

3. Preparation of the Diesel Fuel Blends.

It is of interest to relate the manner in which all fuels, for aircraft as well as for ground forces, were prepared for consumption in war-time Europe.

The utmost secrecy was maintained at all times inside and outside Germany regarding sources of fuels and preparation of blends. Producers were ordered to ship certain quantities of products to locations designated by a number and were not informed of the disposition or ultimate destination of these products. Blending was accomplished upon the orders of certain organizations, without any knowledge of the identity of the products blended. People who had complete knowledge of the fuels and lubricants situation were, for automotive engines, the personnel of the "Zentral Büro für Mineral Oel" in Berlin and for aviation engines, the personnel of the "Oberkommando der Luftwaffe." Under these, the "Wirtschaftliche Forschung Gesellschaft" or WIFO, assisted by the "Reichs Amt für Wirtschafts Ausbau" in Berlin, took care, at strategic points throughout Europe, of the storage, blending and distribution of fuels and lubricants.

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WIFO Depots, such as the huge WIFO No. 1 at Hizacker, on the Elbe south of Hamburg, were equipped not only to store fuels and lubricants in underground tanks and in barrels, but also to make control analysis in a well-equipped laboratory, and to carry on a certain amount of research independently from the manufacturers. This set-up explains some of the difficulties encountered in the attempt to get a complete picture of the liquid fuel situation in Central Europe.

For diesel fuels the usual types of blends were prepared in WIFO depots. For the more elaborate mixtures only, necessitating preliminary treatment, did the manufacturer take a hand in the process.

From the point of view of ignitability alone, Kogasin II from the Fischer-Tropsch process is an ideal product. It has been demonstrated however that, used alone, it is far from being an advantageous diesel fuel. Tests have proven that, compared with a diesel fuel of petroleum origin having a cetane rating of 47 and a specific gravity of .856, Kogasin II with 86 cetane rating and .770 specific gravity, when used in engines adapted to low cetane fuel, the only engines available at this time, showed:

- (1) an increase in consumption of around 5 percent (based on equal heat value).
- (2) an increase in exhaust gas temperature of about 25 percent.

This was attributed to the fact that Kogasin II does not have enough "body", as it is referred to. It ignites too fast but burns too slowly and must be blended with some of the other products listed above. Therefore Kogasin II was used mostly to upgrade the ignitability of other fuels.

Typical blends used as Diesel Fuels, with the specifications indicated above, and obtained by simple mixing, were, for instance:

45 percent Fischer-Tropsch Kogasin II
50 percent Light petroleum gasoil
5 percent Spindle oil distillate or, as alternative:

75 percent of this 45 - 50 - 5 blend
25 percent of a slightly heavier petroleum gasoil.

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When the mixture involves tar oils from the carbonization of coal, or shale oil, serious complications arise from the fact that these oils contain high percentages of asphalt, gum and carbon-forming elements which rapidly clog the injection nozzles, especially in small high-speed engines. Furthermore these components have a tendency to segregate out of the liquid, when Kogasin II is added and to settle in storage tanks. Originally inhibitors were used to prevent this condition, either 2 cubic centimeters of cresol for 100 centimeters of fuel, or 0.02 grams of mono-benzyl-amido-phenol in weak alcohol solution per 100 centimeters of fuel.

It became therefore necessary to refine the mixtures, and Dr. H. K lbel of the "Rhein-Preussen Company" in Homberg, Ruhr, developed several processes for that purpose. The initial process consisted of a 20 percent liquid sulfuric acid wash at atmospheric temperature followed by a caustic wash with fullers earth filtration. Later aluminum chloride was substituted for the sulfuric acid wash, followed by neutralization and filtration. The latest method, covered by Deutsche Reichs Patent No. 730853 dated 28 January 1943 for the "cleaning of mixtures of tar oils and aliphatic hydrocarbons" consists of a treatment by sulfur dioxide SO₂, in gas form, at atmospheric pressure. On the following tabulation can be seen a typical picture of the changes taking place in the fuel by the use of this process.

