatment products. The oil stabilizer product has a primary function of oil stabilization, but also claims to increase motor oil lubricity, with corresponding benefits of reduction in heat, friction and engine noise. Other product benefits listed include elimination of dry starts, increased engine power and fuel mileage, and better retention of oil viscosity at higher temperatures (which would seem to indicate the product contains a viscosity modifier). The manufacturer does not explain how these results are accomplished by the product. Unlike some of the other competitive samples, there were customer testimonials listed on the Lucas web site providing documentation of these claims. However there were no controlled test results listed.

Lucas' cost to treat of $12.00 per oil change ranked 4th out of the nine products tested, one dollar less than the median product cost.

Prolong Engine Treatment (manufacturer: Goldenwest Lubricants)

- ***Treat Rate Per 5 Quarts: 12 oz.***
- ***Cost to Treat: $20.00***

The Prolong formula was developed in the early 1990s and has been sold continually since that time. The Prolong product claims to contain AFMT (Anti Friction Metal Technology) technology that they claim is unique worldwide. The AFMT technology utilizes long-chain molecules derived from paraffin-based hydrocarbons to produce uniquely stable lubricant chemicals (the manufacturer claims the highest results in controlled anti-corrosion lubricant tests). These molecules improve lubrication within the engine by bonding to metal surfaces both molecularly (through polar bonds) and chemically to create a protective buffer on the metal surface that enhances the film strength of the lubricant. The manufacturer also claims this buffer is activated in the presence of heat and pressure.

The Prolong web site was one of the few that listed controlled test results for the product. It should be noted that the CRC L-38 test deals with corrosion resistance, not wear prevention.

METHODOLGY	KEY RESULTS
Nissan KA24E Valve Train Wear Test (328-95)	Reduced cam wear by 78% Reduced rocker arm scuffing by 68% Reduced metal wear for iron by 67%
Ball-on-Cylinder Lubricity Evaluator (BOCLE) (ASTM D 5001-90A)	Reduced wear scarring by 14-19%
CRC L-38 (ASTM D 5119-99)	**PASSED:** 21.6 (below 40.0) rating on the Bearing Weight Loss Scale 9.9 (greater than 9.0) on the Piston Varnish Merits Scale

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Block-on-Ring	14.9% reduction in friction
Friction & Wear Test	36.0 % reduction in friction
	78.9 % reduction in wear

In 1999, the manufacturers of Prolong settled a legal action with the FTC concerning unsubstantiated product claims. The complaint detailing the charges alleged that Prolong made unsubstantiated claims that, compared to motor oil alone, Prolong ETC (Engine Treatment Concentrate) reduces engine wear at start-up and extends the duration of engine life. The complaint also alleged that Prolong made unsubstantiated claims that Prolong ETC reduces corrosion in engines and protects against engine breakdowns. The complaint further alleged Prolong made unsubstantiated claims that the benefits that may be achieved by using Prolong ETC in race cars or under racing conditions can also be achieved in ordinary automobiles in conventional use, and that testimonials and endorsements of consumers made in advertising reflected the typical or ordinary experience of members of the public who use Prolong.

Prolong's cost to treat of $20.00 per oil change ranked 7th of the nine products tested, and made it one of only three products tested to cost at least $20.00 per oil change.

Greased Lightning Engine Treatment (manufacturer: Greased Lightning)

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $13.00***

Greased Lightning is an oil treatment product containing PTFE, commonly known as Teflon. Consumers may recognize this as the active ingredient in the more-well-known product Slick 50. Greased Lightning product claims went as follows:

> ***Greased Lightning Engine Treatment has three times the PTFE/Teflon (friction modifier) of any other Engine Treatment plus Oil Viscosity Stabilizers that prevent oil breakdown during high performance, extended or severe driving conditions. DuPont created PTFE and named it Teflon. PTFE reduces friction to Virtually Zero (named in the Guinness Book of World Records as the slipperiest substance known to man) Mechanics rate Greased Lightning #1 in stopping Friction and Wear in Higher Mileage Vehicles.***

It may be useful to note that Teflon's manufacturer, Dupont, never claimed the Teflon substance would reduce friction within engine conditions.

The Greased Lightning web site contains a mixture of customer testimonials for both the engine treatment and a fuel system treatment manufactured by the same company. Controlled tests cited consist of an SAE paper titled "*Engine Durability, Emissions and Fuel Economy Studies with Special Boundary Lubricant Chemistry*", in which the paper cites "a unique combination of boundary lubricant and surfactant chemistries has produced significant benefits in ring and bearing wear control". Unfortunately it is not made clear within the paper that the "technology" tested is the PTFE technology contained in Greased Lightning, or a different technology.

