SOD-1 Plus Oil Additive

Technical Manual

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What is SOD-1 Plus?

SOD-1 Plus is an ester-based universal oil additive. It delivers a combination of benefits to your vehicle or machine:

- washing away and dissolving ultra-fine particle sludge, oxidated substances such as varnish and other contaminants from lubricated surfaces
- reducing friction, abrasion, and engine noise by boosting lubricity
- softening rubber material in seals to prevent oil leakages
- reducing soot in emissions

Being a universal additive, SOD-1 Plus can be used in all parts of a vehicle or machine in the following addition ratios:

- Engine (10%)
- Transmission (10% manual, 7% automatic)
- Differential/gearbox (10%)
- Power steering (10%)
- Hydraulic system (10%)

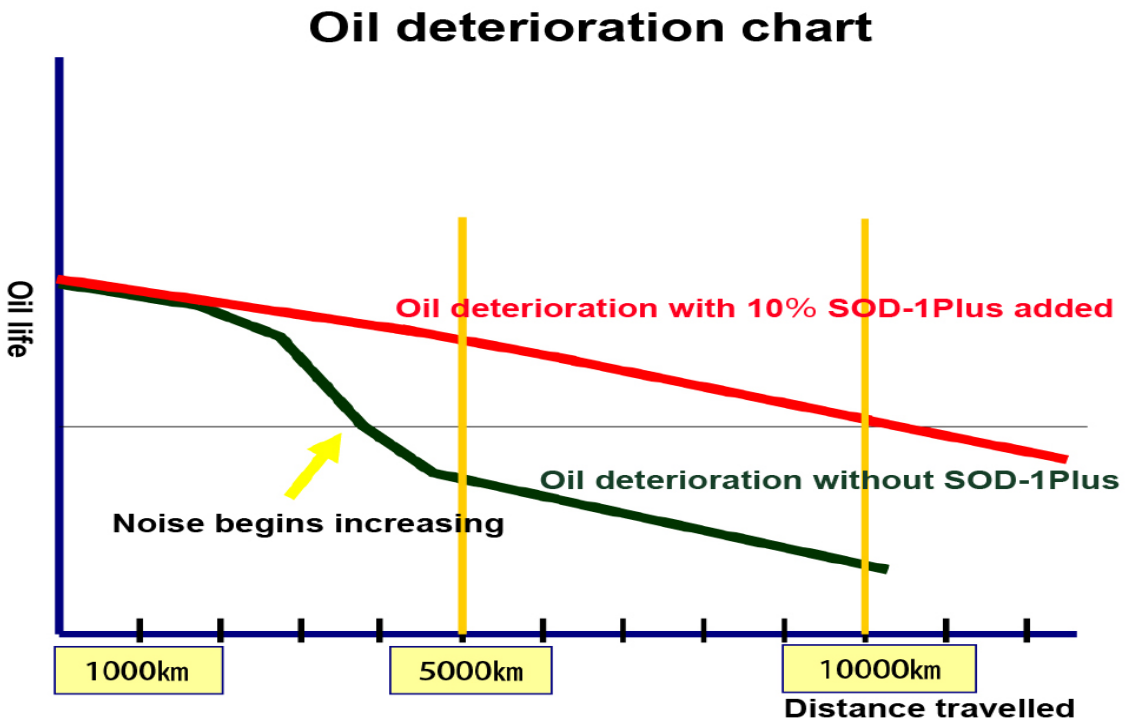
However, SOD-1 Plus cannot be used in brake fluid.

SOD-1 Plus is made from vegetable oil-based ester compounds (VOE), polyolesters (POE), and diesters (DST). It is manufactured in Japan by D1 Chemical Co. Ltd in Fukuoka. This unusual oil additive contains detergents, dispersives, antioxidants, extreme pressure agents, rust-preventative agents, viscosity index improvers, pour point depressants, anti-foaming agents, and friction reducing agents.

In Japan, Korea, and Australia SOD-1 Plus is used as an additive in:

- motor vehicles
- trucks
- boats
- turfcare machinery
- industrial-size cooling fans in a major oil refinery.

Unlike other oil additives for motor vehicles, it is a universal additive – it can be used in the engine, transmission, differential, power steering systems, and hydraulic systems. This eliminates the need for separate additives for each of these parts of a vehicle. SOD-1 Plus extends the life of the base lubricant oil, reducing the frequency of oil changes and saving maintenance costs. If used properly SOD-1 Plus extends the operating life of the vehicle or machine, thus postponing replacement costs.



