

Lube Base Oil

S-OIL Corporation www.s-oil.com/eng/lube/

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Company Outline

Address	Head Office Refinery	60 Yoido-dong, Yongdungpo-gu, Seoul, Korea 360 Sanam-ri, Onsan-eup, Ulju-gun, Ulsan-city, Korea
Foundation		Jan. 1976
Employees		2,524 (as of April, 2009)
Capital Stock		₩ 292 bil. (US\$ 389 mil)
Net Sales		₩23.105 bil. (US\$ 20.95 bil. / FY 2008)

₩/\$ = 1,102.59 '08 year end.

Production Capacity



[Note] "B/D" refers to barrels per day

VISION & HISTORY

Since its foundation in 1976 as the first lube-oriented refiner in Korea, S-OIL has been leading the manufacturing of lube base oils. The first lube base oil production facility in 1981 was the most advanced process at the time.

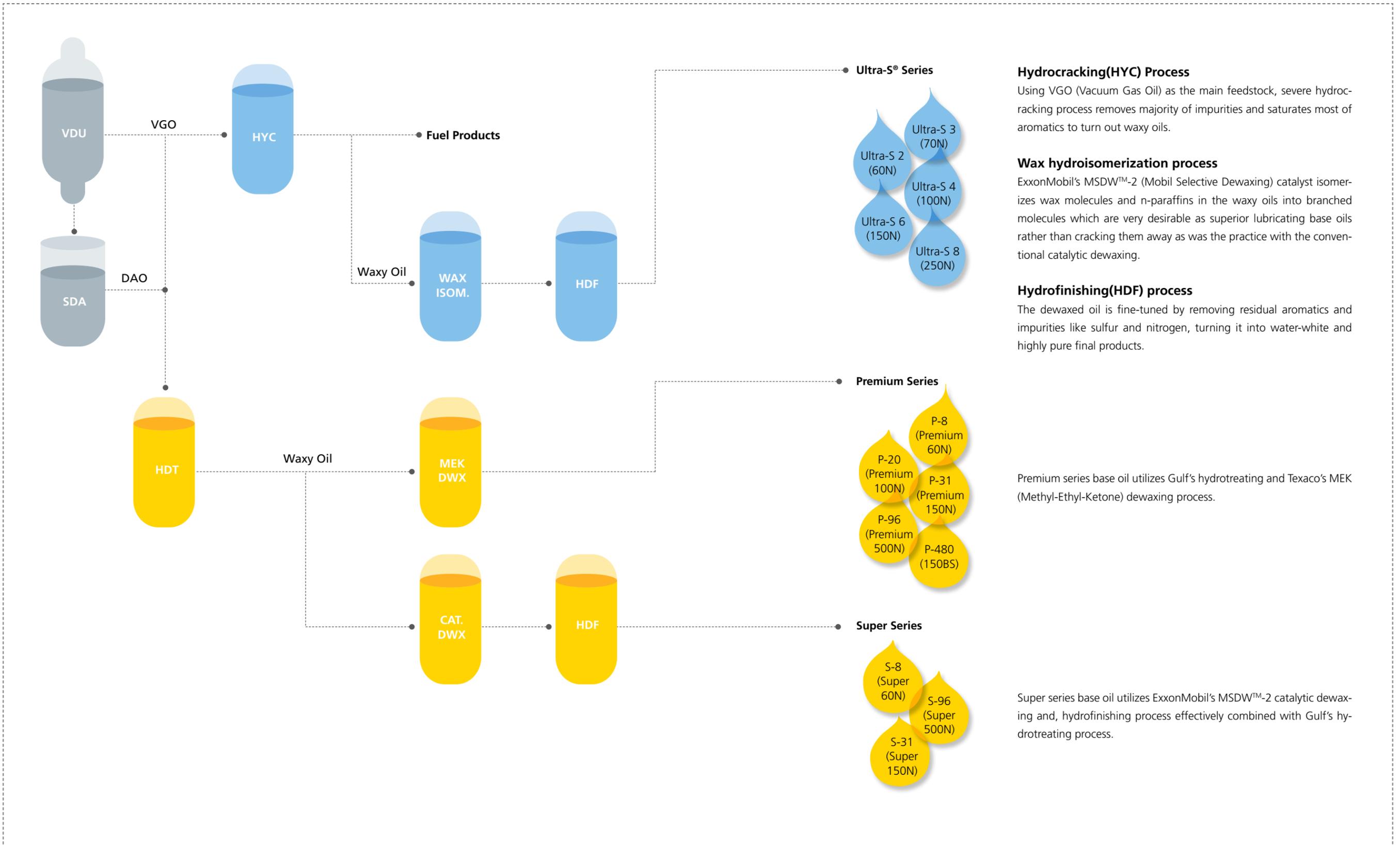
In December 2002, S-OIL began the commercial production of very high viscosity index lube base oils following the expansion and upgrade of its hydrocracking complex. With the completion of all hydroprocessing processes, S-OIL now has a full line-up of API Group III and Group II base oils with daily production capacity of 31,000 barrels, enabling the Company to exercise strong international competitiveness.