Greased Lightning's cost to treat of $13.00 per oil change ranked it 5th of 9 products tested, making it the median product for price.

Hy-Per Lube (manufacturer: Hy-Per Lube Corporation)

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $8.00***

Hy-Per Lube oil supplement was originally formulated in the 1950s. It makes multiple product benefit claims, including improvement of fuel efficiency, horsepower and torque, and lubricity-related claims of reduced oil consumption, reduced friction and lower operating temperatures, increased equipment life, improved compression, noise reduction and reduced cold start-up wear.

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The Hy-Per Lube product claims to work through the functioning of a viscosity improver (which reduces oil thinning at higher temperatures and oil thickening at low temperature). The product also claims to increase the film strength and surface tension of the oil, which causes the oil to cling to cylinder walls and bearing surfaces and remain there for protection against cold starts. The manufacturer claims this characteristic reduces oil leakage and restores compression in old engines, resulting in cleaner combustion and increased fuel efficiency.

Unfortunately, the manufacturer does not give any supporting testimonials or controlled test data to support these claims.

Hy-Per Lube's cost to treat of $8.00 per oil change ranked third of nine products tested.

Products Not Included In Test Pool

Four of the thirteen products originally sent were not included in the final test group. This decision was made in order to keep the size of the test pool at a more manageable size. These products could be included in a follow-up test at a later time.

Marvel Mystery Oil (manufacturer: Marvel Oil Company)

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $5.25***

Marvel Mystery Oil is one of the oldest lubricant products on the market, with its parent company founded in 1923. The exact date of the product's first development is not readily known. It was originally designed to have a detergent action to clean and maintain carburetors in pre WW-II vehicles. Marvel Mystery Oil is designed to work as both a multi-purpose fuel and oil additive. It can be dissolved in fuel to provide lubrication to top cylinder areas and areas of the engine not normally serviced by lubricant oil. When added to the oil, it improves the oil viscosity index while adding extra sludge-fighting and acid-neutralizing properties to the oil.

Claimed product benefits include these benefits, plus improved ring seal which, the manufacturer claims, leads to reduced oil blow-by, improved power and increased fuel mileage. The product also claims to reduce the harmful effects of crankcase oil dilution. There are no controlled test data or customer testimonials listed on the product web site to verify or quantify these product claims.

Marvel's cost to treat of $5.25 was the third lowest of the thirteen products considered. This is in part due to its use as both a fuel additive and oil additive, which necessitates a lower treat cost (consumers are much less likely to use an expensive additive in their fuel as they will in their oil).

NAPA Oil Treatment (manufacturer: NAPA Auto Parts)

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $12.00***

NAPA Oil Treatment is manufactured by NAPA Auto Parts and is sold through NAPA's large network of aftermarket auto supply stores. The product claims are similar to other products in the test pool; it contains viscosity modifiers to reduce oil thinning at high temperatures. This increases the oil film strength, reducing wear, friction and engine operating temperature. The product contains anti-foaming ingredients to reduce the inclusion of entrained air during high-speed operation, which can adversely affect the oil film strength and lubricating ability. Resultant benefits for the engine include longer engine life, reduced oil consumption, increased compression and horsepower and reduced oil burning.

The NAPA web site did not list any information on controlled test data or customer testimonials to document these claimed benefits.

NAPA's cost to treat of $12.00 was slightly less expensive than the median product cost for the products tested.

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Rislone Oil Stabilizer (manufacturer: Bars Products)

- ***Treat Rate Per 5 Quarts: 32 oz.***
- ***Cost to Treat: $13.00***

Rislone Oil Stabilizer is one product in a multi-product line manufactured by Bar's Products (founded in 1947) which includes injector cleaners, radiator products, air conditioner and cooling system repair products, and multiple types of products to stop automotive leaks. The Oil Stabilizer product contains viscosity modifiers to prevent thinning of oil viscosity at high temperatures and pressures. The manufacturer claims Rislone Oil Stabilizer will reduce friction and engine wear, especially during dry start-ups, while also reducing and dispersing oil sludge. Reduction of friction results in less engine wear and a lower engine operating temperature. The product ingredients also list a "tachifier" which causes the treated oil to cling to bearings and metal surfaces to increase lubrication during cold start-ups.

There were no supporting test information or customer testimonials provided to document or quantify these claims.