SOD-1 Plus slows oil deterioration by boosting oil quality

This chart shows how SOD-1 Plus can extend the oil change cycle in an engine by as much as 100%.

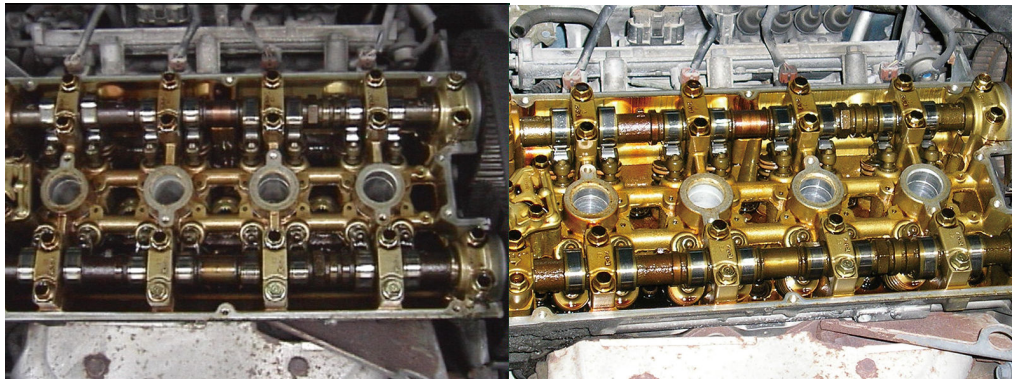
Beneficial effects of SOD-1 Plus

Cleaning away oxidated sludge

Think of SOD-1 Plus as similar to a liquid soap. Because of its high calcium content it works to dissolve and disperse oxidated sludge, varnishes, resins, and other contaminants that result from fuel combustion in a vehicle. A buildup of such contaminants can lead to poor O-ring performance in the cylinders and a loss of compression in the engine. It also leads to excessive toxic particles in emissions.

Over the years we have seen the detergent effect of SOD-1 Plus in our customers' vehicles many times. Dirty engines that undergo an oil change and have SOD-1 Plus added at a 10% addition ratio become clean after as little as 100kms of driving.

Before SOD-1 Plus After SOD-1 Plus



Recently we did a test on a 28 year-old 50cc Honda Cub motorbike which was suffering from poor acceleration. We disassembled the engine and examined the state of the piston. It was dirty. After adding SOD-1 Plus to the new oil we rode the Honda for 100kms and then disassembled the engine to examine the piston again. The sludge deposits on the piston had started to disappear as the calcium in SOD-1 Plus penetrated them and cleaned them away.

The 28 year-old 50cc Honda Cub

Honda Cub piston before SOD-1 Plus added

After SOD1 Plus added and 100kms

Reducing friction and wear

Reduced wear = longer machine life

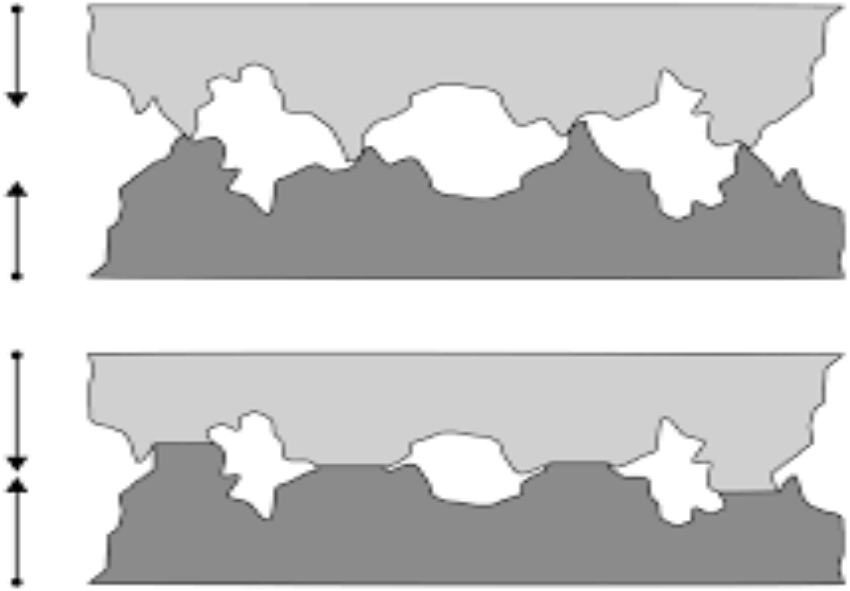
Reduced energy = operating cost savings

"The purpose of a lubricant is to reduce friction and wear between the two contacting surfaces….under the operating conditions of temperature, pressure, load, speed, stress, and time duration."