S-OIL will concentrate all its power on becoming a world's best lube base oil maker by reinforcing existing competitiveness in the lube base oil sector.

- Jan. 1976** The Company was founded as a joint venture between NIOC (National Iranian Oil Company) and Ssangyong Cement Industrial Co.,Ltd.
- Jan. 1981** Commenced commercial operation of lube base oil plant.(3,320 B/D)
- Dec. 1990** Increased production capacity of high VI lube base oil to 8,000 B/D with the commercial operation of MLDW™ (Mobil Lube Dewaxing) process.
- May. 1991** Established strategic alliance with Saudi Aramco by entering into a joint venture agreement and crude oil supply agreement.
- Mar. 1996** Began commercial operation of Hydro-cracking complex including the Hyvahl.
- Mar. 2000** Changed the name of the Company to S-OIL Corporation from Ssangyong Oil Refining Co.,Ltd.
- Dec. 2002** Started commercial operation of wax hydroisomerization process and production of all- hydroprocessed very high VI base oils. (Ultra-S®)
- Apr. 2007** Concluded joint venture agreement between AOC and Hanjin Energy.



S-OIL'S BASE OIL PROCESS



Hydrocracking(HYC) Process

Using VGO (Vacuum Gas Oil) as the main feedstock, severe hydrocracking process removes majority of impurities and saturates most of aromatics to turn out waxy oils.

Wax hydroisomerization process

ExxonMobil's MSDW™-2 (Mobil Selective Dewaxing) catalyst isomerizes wax molecules and n-paraffins in the waxy oils into branched molecules which are very desirable as superior lubricating base oils rather than cracking them away as was the practice with the conventional catalytic dewaxing.

Hydrofinishing(HDF) process

The dewaxed oil is fine-tuned by removing residual aromatics and impurities like sulfur and nitrogen, turning it into water-white and highly pure final products.

Premium series base oil utilizes Gulf's hydrotreating and Texaco's MEK (Methyl-Ethyl-Ketone) dewaxing process.

Super series base oil utilizes ExxonMobil's MSDW™-2 catalytic dewaxing and, hydrofinishing process effectively combined with Gulf's hydrotreating process.

ULTRA-S® SERIES



Performance Features of S-OIL's Ultra-S® Base Oils

Performance Comparison with PAO

S-OIL's Ultra-S® series, an all-hydroprocessed (hydrocracking, wax hydroisomerization and hydrofinishing) base oil, has the following characteristics.

As shown in the performance features, S-OIL's Ultra-S® series closely matches traditional synthetics in the key characteristics like low and high temperature performance (VI, cold cranking simulator viscosity), oxidative and thermal stability and volatility.

S-OIL's Ultra-S® series will make an excellent economical alternative for PAOs for applications like crank-case engine oils, gear and power train lubricants and some industrial lubricants requiring very high quality standard and extended life.

Very High Viscosity Index

S-OIL's Ultra-S® series has very high viscosity index ranging from 120 to 130 while VIs of conventional Group I or Group II base oils range from 95 to 105. The high viscosity index of S-OIL's Ultra-S® series guarantees adequate engine lubrication under wide temperature range and saves your VI improver treatments for multi-viscosity applications while improving fuel efficiency.