Rislone's cost to treat of $13.00 was equal to the median product cost for the nine products tested.

Torco Oil (manufacturer: Torco Oil Company)

- ***Treat Rate Per 5 Quarts: 1:1 ratio – 160 oz.***
- ***Cost to Treat: $42.50***

Torco's manufacturer started in 1948 producing lubricants and products for racing applications. The company has a wide range of product line consisting of synthetic oils, transmission fluids, gear oil and diesel oils, lubricants for racing oils and lubricants for engine builders.

Torco's lubricating oil formulations utilize high amounts of ZDDP in their proprietary blends. ZDDP is a common oil additive which contributes greatly to the oil's ability to provide a high film strength to provide adequate lubrication in high-pressure applications such as racing. The ZDDP will form a molecular complex on the metal surfaces (somewhat in the same way that some of the other additives in the test pool claim); this molecular complex provides lubrication to the metal surface. The resulting reduced friction gives the consumer the same kind of ancillary benefits listed with other products claiming the same type of benefit – increased engine life, reduced wear, reduced noise and lower engine operating temperature. Most mainstream oils have limited or reduced the amount of ZDDP in their base formulations, due to concerns by the EPA over the zinc and phosphorus in ZDDP causing fouling of catalytic convertors. For racing applications, such a concern is not a high priority, and thus Torco has been a strong presence in the racing market for a number of years.

Torco claims a quantified increase in horsepower and torque of as much as 3%. There were no controlled test data or customer testimonials cited on the product web site to support these specific claims.

The Torco product was the most expensive of the products sent by a wide margin, costing over $40.00 per 5-quart oil change. This was due to the Torco product being used as a straight 1:1 substitute for engine oil, instead of a 1:5 or great treat ratio as with other products in the test pool.

The Torco product was not included in the pool of product tested because the sample was unable to be located at time of testing. It is anticipated to be able to do a similar comparison test between X-tra Lube and Torco in the future.

Testing Protocols

As seen above, many of the oil products supplied claim multiple benefits. For these major benefits, there are ASTM and other tests which can be used to document their levels of effectiveness for each function. However, the most important characteristic of these products would be their lubricating ability – the ability to protect the metal surfaces against friction and wear. Many of the products also claim multiple ancillary benefits – oil stability, corrosion protection, increases in fuel mileage and reductions in emissions. One could employ a myriad of tests to document and compare these results; however, for the purposes of this testing battery, we will focus on documenting the most important characteristic - lubricating and friction-reducing ability.

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A number of ASTM tests may be employed to test a lubricant's ability in this respect. To most accurately assess a lubricant's true ability, tests should be employed to test both 1) a lubricant's maximum load bearing ability and 2) its ability to bear load and lower friction under conditions of steady pressure and force. A lubricant may be superior in one aspect but not the other. The first test may document a substance's lubricating strength while the second test can simulate the performance of the lubricant in conditions more similar to those existing within a engine (without the corresponding heat). Accurate test data measuring both types of wear situation should be gathered so as not to paint an inaccurate picture of a lubricant's effectiveness.

The two tests selected to compare these properties across the samples were:

TESTING FOR MAXIMUM LOAD-BEARING ABILITY

Test: ASTM D-2783 Four Ball EP Wear

The "Four Ball EP Wear" test is designed to document a lubricant's load-bearing capacity at increasing loads over a period of time. The test gives a number of important data points which illustrate this: Load Wear Index, Last Seizure Load, Last Non-Seizure Load, Scar Diameter, and Weld Point.

PROTOCOL: Three 1/2 inch 52100 steel balls are locked into a pot containing the fluid which is forced against a fourth rotating ball (1800 rpm) at increasing loads and run for 10 seconds. The wear scars on the stationary balls are measured and the load is increased until lubrication breaks down completely, causing the balls to weld together (Weld Load).

By mathematical treatment of the scar sizes at the increasing loads, an indexing value which characterizes the load carrying capacity of the fluid is obtained and reported as the **Load Wear Index (LWI)** along with the **Weld Load**. It is important to note that it is possible for one lubricant to have a higher calculated **Load Wear Index** value than another lubricant, while at the same time having lower or less-desirable values for other measurements (such as **Last Non-Seizure Load**).

Most lubricating fluids exhibit a load at which metal to metal contact is minimal and the amount of wear produced (on the basis of scar diameter) is no more than 5% greater than the impression diameter (the plastic deformation of the balls under point contact load without turning the machine on). The final point where this is still true is termed as the **Last Non-Seizure Load**. In this respect "non-seizure" is somewhat of a misnomer, as the reading doesn't really refer to seizure or welding of the steel balls, but refers instead to the highest load applied that does not cause a wear scar more than 5% greater than the initial "Hertz Load Impression" – the impression made on the steel balls by each other with no load applied.