Dr S.P Srivastava, a former executive director of the R&D center of the Indian Oil Corporation.

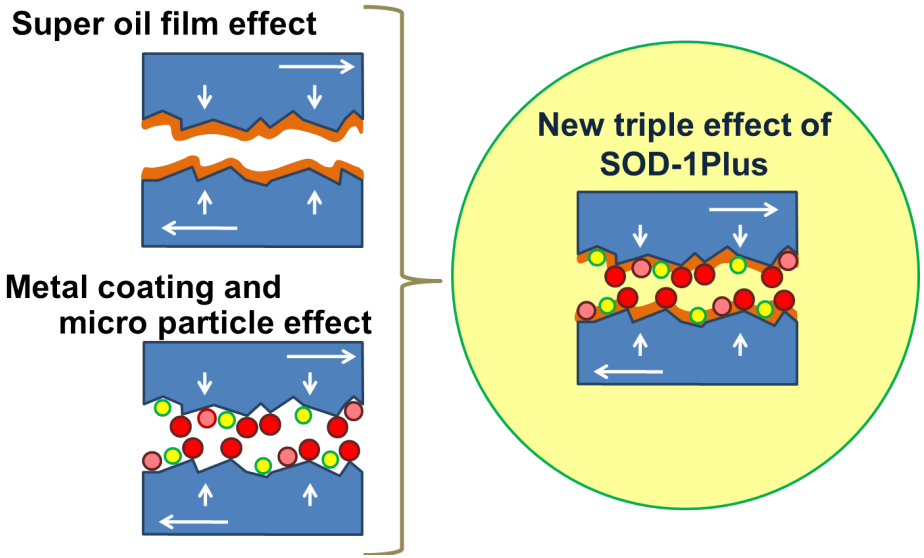
All surfaces are not molecularly smooth. They have peaks or asperities, and valleys. It's the asperities that require attention in understanding lubrication. Metal surfaces react with air and form oxides. Sulfur, chlorine, and nitrogen becomes sulfides, chlorides, and nitrides. So the metal surfaces are complicated things. Layers or films develop which influence lubrication performance.

Have a look at Diagram 1 below:



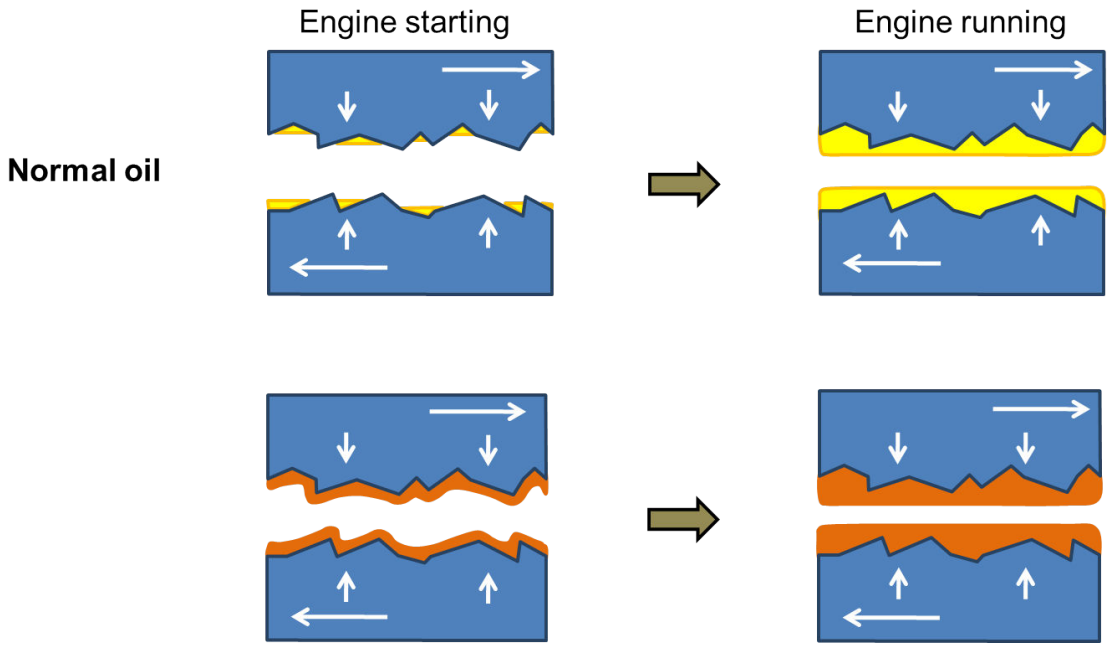
This image clearly illustrates the asperities and valleys of two metal surfaces in contact with each other. As the load increases, contact becomes broader. The contact area increases as the asperities are compressed.