Excellent Response to PPD

S-OIL's Ultra-S® series responds to pour point depressants very effectively. Therefore, the actual difference in pour points of finished lubricant products between Ultra-S® series and PAOs is not outstanding except for extremely low temperature applications.

Excellent Low Temperature Performance

Due to very high viscosity index, the CCS (cold cranking simulator) viscosity of S-OIL's Ultra-S® series exhibits a result comparable to that of PAOs of similar viscosity grades. This feature makes S-OIL's Ultra-S® series a very effective substitute for PAOs for fuel-efficient multi-grade crankcase engine oils.

With the wax hydroisomerization process turning wax molecules into highly stable isoparaffinic structures and hydrofinishing process almost completely eliminating unstable components and impurities, S-OIL's Ultra-S® series shows excellent oxidative and thermal stability comparable to that of PAOs, which guarantees extended life of finished products.

For fear of oil consumption and poisoning of catalytic converters, low volatility has become a very important factor required from the base oil sector. Most recent engine oil specifications like ILSAC GF-4 and ACEA A5/B5, require very stringent volatility from the finished products. S-OIL's Ultra-S® series shows the result amounting to that of PAOs, which make it a perfect platform for engine oils satisfying the newest specifications.

1. Flash Points / Fume

S-OIL's Ultra-S® series has higher flash point than the conventional Group I or Group II oils due to narrower distillation width. This feature, by reducing the possible fume and hazard of fire, contributes to making the workplace safer and cleaner for industrial applications.

2. Saturates and Purity

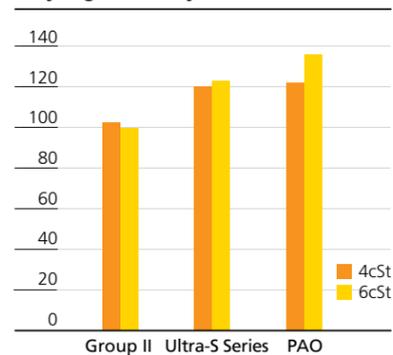
The all-hydroprocessing routes at S-OIL's Onsan Ultra-S® base oil plant ensures only a traceable amount of aromatics and impurities present in the final product leaving most desired components like isoparaffins and 1-ring naphthenes. Because these components have the highest oxidation and thermal stability while preserving very high VIs, S-OIL's Ultra-S® series exhibits superior stability over conventional base oils including even the earlier generation Group III oils. Furthermore, only a traceable amount of aromatics in the base oil ensures superior stability as white mineral oils as well.