In analysis, the **Last Non-Seizure Load** reading is sometimes of interest for comparative purposes as well as an indicator of the upper limits of transition from elastohydrodynamic to boundary modes of lubrication in terms of the test conditions.

Greater loads which are termed **Last Seizure Load** typically produce much larger scars with scoring due to heavy metal to metal contact. The **Last Seizure Load** reading is defined as the highest load applied BEFORE welding of the balls occurs. Once a load is applied that results in the steel balls welding together, this load is defined as the **Weld Point**. Many engineers consider the **Last Seizure Load** to be more useful than the **Weld Point** reading in calculating the maximum stress load limit of a lubricant, as the **Weld Load** is the point at which the stress limit of the lubricant has actually been exceeded.

This test indicates not only the dynamic load-bearing and friction reducing ability of the lubricant but also gives the maximum load-bearing capacity, as indicated by the **Last Non-Seizure** and **Last Seizure** values of the test, along with the corresponding scar sizes for those loads.

Test Sample Preparation

A total of ten samples were prepared for testing. These samples consisted of X-tra Lube Concentrate plus eight other oil treatment products and a tenth sample of untreated base oil.

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The same base oil (**Exxon 15W-40)** was used for all samples. Each sample was approximately 450ml in size. Each sample consisted of a sample product mixed into a base oil at the treat ratio recommended by the product manufacturer. For 450ml samples, the following amounts of additive product were added to base oil:

- X-tra Lube: 6 ml
- Z-Max: 35 ml
- Slick 50: 90 ml
- STP Oil Treatment: 42 ml
- MotorPurr: 55 ml
- Lucas Stabilizer: 90 ml
- Prolong: 35 ml
- Greased Lightning: 22.5 ml
- Hy-per Lube: 90ml

Of the product samples provided, the Rislone, NAPA and Marvel Mystery Oil products were not used. These may be tested at a later time. Additionally, the Torco product was supposed to be included in the test but the product sample was unable to be located. A comparison between X-tra Lube and Torco may be done at a later time, if desired.

The samples were all blind-labeled with letters from A-N and submitted in identical 16-oz plastic bottles with induction-sealed foil-lined caps.

Prepared 450-ml samples of the nine oil treatment products plus the sample of untreated base oil were submitted to Petrolube Testing Laboratories, an accredited third party laboratory specializing in the testing of lubricants and grease. Petrolube is ISO9000:2000 certified with almost thirty years of experience in conducting ASTM, ISO, FLT and other testing protocols on oils, greases, hydraulic fluids and other liquids.

Before each test protocol was initiated, all samples were re-mixed by the laboratory for 20 seconds before each test. These instructions were given to combat any settling which may have occurred during sample transit and to ensure the proper distribution of additive within the oil samples before execution of test procedures. This was especially important for the X-tra Lube-treated oil, which contains micro-metallic particles which can settle in the bottom of an oil sample over time. The X-tra Lube product manufacturer recommends thorough mixing of the product in base oil before addition to the vehicle crankcase.

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ASTM D-2783 Four Ball EP Load Wear Testing Results

RED = Best value for that parameter **BLUE = Worst Value for that parameter**

ASTM D-2783 FOUR BALL EP LOAD WEAR							
Sample	**Product Name**	**Load Wear Index[1]**	**Last Non-Seizure Load (kg)[2]**	**Non-Seizure Load Scar (mm)[3]**	**Last Seizure Load (kg)[4]**	**Seizure Load Scar (mm)[5]**	**Weld Load (kg)[6]**
A	STP	41.63	80	0.4	160	2.42	200
B	MotorPurr	41.97	80	0.39	160	2.40	200
C	Prolong	39.49	80	0.41	200	2.43	250
D	Greased Lightning	31.26	63	0.39	200	3.15	250
F	Lucas Oil Stabilizer	34.63	63	0.38	160	2.75	200
G	Slick 50	31.38	63	0.38	200	2.98	250
H	X-tra Lube	38.63	80	0.38	200	2.38	250
J	Z-Max	36.64	80	0.41	200	2.92	250
M	Hy-Per Lube	36.75	80	0.41	200	3.06	250
N	Exxon 15W-40 Base Oil Untreated	31.83	63	0.34	200	2.79	250

Definitions

1. **Load Wear Index** – an index value calculated by assessing all of the scar measurements in relationship to the ascending load values administered during the test. This calculation is a useful tool for comparing the load bearing values of different lubricants, but is not a perfect reflection as it remains possible to have a higher load wear index calculation while simultaneously having lower values in other relevant measurements.

