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### Background

Lube oils are blended from a range of hydrocarbon oils of varying composition but largely of a similar molecular size, giving controlled thermal and viscosity performance. Generally double bonds or “un-saturation” in any oil molecule results in less stable (or more reactive) lube oils than those containing higher proportions of single bonds (or saturates).

During normal operations, engine oils are exposed to elevated temperatures for sustained periods, which increases the tendency for these reactive double bonds to react with atmospheric oxygen to form oxidised by-products in the lube oil. These oxidised by-products include organic acids, and the formation of filtrable solids such as carbonaceous compounds.

Reported evidence from customers has noted that the thermal stability of SOR base oils is superior to similar virgin base oils. This is believed to be related to the high saturates level in the SOR base oils, in part due to unsaturated compounds having oxidised in virgin use, effectively giving a pre-treated raw material for the SOR re-refinery and in part due to the efficiency of the SOR process.

SOR has conducted a range of tests on Group 1 virgin and re-refined base oils including a simplified ASTM D943 test for thermal oxidation. This measures the difference in oxidation stability performance by exposing SOR and comparable virgin base oils to air at elevated temperatures (150°C), for a sustained period (168 hours - 7 days), and in the presence of metal billets to provide for metallic catalyst effects. Although this does not precisely replicate the life cycle in an automobile engine, it does simulate the thermal stress placed on the oil at temperature in an automotive oxidising environment.

This test method is an indicator of the response to the thermal stress placed on a pure base oil in an engine but it does not reproduce the effect of additive components such as detergents, antioxidants and viscosity stabilisers, all of which have been developed to help reduce the well-known tendency for mineral base oils to oxidise in use. It does however represent the underlying thermal stability of the base oil and therefore the extent of its dependence on these additives to retain its original performance properties.

### Saturates Level Measurement

In addition to this thermal stability test, SOR regularly have the saturates level of our base oil products determined by an independent laboratory. This measurement is carried out to the relevant standard (ASTM D2007). The results of these tests are included with the results for the thermal stability tests.

### Discussion

The thermal stability test results for all base oils (virgin and re-refined) show an increase in colour, viscosity, acid number, and suspended solids under the test conditions. For both light and heavy base oils the increase in colour, viscosity, acid number and suspended solids was typically 30% to 90% worse for virgin oils compared to SOR re-refined oils. This difference was reasonably consistent under the conditions of the test programme.

# SOUTHERN OIL REFINERIES

While the percent saturates results for the light base oils show the SOR product to be at least equal to virgin base oil, SOR heavy base oil shows an improvement in saturates level of over ten percent over virgin base oil.

Not quantified but strongly evident was that the deposition of oxidation products on the hardware (glass and metal surfaces) for the virgin oil was worse and much harder to clean after the test programme indicating a tendency for the lower level of SOR re-refined oxidation products to be softer and more easily treated with lube oil additive components.

These test results specifically represent SOR re-refined base oils against a limited range of virgin base oils. The continuing development of lubricating oils with Group II properties and synthetic oils will generally show further improved thermal stability, again due to the reduction in unsaturated compounds by hydrotreating or by synthetic oil manufacturing techniques.

However SOR has sought from its earliest days to manufacture a product at least equal to virgin base oils and, in its quest for excellence, has achieved an even higher standard enabling re-refined base oils to stand as premium base oil products in the marketplace.

## Test Results

<b>Thermal Stability Test Results</b>					
<b>Light Base Oil</b>					
		<b>SOR 150SN</b>		<b>Virgin 150SN</b>	
<b>Test</b>	<b>Units</b>	<b>Initial</b>	<b>Final</b>	<b>Initial</b>	<b>Final</b>
<b>Density @ 15°C</b>	kg/L	0.866	0.866	0.865	0.865
<b>Colour</b>	ASTM	1.5	55	1.5	80
<b>KV100</b>	cSt	5.14	5.41	5.16	5.53
<b>T.A.N.</b>	mgKOH/g	0.030	0.850	0.030	0.900
<b>Susp. Solids</b>	%w/v	0.014	0.371	0.011	0.709
<b>Saturates (ASTM D2007)</b>	%w/w	83	-	82	-

<b>Heavy Base Oil</b>					
		<b>SOR 300SN</b>		<b>Virgin 250SN</b>	
<b>Test</b>	<b>Units</b>	<b>Initial</b>	<b>Final</b>	<b>Initial</b>	<b>Final</b>
<b>Density @ 15°C</b>	kg/L	0.874	0.874	0.882	0.882
<b>Colour</b>	ASTM	2.5	65	1.5	75
<b>KV100</b>	cSt	7.65	7.97	7.49	7.96
<b>T.A.N.</b>	mgKOH/g	0.030	0.650	0.030	1.100
<b>Susp. Solids</b>	%w/v	0.005	0.046	0.009	0.670
<b>Saturates (ASTM D2007)</b>	%w/w	78	-	72	-