Excellent Oxidative and Thermal Stability

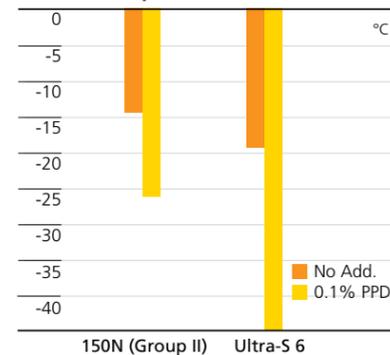
Very Low Volatility

Other Technical Merits

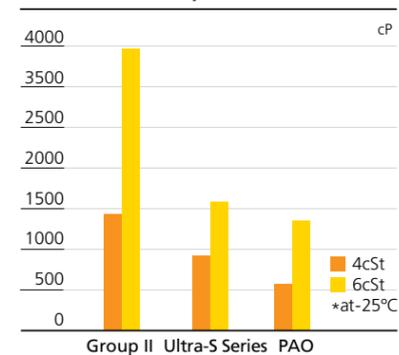
Very High Viscosity Index



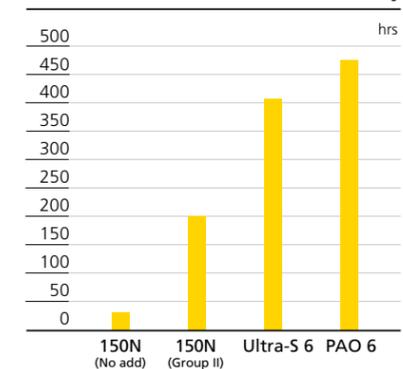
Excellent Response to PPD



Excellent Low Temperature Performance

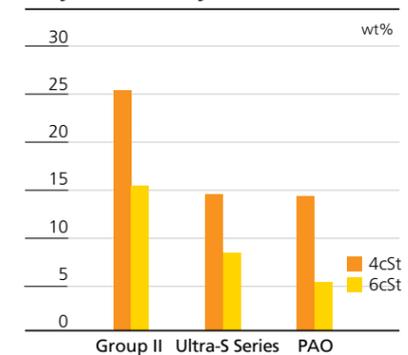


Excellent Oxidative and Thermal Stability

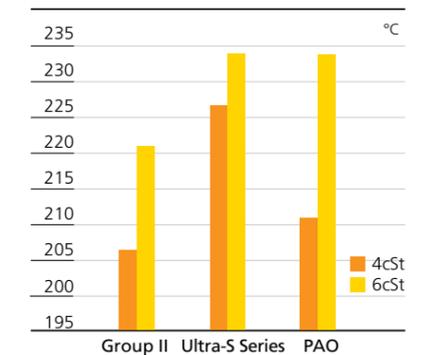


Result of RBOT
(0.3% of hindered phenol antioxidant added)

Very Low Volatility



Other Technical Merits



ULTRA-S® SERIES



Typical Characteristics and Applications

S-OIL's Ultra-S® series consists of five viscosity grades, Ultra-S® 2, 3, 4, 6 and 8, named according to their viscosity(cSt) at 100 C.

Typical Properties

Test Items	ASTM	Ultra-S 2	Ultra-S 3	Ultra-S 4	Ultra-S 6	Ultra-S 8	
Appearance	Visual	B & C	B & C	B & C	B & C	B & C	
Sp.Gravity, 15/4 °C	D 1298	0.820	0.827	0.834	0.843	0.847	
Color, Saybolt	D 156	+30	+30	+30	+30	+30	
Kin.Vis @40 °C, cSt	D 445	7.117	13.47	19.62	33.32	43.89	
		@100 °C, cSt	2.174	3.315	4.247	6.0	7.234
Viscosity Index	D 2270	109	117	123	127	127	
Flash Point, °C(COC)	D 92	158	204	228	235	256	
Pour Point, °C	D 5950	-37.5	-25.0	-20.0	-20	-15.0	
Carbon Residue (CCR), wt%	D 4530	<0.01	<0.01	<0.01	<0.01	<0.01	
Copper Corrosion, 100 °C/3hr	D 130	1a	1a	1a	1a	1a	
Sulfur Content, wt ppm	D 5453	<1.0	<1.0	<1.0	<1.0	<1.0	
TAN, mgKOH/g	D 974	<0.01	<0.01	<0.01	<0.01	<0.01	
Ring Analysis, wt%	D 3238	CA	0.1	0.2	0.2	0.2	
		CN	21.9	17.3	17.7	17.3	20.9
		CP	78.0	82.5	82.1	82.5	78.9
Aniline Point, °C	D 611	101.8	111.3	115.8	119.8	124.0	
UV Absorbance, 260-350nm	D 2269	<0.1	<0.1	<0.1	<0.1	<0.1	
Noack, wt%	D 5800	-	-	14.5	8.0	4.1	
Saturates, wt%	D 2007	>99	>99	>99	>99	>99	

Very high viscosity index of Ultra-S® series ensures adequate engine lubrication under wide range of temperatures and consequently improves fuel economy. Low CCS viscosity ensures low temperature startability and fuel economy for wide range multi-grade engine oils. Low volatility ensures low oil consumption and satisfies the requirements for the stringent engine oil specifications like ILSAC GF- 4(15% max) or updated ACEA As/Bs.(13% max) Ultra-S® series can also be used as a correction fluid to be applied in combination with conventional Group I or Group II base oils to meet these specifications. Excellent oxidation stability ensures longer drain intervals. Recent engine oil specifications like ILSAC GF-4 and upcoming GF-5 add requirements for aged oils, which call for better oxidation stability.