2. **Last Non-Seizure Load** – the highest load applied that does not cause a wear scar more than 5% greater than the initial Hertz load impression with no load applied.

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3. **Non-Seizure Load Scar** – the measured size of the scar left at the Last Non-Seizure Load. Smaller scar sizes indicate less wear.

4. **Last Seizure Load** – the highest load applied BEFORE welding of the steel balls occurs**.**

5. **Seizure Load Scar** – the measured size of the scar left at the Last Seizure Load. Smaller scar sizes indicate less wear.

6. **Weld Load** – the load applied at which point the steel balls weld to each other, indicating loss of lubricating protection sufficient to allow that to happen.

In reviewing the test results, there are some trends which are noteable:

1. **Load Wear Index -** The top four load wear index figures were assigned to MotorPurr, STP, Prolong and X-tra Lube. The worst two figures belonged to Greased Lightning and Slick 50, which were the only 2 treatments which had Load Wear Index values actually LESS than the untreated base oil.

2. **Last Non-Seizure Load -** Three of the treatments – Greased Lightning, Lucas, Slick 50 – have Last Non-Seizure Loads identical to that of the base oil (63 kg). This left six treatments with Last Non-Seizure Loads superior to that of the base oil – 80 kg vs 63 kg. Recall that the Last Non-Seizure Load is the highest load before the wear scar figures start increasing significantly; i.e., it represents a measure of the friction-abating ability of the lubricant.

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3. **Wear Scar (Last Non-Seizure Load) -** For comparison of the six treatments with the higher Non-Seizure Load ratings (80 kg), it is useful to examine the scar diameter left at the Non-Seizure Load point. The scar diameters at the Last Non-Seizure Load had a range of values from 0.41mm to 0.38 mm. Small scar sizes are better, as they indicate less metal-to-metal wear at the Load point. Larger scar sizes are less desireable, as they indicate more metal-to-metal wear at the same Load point. These values ranged as follows:

   WORST
   0.41 mm – Prolong
   0.41 mm – Z-Max
   0.41 mm – Hy-Per Lube
   0.40 mm – STP
   0.39 mm – MotorPurr
   0.38 mm – X-tra Lube
   BEST

   In this comparison, the X-tra Lube oil treatment product had the best results, combining the highest Last Non-Seizure Load rating with the lowest wear scar diameter at that load.

4. **Last Seizure Load** – Three of the treatments – STP, MotorPurr and Lucas – had Last Seizure Load ratings (160 kg) LESS than that of the untreated base oil (200 kg), and therefore had the least desirable results. This left six treatments with Last Seizure Load ratings equal to that of the base oil. Recall that the Last Seizure Load rating is significant in that it represents the highest load applied before the Weld Point occurs; hence, it is a representation of the highest load-bearing ability of the lubricant before lubrication completely breaks down.

5. **Wear Scar (Last Seizure Load) -** To differentiate between the six treatments (plus base oil) that have the equal higher Seizure Load ratings, we can examine the wear scar size for that load. Smaller wear scars mean less metal wear (and superior lubrication) leading up to the Seizure Load point. Larger wear scar size is less desirable, indicating great metal-to-metal contact allowed by the lubricant. The scar sizes for the six lubricants were:

   WORST
   3.15 mm – Greased Lightning
   3.06 mm – Hy-Per Lube
   2.98 mm – Slick 50
   2.92 mm – Z-Max
   2.43 mm – Prolong
   2.38 mm – X-tra Lube
   BEST

   In this comparison, the X-tra Lube oil treatment product had the best results, combining a high Last Seizure Load rating with the lowest wear scar diameter. The scar size for X-tra Lube was almost 25% less than the Greased Lightning product and 20% less than popular Teflon-based product Slick 50.

   It is also notable that the wear scars for the three products which produced inferior Seizure Load ratings of 160 kg (vs .200 kg) ranged between 2.43 and 2.40 – all larger than X-tra Lube but smaller in size to Prolong and the other four products with better Seizure Load results. This phenomenon is due to greater load producing larger scars by default. It is reasonable to conclude that if these three lubricants had been subjected to equal 200 kg loads as the other six, the lack of lubricity caused by their failure would have produced much larger scars than even the worst of the six (Greased Lightning, 3.15 mm).