All this is relevant to an understanding of SOD-1 Plus and its chemical and physical effects as a lubricant additive. Diagram 2 below illustrates how the micro-particles of SOD-1 Plus work to form that extra layer of protection.



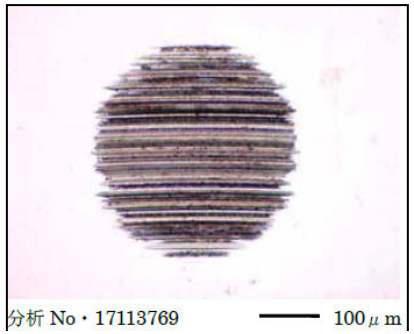
The yellow dots in the diagram represent the adsorption layer that SOD-1 Plus creates. This is the phosphorous and other chemicals sticking to the metal surfaces to add a layer to what the base oil already supplies.

Diagram 3 below shows how this works in practice. When an engine is cold the asperities of the metal surfaces are bare of protection and you get a dry start: needlessly high friction and wear that damages the surfaces. The lower part of the diagram shows the effect of SOD-1 Plus in the orange-coloured layer that remains on the surfaces even when the engine is cold. That's because of the adsorption, the chemical effect that Dr Srivastava described in the quote above, "…These polar molecules are asymmetrical and have a strong affinity for a metal surface, forming adsorbed layers at the rubbing metal surfaces…."

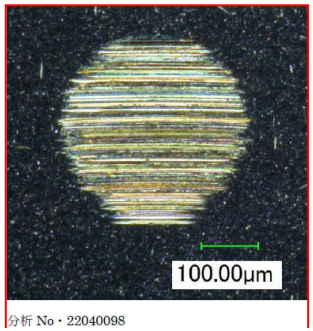


How do we know that SOD-1 Plus provides extra lubrication? The basic test for lubricant oils is the Shell 4-ball Wear Test, which determines the friction properties of extreme pressure oils and greases by grinding at high speed four ball bearings against a stationery ball bearing. The more shallow the wear scar on the stationery ball bearing the higher the lubricity of the oil solution used. Deep scar, bad. Not so deep scar, good.

In April, 2017 we asked the Japan Analyst laboratory to test our new version of SOD-1 Plus in a comparative test with a base lubricant oil (0W-8). The result was very encouraging – 35mm wear scar with SOD-1 Plus versus 43mm without SOD-1 Plus:



Wear scar of 0W-8 base oil – 43mm



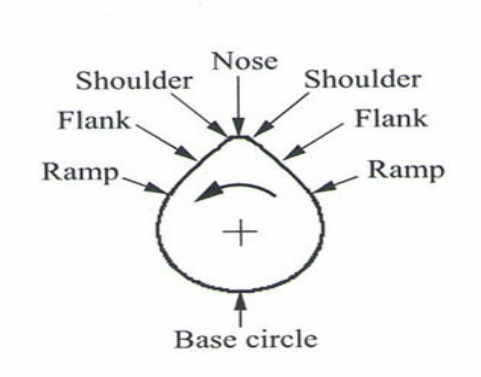
Wear scar of base oil with 10% SOD1 Plus - 35mm

The test was carried out at a temperature of 75°C, a load of 40kg/ cm^2 and a speed of 1200 rpm for 60 minutes.