Excellent low temperature performance and high VI of Ultra-S® series guarantees sufficient gear lubrication and low temperature fluidity. Excellent oxidation stability ensures extended drain intervals.

Excellent oxidation stability ensures longer drain interval for turbine and hydraulic applications. Higher flash points and less fume ensures safer and cleaner operation for metalworking applications.

UV absorbance(DMSO) test and carbonizable substances test results show only a traceable amount of aromatics present in the Ultra-S® series, which ensures excellent stability as white mineral oils.

Applications

Semi and Full Synthetic Crankcase Engine Oils

ATFs and Extended Drain Gear Oils

Industrial Lubricants

White Mineral Oils



Semi and Full Synthetic Crankcase Engine Oils



ATFs and Extended Drain Gear Oils



Industrial Lubricants

PREMIUM SERIES

Premium series base oils are widely accepted in the industrial, marine and mechanic oils as well as in automotive engine oils.

Premium series base oils are presented in five viscosity grades; P-8(Premium 60N), P-20(Premium 100N), P-31(Premium 150N), P-96(Premium 500N) and P-480(150BS).

Test Items	ASTM	P-8 (Premium 60N)	P-20 (Premium 100N)	P-31 (Premium 150N)	P-96 (Premium 500N)	P-480 (150BS)
Sp.Gravity, 15/4 °C	D 1298	0.8773	0.8520	0.8666	0.8811	0.8940
Color, ASTM	D 1500	L 0.5	L 0.5	L 1.0	L 2.0	L 2.0
Kin.Vis @40 °C, cSt @100 °C, cSt	D 445	7.498 2.036	20.31 4.166	30.14 5.189	95.79 10.97	480.6 31.32
Viscosity Index	D 2270	66	107	101	99	98
Flash Point, °C(COC)	D 92	156	208	212	242	310
Pour Point, °C	D 5950	-20.0	-15.0	-12.5	-12.5	-12.5
Sulfur Content, wt ppm	D 5453	<10	<10	<100	<100	<100
Carbon Residue (CCR), wt%	D 4530	<0.01	0.01	0.01	0.01	0.20
Copper Corrosion, 100 °C/3hr	D 130	1a	1a	1a	1a	1a
TAN, mgKOH/g	D 974	<0.01	<0.01	<0.01	<0.01	<0.01
Ring Analysis, wt% CA wt% CN wt% CP	D 3238	8.4 42.5 49.1	2.2 29.4 68.4	1.8 32.1 66.1	7.2 26.0 66.8	7.3 21.7 71.0
Aniline point, °C	D 611	77.8	107.0	107.1	116.3	129.7



SUPER SERIES

Super series base oils are highly purified water-white color products which have low aromatic and high naphthenic content with high viscosity index.

Super series base oils are presented in three viscosity grades; S-8(Super 60N), S-31(Super 150N) and S-96 (Super 500N).

Test Items	ASTM	S-8 (Super 60N)	S-31 (Super 150N)	S-96 (Super 500N)
Sp.Gravity, 15/4 °C D 1298	D 1298	0.8719	0.8634	0.8762
Color, Saybolt	D 156	+30	+30	+30
Kin.Vis @40 °C, cSt @100 °C, cSt	D 445	8.186 2.244	29.97 5.174	96.66 10.93
Viscosity Index	D 2270	72	101	97
Flash Point, °C(COC)	D 92	158	214	242
Pour Point, °C	D 5950	L-40.0	-15.0	-15.0
Sulfur Content, wt ppm	D 5453	<10	<10	<10
Carbon Residue (CCR), wt%	D 4530	<0.01	<0.01	<0.01
Copper Corrosion, 100 °C/3hr	D 130	1a	1a	1a
TAN, mgKOH/g	D 974	<0.01	<0.01	<0.01
Ring Analysis, wt% CA wt% CN wt% CP	D 3238	1.6 39.4 59.0	0.6 34.0 65.4	0.1 32.6 67.3
Aniline point, °C	D 611	84.5	110.8	-