6. **Weld Point -** All treatments had equal Weld Points of 250 kg except for three products which failed to reach this level and which had Weld Points of only 200 kg – STP, MotorPurr and Lucas. The fact of equal Weld Points is not a surprise, as the nature of the test dictates that loads are administered at pre-determined values, with 200 kg and 250 kg being two of the load values administered. Hence it is logical that 200 kg would be a Last Seizure value and 250 kg would be the Weld Point.

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Further Four Ball Test Analysis By Product

Having discussed results on the individual tests, it may be useful to judge where each product ranks for overall performance by using an index ranking system, awarding one point for best results and 10 points for worst performance, in each parameter. Points are totaled to give a final score, which can serve as a quantitative indicator of performance in the six categories. Multiple products with tie scores in a parameter would have their scores averaged across the relevant positions. Because Weld Point is considered by some engineers to be a duplicate measure of maximum load bearing capacity (similar to Seizure Load), we may also disregard the Weld Point and figure a second total.

INDEX RANKING - ASTM D-2783 FOUR BALL EP LOAD WEAR							
Product Name	**Load Wear Index[1]**	**Last Non-Seizure Load (kg)[2]**	**Non-Seizure Load Scar (mm)[3]**	**Last Seizure Load (kg)[4]**	**Seizure Load Scar (mm)[5]**	**Weld Load (kg)[6]**	**Total/Total without Weld Point**
STP	2	3.5	7	9	3	9	33.5 / 24.5
MotorPurr	1	3.5	5.5	9	2	9	30 / 21
Prolong	3	3.5	9	4	4	4	27.5 / 23.5
Greased Lightning	10	8.5	5.5	4	10	4	42 / 38
Lucas Oil Stabilizer	7	8.5	3	9	5	9	41.5 / 32.5
Slick 50	9	8.5	3	4	8	4	36.5 / 32.5
X-tra Lube	4	3.5	3	4	1	4	19.5 / 15.5
Z-Max	6	3.5	9	4	7	4	33.5 / 29.5
Hy-Per Lube	5	3.5	9	4	9	4	34.5 / 30.5
Exxon 15W-40 Base Oil Untreated	8	8.5	1	4	6	4	31.5 / 27.5

From these results, it is clear that the product with the best overall results on ASTM D-2783 test was **X-tra Lube**. It is equally clear that the product with the worst showing on the test was **Greased Lightning**. Based on the combination of these results, products could be ranked as follows, according to their cumulative scores NOT including Weld Load:

1. **X-tra Lube (15.5 pts)** – The X-tra Lube product claims to reduce friction and metal wear by using micro-metallic particles to fill friction-producing voids in metal surfaces. X-tra Lube was the only product to score consistently at or near the top for all five parameters. The calculated Load Wear Index was its worst parameter, still ranking 4th out of 10. It finished in the top group for both Non-Seizure Load and Seizure Load, while finishing 2nd and 1st for the scar diameter measurements. The only sample with a smaller scar on the Last Non-Seizure Load was the untreated Base Oil, which can be attributed to the Base Oil topping out at a lower Load level than X-tra Lube (63 kg vs 80 kg) – hence X-tra Lube actually had the best (smallest) scar size for all products reaching the higher Load level. X-tra Lube's scar size for the higher-pressure Seizure Load reading was significantly lower (> 20% lower) than other products with the same Seizure Load, which indicates superior lubricating and friction-bearing ability. X-tra Lube also appears to provide the best combination of superior results on this test with a very low product cost (2nd lowest).

2. **MotorPurr Oil Stabilizer (21 pts)** – MotorPurr is an oil stabilizing product which claims to reduce friction and leave a protective oil film on metal surfaces. MotorPurr scored in 2nd place once the Weld Load reading was taken out. MotorPurr scored the best Load Wear Index rating (its largest advantage over X-tra Lube) but lost points for having an inferior Last Seizure Load of only 160 kg. Both of its scar sizes were well above average but marginally worse than those of the X-tra Lube product. However, it should be noted that the small difference in the Seizure Load scar (2.40 vs. 2.38) is magnified by it being measured at the lower Load for MotorPurr (160 kg) than the X-tra Lube scar was measured at (200 kg). So in this respect, the difference in protection between the #1 and #2 product is larger than first thought. MotorPurr was the 2nd most

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~~expensive~~ product tested but was able to provide very good results compared to some other products which cost less to treat. However it did not achieve the same level of results as the #1 product X-tra Lube, which also cost ~~72% less to treat~~.