Adsorption – the chemical effect of SOD1 Plus sticking to metal

Ester-based lubricants have something that normal oil lacks – adsorption. This is a chemical reaction between the metal surfaces in a vehicle or machine and the phosphorus in SOD-1 Plus whereby the SOD-1 Plus liquid sticks to the metal because of polarity. Adsorption provides an extra layer of lubricating film which works to reduce friction and wear. Because of this the base oil last longer, and the operating life of the vehicle or machine is extended.

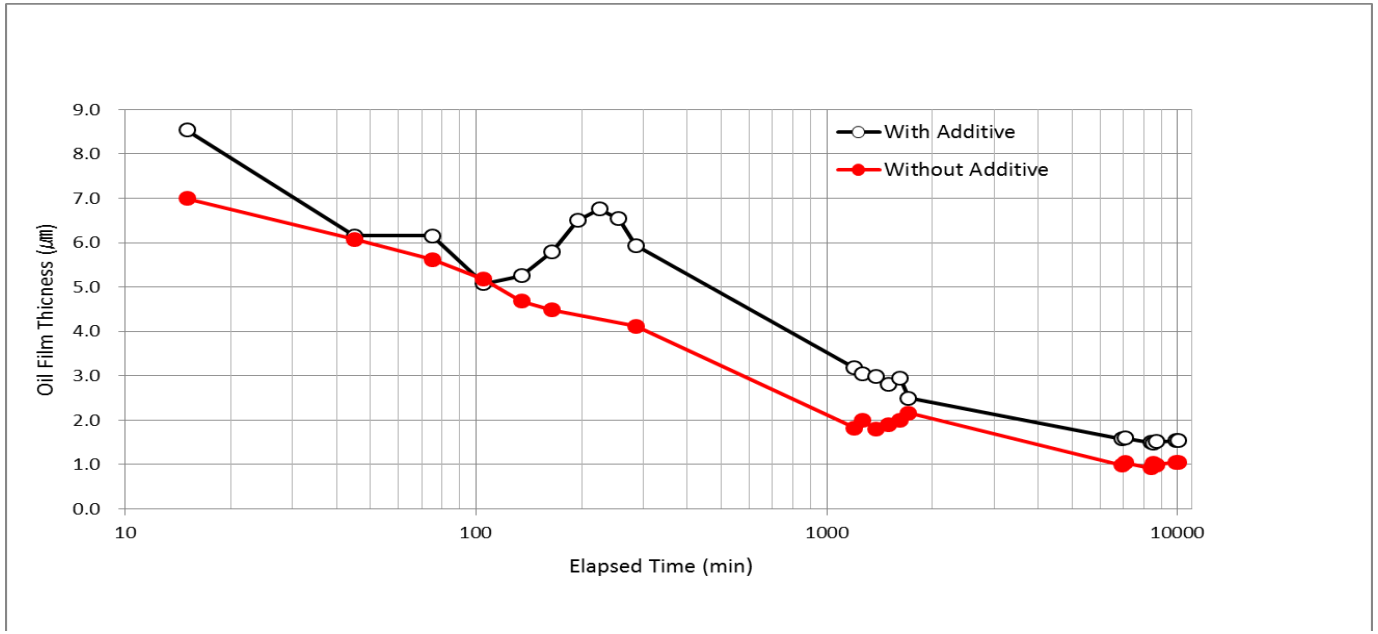
Dr Takashi Watanabe, our Technical Advisor, conducted a test on oil film thickness that demonstrated the adsorption effect of SOD-1 Plus. The control lubricant oil used was Toyota brand 0W-20 oil for the first sample. For the second sample SOD-1 Plus was added to the control oil at a 10% ratio by volume. Because the cams on a camshaft are vulnerable to excessive friction from dry starts Dr Watanabe examined the shape of the cams and measured the angles around it at the nose, shoulder, flank, ramp, and base circle.



When the cam is idle the oil film that coats it will lose thickness according to gravity, the oil gradually slipping downwards. The angle at the nose of the cam is 0°, at the shoulder 30°, at the flank 60°, and at the side 90°. Dr Watanabe recreated these angles using test plates of identical material. He then heated the plates and the oil samples to 90°C to simulate the environment of an operating engine. Using a Fischer-Scope MMS PC2 measuring instrument with a beta emitter to measure the oil film thickness in microns, he plotted the gradual deterioration in film thickness over a period of 10,000 minutes, with major benchmarks at 100, 1000, and 10,000 minutes.