	Kogasin II	Tar Oil	Mixture of Diesel Fuels		Petroleum gas-oil (for comp)
			Before Treatment	After Treatment	
Spec. gravity	.760	1.060	.862	.855	.857
Color	Water Clear	Black	Brown; not translucent	Yellow; Translucent; Fluorescent.	Yellow
Boiling Index	218°C	260°C	260°C	260°C	275°C
Cetane Rating	96	20	60	60	50
Flash Point P.M.	48°C	114°C	70°C	70°C	90°C
Pour Point	-20°C	Zero	-20°C	-20°C	-30°C
Lower Calorific value	10500 Cal	9980 cal	-----	10100	10100
Conradson Carbon	.03 %	.26%	no data	.004%	.05%

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	Kogasin II	Tar Oil	Mixture of Diesel Fuels		Petroleum gas-oil (for comparison)
			Before Treatment	After Treatment	
Hard Asphalt (Hagemann & Hammerich)	Zero	2.5%	.46%	.03%	.06%
Insoluble in Benzine	Zero	4.8%	.87%	.05%	.11%

Proportions of carbon and hydrogen in these mixed Diesel fuels are:

87-90 percent C, to 9-12 percent H with a fraction of one percent of sulfur compared with following proportions in the Kogasin:

C - 85 percent
H - 15 percent
No sulfur

The proportions of Kogasin II in the mixtures vary according to the results desired. It has been found that the cetane rating increases practically in proportion to the quantity of Kogasin in the mixture; thus 35 percent tar oil and 65 percent Kogasin has a cetane rating of 57 while a 50-50 mixture has a cetane rating of 52.

The refining process is said to be inexpensive, as the loss of SO₂ is extremely small, the bulk being used over and over again. The amount of heavy tar, asphalt, and carbon precipitated out of the fuel during the treatment is about 10 percent of the total in weight. The phenolic products eliminated can be recovered and marketed.

The refined mixture, known as diesel fuel "R" is clear, stable, mixes readily with all other diesel fuels, and is even less corrosive (zinc test) than petroleum gas oil. Diesel motor tests have shown that it compares advantageously with petroleum diesel fuel as to exhaust gas temperature, low CO content of these gases, and consumption per horsepower.

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For production of a low pour point diesel fuel with high cetane rating, distillates of paraffinic nature can be treated by liquid SO_2 followed by a butane extraction, to remove most of the waxes that cause a high pour point. This process is very similar to the Edleau process, but was not used extensively in Germany on account of the low yield. For example 200 kilograms of distillate from the liquefaction of brown coal, treated as above, will yield only 60 kilograms of diesel fuel of -31°F pour, 53 cetane; or 88 kilograms of diesel fuel of -5°F pour, 44 cetane.

(a) Use of Gasoline in Diesel Engines.

At various times during the war the Germans experienced a serious shortage of adequate diesel fuel. These shortages were partly due to the necessity of concentrating production efforts upon the preparation of high-test aviation gasoline. It was necessary at these times to operate diesel engines on gasoline and gasoline blends which were or could be made available locally. Regardless of the type of gasoline blend used, an addition of 5 percent of motor oil to the fuel was prescribed, to protect the fuel injection pumps and not to improve the ignitability. There is a basic difference between diesel injection pumps, lubricated and sealed by the fuel itself and gasoline injection pumps, used currently on aircraft engines, lubricated by a supply of motor oil. Naturally the situation being temporary, no change over of the injection system was made. The only difficulties mentioned in connection with the use of gasoline in diesel engines were the excessive overheating of the engine and some tendency to vapor-lock in hot weather. In certain cases additives were needed to reduce the octane rating and bring the fuel more in line with a diesel fuel. Chlorpicrin was used as one of these additives. A cetane rating of 35 was aimed at. It can be obtained either by fractionating properly the Fischer-Tropsch gasoline, or by blending a gasoline of as high as 60 octane with a high cetane diesel fuel. Naturally low aromatic gasolines such as "Ruhrbenzin" were selected in preference to higher grades.

An attempt was made to use benzol. Ignition was possible only by mixing ethyl nitrate vapour with the air used for combustion; the engine stopped as soon as this addition of vapour was cut off.

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The ethyl nitrate was kept in a brass container in a water bath, as its boiling point is 194°C . The vapour circuit had to be absolutely tight as ethyl nitrate vapours are toxic. Approximately .3 cubic centimeters of nitrate was used per one liter cylinder. An attempt to spray liquid ethyl nitrate in very small quantity into the cylinder resulted in a serious explosion.

During the diesel fuel shortage of 1941-42 tests were conducted at the Leuna plant of I.G. Farben for the use of a 50-50 mixture of diesel fuel and Leuna gasoline produced from the hydrogenation of brown coal tar, and having a cetane rating of 35. No difficulties were noted except a slight reduction in power in trucks and locomotive diesels or in small construction engines. In large, slow-speed diesels vapor-lock difficulties developed.