3. **Prolong Engine Treatment (23.5 pts) –** The Prolong Engine Treatment claims to reduce friction and heat by chemically bonding to the metal surfaces of the engine. Prolong had the second lowest score until the Weld Load was removed, which dropped it to third. Prolong's most positive scores came from a good Load Wear Index, good scores in both Non-Seizure and Seizure Load, and a very good scar size at the higher-pressure Seizure Load – Prolong was one of only four products with a scar size less than 2.5 mm at 160-200 kg of Seizure Load. Prolong's worst score was on scar size for the lower-pressure Non-Seizure load, where it finished next to last. So the data paints a picture that the Prolong product gave very good scores in almost all categories. In comparison to the #1 product X-tra Lube, Prolong's Load Wear Index was slightly better (39.49 vs. 38.63) and it achieved equal Non-Seizure and Seizure Load readings. However it fell just short of the X-tra Lube values for both kinds of scar (0.41 vs 0.38 and 2.43 vs. 2.38). Like MotorPurr, Prolong also cost at least $20.00 per treatment, but provided above average results for the cost.

4. **STP Oil Treatment (24.5 pts) –** STP claims to reduce engine wear and friction through a viscosity-modifying formula which provides a thicker cushion of oil between moving engine parts. The STP product achieved a very solid 4th place , due to positive results in Load Wear Index (2nd) and high-pressure Seizure Load Scar size (3rd). The product's score was hurt by lower scores for lower-pressure Non-Seizure Load Scar size (7th) and for being one of only three products that could not reach a 200 kg Seizure Load reading, falling short at 160 kg. In comparison with the #1 X-tra Lube product, STP's Load Wear Index was the only reading where it achieved a more favorable value. STP was the least expensive product tested, but did not achieve the same high level of results as X-tra Lube achieved for a 50 cent per application cost difference. The STP product did outperform a number of far-more expensive products, however.

5. **Base Oil (27.5 pts) –** The untreated 15W-40 base oil actually outperformed over half of the additized oil samples according to test criteria. The base oil performed poorly on the Load Wear Index (8th) and Non-Seizure Load but had the smallest Non-Seizure scar. This might be explained by low Non-Seizure Load (only 63 kg); however, the associated scar was still smaller than Lucas, Slick 50 and Greased Lightning at the same 63 kg low-pressure load. The base oil achieved the same high Seizure Load level and actually had an associated scar that was smaller (2.79 mm) at the 200kg than all but the X-tra Lube (2.38 mm) and Prolong (2.43 mm) products. It is notable that the base oil achieved equal Seizure- and Non-Seizure Load readings as Slick 50 but produced smaller scars at both levels than that product.

6. **Z-Max Friction Reducer (29.5 pts) –** The Z-Max product claims to treat the metal in the same manner that the X-tra Lube product claims, using "ester technology" to chemically bonds to the metal surface to reduce friction and heat. However the results for Z-Max were significantly worse. Z-Max was slightly below mid-point in Load Wear Index while attaining a high Non-Seizure load (80 kg). However, its scar at that 80 kg load (0.41) was tied with Prolong and Hy-Per Lube for the worst scar reading. Z-Max also received an unsatisfactory scar rating at its higher 200 kg Seizure-Load level, placing 7th out of 10 with a scar a full 22% larger than that of the leading X-tra Lube product. Z-Max was the most expensive product tested ($30.00 per application); it is up to the consumer to judge whether this expensive price justifies the body of results which ranked it 6th out of ten products.

7. **Hy-Per Lube (30.5 pts) –** Hy-Per Lube claims to provide friction-reducing protection through viscosity improvers and a high film-strength additive which causes oil to stick to metal surfaces to increase protection. Hy-Per Lube finished just one point behind Z-Max in 7th place among the ten products. It received identical scores to Z-Max for Non-Seizure Load, Seizure-Load and Non-Seizure Scar. The Load Wear Index for Hy-Per Lube was slightly superior to Z-Max, but it lost two points by having a Seizure-Load Scar that was 2nd worst among all products (3.06). In fact, Hy-Per Lube had the worst combined score for the two wear scar readings of all products, finishing 9th out of ten in both cases. Hy-Per Lube's price of $8.00 per treatment was significantly more than superior products ahead of it in these test ranks, but less than the three products finishing below.

   It is notable that, of the three products remaining, two of them are products which contain Teflon, long marketed for its supposed friction-fighting abilities.