Measuring the plates with a beta emitter to measure the oil film thickness in microns

In the chart below the oil film thickness with SOD-1 Plus added at a 10% ratio by volume was significantly greater. Using the 30° angle test pad the film thickness at 10,000 minutes was 1 micron for the control oil-only sample, and 1.5 microns for the sample with SOD-1 Plus added, a significant increase of 50%.



Before looking at the test results it's important to understand something of the difference in metallurgical makeup of the two samples tested. SOD-1 Plus is an ester-based lubricant additive made from a blend of VOE (vegetable oil ester), POE (polyol ester), and DST (diester). This gives it a particular chemical and metallurgical profile with elevated levels of phosphorus (P), zinc (Zn), calcium (Ca), and magnesium (Mg) as the table below shows.

Table 1　Metallurgical analysis of oils used　S method（mass ppm）

	Iron Fe	Lead Pb	Copper Cu	Chromium Cr	Aluminum Al	Nickel Ni	Silver Ag	Tin Sn	Silicon Si
Control oil	0	0	0	0	0	0	0	0	**7**
Control oil + SOD1 Plus	0	0	0	0	0	0	0	0	**6**

	Boron B	Sodium Na	Phosporus P	Zinc Zn	Calcium Ca	Barium Ba	Magnesium Mg	Molybdenum Mo
Control oil	**73**	0	**287**	**4**	**138**	0	**1**	**0**
Control oil + SOD1 Plus	**68**	0	**349**	**94**	**647**	0	**21**	**1**

Dr Watanabe wrote in his report"

" Normally the phosphorus element in lubricant oils sticks to solid particles and then decomposes, reacting with the surface. It serves to form a coating with a high fusion or melting point with little shear strength. Accordingly, in specific terms, the phosphor compounds in SOD-1 Plus – the phosphoric acid ester and phosphonic acid ester – form another coating with the iron phosphate. This is likely to be the cause of the oil film thickening after 165 minutes. Further, we judge that there is no effect on the surface tension from the relative increase in the oil film caused by the SOD-1 Plus.

" The ester base of the additive SOD-1 Plus – polyolester, diester, and vegetable oil ester – is a material that has a long chain of hydrocarbons and polarity in its molecular makeup, and because of this strong polarity it has greater chemical and physical adsorption power with friction surfaces and thus can form an adsorptive film on those surfaces."

Clearly the addition of the ester-based additive SOD-1 Plus to the control oil increased the thickness of the oil film. This helps to reduce the friction and wear arising from a dry start. If your car remains unused for a period of a week or more the engine will suffer some damage from a dry start because the oil film within the engine will have deteriorated to a thickness of 1 micron or so. Adding SOD-1 Plus to the oil increases the film thickness by a significant degree.

Softening rubber material in oil seals to prevent oil leakages

Leaky oil seals – a problem for many old vehicles and hydraulic machinery. In engines the rubber material in O-ring seals hardens over time, leading to a loss of compression in the cylinders and to oil leaks in other parts of a vehicle. Why does this happen? What can we do to prevent it happening?

Hardening of rubber and neoprene material in seals and O-rings is caused by elastomer hardening, evaporation of plasticizers, and oxidation that brings on cracking. This is often caused by excessive temperatures. Think of going snorkeling at the beach. If you leave your mask and snorkel out in the sun for days on end the rubber will perish, hardening and cracking up. An oil seal is the same.

Within a vehicle or machine lubricant oil quality deteriorates with time. As it does so oil formation gets worse and friction increases between the metal surfaces. The higher the friction the higher the temperature. This is what causes oil seals to harden and crack, leading to oil leaks.

What can we do? Two things.

First, oil quality should be boosted. This is the function of SOD-1 Plus. Its triple-ester makeup provides adsorption – an extra-thick layer of lubricant sticks to metal surfaces – and it strengthens the molecular structure of the base oil. This renders the base oil stronger under pressure and high temperatures. The result is a lower temperature because friction is greatly reduced. The rubber in the oil seals will last longer because of this.

Second, because SOD-1 Plus has smaller micro-particles than base oil it penetrates the tiny cracks and fissures in the seal material and re-elasticizes the material – it softens the rubber and allows it to expand again, thus sealing off any spaces through which oil might leak or compression might be lost.

