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## Testing of Polyglycol Ethers of Multivalent Alcohols and Lubricants

(Oppau Technical Testing Station)

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Survey: The water soluble lubricant LK2200 behaves with respect to its resistance to cold, lubricating properties and corrosion like a good auto oil. Very little residue is formed in the water-cooled automobile motor as well as in the air-cooled aeroplane motor, which operates under harder conditions. The time of operation until the ring begins to stick is 30 hours and this length of time may be designated as being very favorable. The consumption of oil is normal. A disadvantage is its high content in dissolved ashes. This is probably effecting the granular sediment which has been observed in motor tests. Lubricants of this type are not soluble in mineral oil. For this reason they cannot be used in those combustion motors, where it has been specified that various lubricants may be used interchangeably.

Its solubility in water makes LK2200 suitable for the lubrication of torpedo engines, since there is no oil trace visible. Furthermore, it may be used for textile machines and hydraulic machinery. LK2200 mixed with water can be used as a non-compressible cooling liquid.

### Project

Several polyglycol ethers of multivalent alcohols were to be tested with respect to their suitability as lubricants. Five samples were tested. LK2200 seemed to be the most suitable.

#### A.) Laboratory Tests

Oil Analyses: The most outstanding property of this product is its behavior towards the ordinary solvents. In water and alcohol it is solvent in any proportion, but in benzol and benzine it is not at all soluble.

The specific gravity is higher than that of the usual oils and higher than water. This property may result in the phenomenon that sludge and other contaminations fail to settle and may remain floating on the surface, thus re-entering the motor. Whether the higher specific gravity would really have these disadvantageous effects in practice would have to be tested.

LK2200 is approximately of the viscosity of a summer auto oil; the viscosity-temperature ratio is also very favorable with a VJ of 117. Solidification point, flash and fire points are also very favorable. LK2200 is somewhat hygroscopic. In 24 hours it absorbed 0.45 g of water at 20°C. Under the same conditions 4.5 g of water have been absorbed in the presence of sulfuric acid.

The viscosity of the anhydrous product is 116.8 c St. at 38°C; that of a product containing 4% of water is 105 c St.

Fig. 1 plots the solidification point as a function of the water content. Up to a water content of about 30% the solidification point goes down and lies here at -47°C. If the water content is further increased, the lubricant becomes cloudy, even at comparatively high temperatures, due to the formation of ice crystals. These tests show that admixtures of water up to 30% do not seriously effect the nature of the solidification point. LK2200 has an alkaline reaction, as may be seen from the negative acid and saponification numbers. The content of asphalt is 0, that of ashes, 0.025, that is, comparatively high. Without any doubt, in the course of the further development, this content can be substantially reduced. The high Conraison test looks rather unfavorable. But it does not warrant inferences with regard to the probable formation of residues, as the motor tests show.

The LK2200 behaves well in the artificial aging tests according to the Indiana method (Fig. 2). The slowness of the increase in the acid number is particularly noteworthy. Saponification numbers behave in the opposite manner. We may infer from this phenomenon that pre-eminently esters are formed when LK2200 ages; it is a well-known fact that esters are good lubricants; thus, this phenomenon may not be regarded as unfavorable.

The analysis of an oil aged in the BMW-motor (Fig. 3) agrees with the results obtained for the artificially aged oil. Again, the saponification number goes up, that means that esters are being formed. The acid number remains comparatively low. The thickening of the oil is hardly perceptible. During an eight-hour test the content of ashes remains zero with Rotring. With LK2200 the content of ashes which is present already in the fresh oil does not go up either during the first hours; but it does go up during the last ten hours of the test. This enrichment in dissolved ashes is probably due to the consumption of oil and the contamination of the oil with lead compounds, originating from the fuel. Since LK2200 runs nearly four times as long as Rotring, these features have a substantial effect.

Oils aged after 50 hours in the Opel motor give the same results (Table 1). We compared it with Wehrmacht Unity Oil. LK2200 was of somewhat higher saponification and acid numbers, and higher content of ashes. But no asphalt has been formed. Both of the oils thickened very little and about equally.

Testing the lubricating efficiency

(a) Four-ball engine

LK3 (which is of the same nature as LK2200) attains in the four-ball engine, that is, at very high face pressures, about the same values as Rotring D and better ones than Areoshell. In this respect it is as good as good motor oil.

(b) Wear-and-tear engine

LK2200 shows a very low wear-and-tear value. It behaves about as normal, whereas the thin liquid Shell AB 11 and both of the motor oils Areoshell medium and Rotring 3 have multiples of these values. In this apparatus LK2200 is widely superior to mineral oils.

(c) Heat test

The bearing of the Wieland-bearing-engine has been charged with a uniform charge of 210 kg/cm<sup>2</sup> and has been fed 12 cm<sup>3</sup> of oil. In given intervals the temperature of the oil has been measured, after starting the engine. Wehrmacht oil reached permanence at 43°C, LE2200 already at 39°. On repeating this test, the result in question has been confirmed. The difference between room temperature and oil temperature is thus: 23°C with Wehrmachtsöls, with LE2200, 19°C. That is a difference of 20%. This feature is due to the better conductivity and higher spec. heat of substances of this type. Such a behavior is desirable in many practical cases. With alternating operation at vehement fluctuations in temperature, LE2200 does not suffer as great variations in temperature as does ordinary oil. The viscosity will therefore change only within a narrow range. This behavior increases the effect of the viscosity index which is already very high.

Corrosion test

Along with LE2200 several other products of a similar character have been subjected to this test. The test was carried out at 100°C in a test tube without passing air; it lasts 96 hours. After every 24 hours, the oil has been renewed.

All of the fresh oils corroded zinc, which showed a perceptible loss in weight. All the products behaved normally with respect to the other metals...

With used LE2200, which comes from the Opel motor, electron undergoes an extraordinarily large increase in weight.

Cold Resistance

This test has been carried out in the Schwalger apparatus at -30°C; there was nothing unusual...

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B.) Motor Tests

Tests in an automobile motor

The residues at the bottom of pistons, combustion room and at the valves are very slight and easy to remove. In practice, the high Conradson test show no harmful effect.

The oil consumption is 25.5 g/hr, being higher than with Wehrmachtöls. But this plus may be due only to a lack in accuracy in measuring the oil. The BMW-aviation motor tests, where greater accuracy in measuring the oil was possible, show the consumption of LE2200 to be like that of good motor oils.

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Ring-Sticking Test, /a BMW-aviation Motor

In these tests, the BMW-132 aviation motor was operated under particularly severe conditions, so that the calibrating oil, Rotring O, resulted in ring sticking after an operating period of eight hours. LE2200 has been tested under the same conditions.

The operating period of 30-1/2 hours may be deemed very good. It equals that of highest grade aviation motor oils. The oil consumption is normal. The result of the piston-ring tear-and-wear test is favorable; there is less tear and wear than with Rotring.

There is some granular sediment, not only on the piston but also on parts of the gearing. After the test the connecting rod did not operate smoothly. This may also be due to these residues. The formation of these residues is probably caused by the high content in dissolved ashes.

Utilization

Nothing would prevent LE2200 from being used as motor oil. The change-over from normal oil to this product and vice versa, is however difficult since we do not know of any solvent which would dissolve both of these lubricants.

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(Tables and graphs may be given  
upon request. M.B.)

M. Beth  
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cc: All Divisions