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8. **Slick 50 (32.5 pts)** – Slick 50 tied with Lucas Oil Stabilizer but had a superior Weld Load rating, and so is awarded 8th place. Slick 50 may be the most well-known of the products tested, with a long-standing reputation for reducing friction through the use of Teflon ("the slipperiest substance on earth"). Slick 50's results on the test protocol seem to void this reputation. It was one of only two samples which had a Load Wear Index actually lower than that of the base oil alone. It was one of four samples which attained a unsatisfactory lower Non-Seizure Load rating (63 kg). The scar associated with this Load was one of the smaller scars, but this is tempered by the fact it was attained at a lower load – it's 0.38 mm scar was tied with X-tra Lube and Lucas for the second-smallest scar measurement; however, only X-tra Lube attained this designation while also doing so at the highest Non-Seizure Load of 80 kg; both Lucas and Slick 50 attained the scar measurement at 63 kg only. For the higher-pressure Seizure Load, Slick 50 did achieve the higher 200 kg reading alone with six other samples. However, its associated scar at that Load (Seizure Load Scar) ranked it 8th out of ten products. Slick 50's product cost was also well-above average at $19.00 per treatment.

9. **Lucas Oil Stabilizer (32.5 pts)** – The Lucas product is primarily an oil stabilizer which claims also to reduce friction and improvement oil lubricity. Unfortunately it ranked next to last in that respect. The Lucas product received average to below-average rankings in every parameter but one. The only parameter it received an above-average score in was low-pressure Non-Seizure scar (0.38 mm). However, it attained this scar only at the lower Non-Seizure Load of 63 kg, making it inferior to products like X-tra Lube (0.38 mm at 80 kg) and even Prolong (0.39 mm at 80 kg). The Lucas product also received a higher-pressure Seizure Load Scar measurement of 2.75 mm, which placed it 5th among the ten product. However, like it's other scar, this scar was attained only at a Seizure Load level which was lower than other products – 160 kg. Lucas' Seizure Load Scar of 2.75 mm @ 160 kg is judged to be inferior even to the untreated base oil rating of 2.79 mm @ 200 kg. Lucas was also one of only three product (STP, MotorPurr) to attain only 200 kg for Weld Load. Lucas' product cost of $12.00 per treatment is less than some of the other products on the list (though much higher than both X-tra Lube and STP), but its overall results seem to call into question the value of its lubrication-enhancing claims.

10. **Greased Lightning (38 pts) –** Greased Lighting is marketed as a direct competitor to Slick 50, contrasting itself by claiming to contains three times the PTFE of "other brands" (Slick 50 by inference). How valid and meaningful these claims are should be evident by its poor performance in the testing protocol. The Greased Lightning product finished dead last among the samples tested, and it was not by a small margin. The product was hurt by the worst Load Wear Index and high-pressure Seizure-Load Scar ratings of all samples. Even though it reached only an inferior Non-Seizure Load maximum of 63 kg, its corresponding scar of 0.39 was tied for 6th place with a product (MotorPurr) which attained that scar at 80 kg, not 63. The Greased Lightning product did attain a high-pressure Seizure Load rating equal to the highest level achieved by other products, but it also achieved the largest (and worst) scar associated at that Load. Its Seizure Load scar of 3.15 mm was over 30% larger than the #1 product in that category, X-tra Lube. Noticing that Greased Lightning actually performed worse in almost every parameter than untreated base oil, the consumer may be better off keeping their money than buying this product, based on these test results.

Conclusion – Four Ball EP Load Wear Index Test Results

X-tra Lube was the only product to consistently score at the top of every parameter measured and is the clear winner in the test. MotorPurr, Prolong and STP also achieved reasonable good results. MotorPurr was the only one of the most expensive products ~~($20+ for application)~~ which produced above-average results, though it still finished behind X-tra Lube ~~which cost 400% less to treat~~. Slick 50, despite its long and favorable product reputation, fared poorly on the test. Lucas Oil Stabilizer proved to be a poor friction-reducing product, as did Greased Lightning.

Of the five products which claimed to work by using some sort of unique molecular action to "treat the metal surface", X-tra Lube was clearly the most superior product, while Prolong produced reasonably good results, though not in the range of how X-tra Lube performed. Z-Max and Slick 50 produced well below-average results despite their product claims and high product costs. Greased Lightning performed dead-last among all products of all kinds.

It may be reasonable to conclude from the results of this test that the X-tra Lube product provided the best lubrication protection, while doing so at an extremely competitive cost-to-treat price.