SOD-1 Plus means:

- lower friction, lower temperature, longer lasting rubber seals
- penetration of rubber material and re-elasticizing of rubber

To test the effect of SOD-1 Plus on rubber seal material we asked the Japan Analyst laboratory to run a test for us in 2015. The material used was a rubber automatic transmission seal. Sections of the seal were immersed in two solutions for 72 hours and then tested for durability and capacity. The first solution was 100% ATF fluid; the second was 90% ATF fluid and 10% SOD-1 Plus. The results show the increase in the mass and capacity of the rubber. This shows the swelling effect of SOD-1 Plus. Further, the greater length before breaking shows how much softer the material became after SOD-1 Plus was added to the oil.

Test	**100% ATF fluid**	**90/10 ATF fluid + SOD-1 Plus**
Immersion test JISK6258		
Tensile strength change ratio(%)	+2	+1
Length increase at breaking change ratio (%)	-5	+/-0
Hardness change	-2	+1
Mass change ratio (%)	+1	+2
Capacity change ratio(%)	+3	+4
Size change ratio (%)	+1	+1

Financial Analysis

How SOD-1 Plus saves you money

SOD-1 Plus Comparative Calculation 100,000kms per annum

Costs with ordinary lubricant oil only Castrol GTX 15W40 @ $35/5 litres

No. of oil changes **10 times** every 10,000Km
Oil filter changes **10 times** every 10,000Km

Engine oil capacity	4 L
Oil used	4 L

Costs $		
Oil	7	litre
Oil filter	24	1 filter
Labour cost - oil	100	
Labour cost - filter	100	

Cost calculation	Every 10,000Km		Frequency	$ cost/100,000Km
oil	28	×	10	280
SOD-1Plus		×		
Oil filter	24	×	10	240
Oil- labour	100	×	10	1,000
Filter - labour	100	×	10	1,000
	252			2,520

Cost with SOD-1Plus added **SOD-1Plus $150/litre**

No. of oil changes **5 times** every 20,000Km
Oil filter changes **2 times** every 50,000Km

Engine oil capacity	4 L
Oil used	3.6 L
SOD-1Plus(10%added)	0.4 L

Costs $		
Oil	7	litre
SOD-1Plus	60	0.4L
Oil filter	24	1 filter
Labour cost - oil	100	
Labour cost - filter	100	

Cost calculation	Every 20,000Km	Every 50,000Km		Frequency	$ cost/100,000Km
Oil	25		×	5 times	125
SOD-1Plus	60		×	5 times	300
Oil filter		24	×	2 times	48
oil- labour	100		×	5 times	500
filter - labour		100	×	2 times	200
	185	124			1,173

SOD-1 Plus Cost advantage	1	$	1,347	per 100,000Kms
Saving on engine repair		$	1,000	
Resale premium		$	1,000	
Total estimated saving		$	3,347	
Vehicle life extension saving	extra 200,000kms $40,000 replacement cost x 5% x 2 years	$	4,000	

Vehicle Life SOD-1 Plus Cost Table

400,000kms over 4 years
Normal size vehicle
SOD1 Plus cost @ $150/litre

	Frequency	SOD1Plus (cc)	Cost $
Engine oil change @ 20,000kms	20	400	1,200
Transmission oil change @ 50,000kms	8	500	600
Differential/gear oil change @ 50,000kms	8	150	180
Power steering fluid change @50,000kms	8	100	120
		TOTAL	2,100
Saving per 100,000kms = $3,347			13,388
Vehicle life extension saving			4,000
		TOTAL	17,288
		TOAL SAVING	$15,288

Saving time horizon

Year 1	3,347	Mainteneance saving
Year 2	3,347	Maintenenace saving
Year 3	5,347	Mainteneance + vehicle life extension
Year 4	5,347	Maintenance + vehicle life extension
TOTAL	17,288	
SOD1Plus	-2,100	
TOTAL	15,288	

Using SOD-1 Plus in a vehicle or machine

SOD-1 Plus is a universal additive. When using it in your vehicle or machine you should add it to the base lubricant oil in the following ratios by volume:

- Engine (10%)
- Transmission (10% manual, 7% automatic)
- Differential/gearbox (10%)
- Power steering (10%)
- Hydraulic system (10%)

For more information please email us at info@d1-chemical.com