XIII. AVIATION FUEL MANUFACTURE AND ENGINE TESTING.

Introduction:

The following information was obtained by interrogation of Dr.Ester, Mr.Scholz and Mr.Honicker.

The test engines originally installed at Leuna have now been evacuated to Wethau and Stössen. These locations were visited..

Octane Number Determination and Specification:

For day-to-day control of aviation gasoline component quality, Octane Number tests were carried out on C.F.R. Motor Method engines and on the I.G. Prüfmotors; the latter being used almost exclusively as spare parts for the C.F.R. engines became impossible to obtain. In 1944 there were 170 of these engines in use in Germany.

The Octane Number specifications in force in early 1945 were as follows:

D.H.D. Gasoline	78 Octane No. clear
Hydro Gasoline	70 " " "
	87 " " with 0.09% vol.T.E.L.

I.G. Prüfmotor

Swept volume	342 ccs.
Compression Ratio	Variable up to a max. of 14:1
R.p.m.	900 for Motor Method 600 for Research Method
Spark Advance	26° for Motor and Research Method
Jacket Temperature	100°C for Motor Method 100°C for Research Method
Mixture Temperature	165°C for Motor Method Room temperature for Research Method.

This engine is used with a multi-bowl carburetter in the usual way and all Octane Number determinations are made at max. knock mixture strength. Bouncing pins and knock meters made by Siemens are employed. The normal method of carrying out Octane Number determinations is to adjust the mixture strength to max. knock; increase the compression ratio until a standard rating on the knock meter is obtained; measure this compression ratio by a conventional micrometer and determine Octane Number directly from a standard chart in which Octane Number is plotted against compression ratio. The Octane

Number can also be directly read from a scale attached to a mechanism geared to the movable cylinder head.

This engine has also been used for supercharged tests and 5 to 10 supercharged engines were stated to be in use in various parts of Germany. This development followed initial tests in 1941 in Oppau, and Leuna first carried out supercharged tests of this nature at the end of 1941. In these tests pressure fuel tanks and a pressure carburetter are employed together with an air meter and the standard boost pressure is 1,000 mm. absolute. Test results are expressed in the form of a graph relating air/fuel ratio to compression ratio for constant knock, but a direct octane scale can be used in this case also.

B.M.W. 3-litre Single-cylinder Aero Engine:

This engine was employed at Leuna for official acceptance tests. Due, however, to air raids, this engine had been dismantled and crated for erection at some other location. The tests were only carried out to obtain acceptance of the aviation fuel components since blending of the finished fuel was carried out at the WIFO blending stations. Laboratory blends conforming to the official formula were prepared and tested. The engine operates at a constant compression ratio of 6.5 : 1 with variable supercharge. Other operating conditions are 1600 r.p.m., ignition 30° B.T.D.C., inlet air temperature 130°C., air cooled and direct injection. Tests are carried out in a normal manner by plotting air/fuel ratio against M.E.P. Acceptance was granted when the M.E.P./air fuel ratio curve approached the standard acceptance curve.

Aviation Gasoline:

The following information on the development of aviation gasoline was obtained from Dr.Ester, chemist in charge of gasoline quality control by engine testing.

The necessity for manufacturing a fuel with high aromatic content was due to the development by BMW and Daimler-Benz of engines which had a mean effective pressure of 294 psi at an air/fuel ratio of 0.75 for starting and combat and m.e.p. of 147 psi at an air/fuel ratio of 1.2 for cruising. The Junkers engine, however, was said to operate on 90 octane fuel which was prepared from hydrogenation gasoline with 4.5 cc of TEL per gallon and represents the normal grade aviation fuel (B_4). Inspection of the lean and rich mixture curves indicated that iso-octane would have been the ideal fuel for the German engines. Since a fuel of this kind could not be obtained, it was necessary to incorporate 35-45% vol. of aromatics into the aviation fuel. No isopentane blending was practised and the components themselves were stabilised to give a Reid vapour pressure below

7.4 for the final blend.

The source of the blending component with a high concentration of aromatics was the hydroforming of the hydrogenation gasoline (DHD process). Alkylate was obtained by dehydrogenation of n-butane and conventional alkylation of the resulting n-butylenes with iso-butane, using concentrated sulphuric acid as the catalyst. Iso-octane is obtained by hydrogenation of diisobutylene.

The fighter grade aviation fuel (C_3) was blended as follows:

80% DHD gasoline
20% alkylate or ET 120 or mixture of both
4.5 cc TEL/gallon

The DHD gasoline contains 0.1% by volume of mixed cresols as gum inhibitor. This fuel was slightly better than engine requirements but it was expected that engine design would very shortly make full use of it.

All German aviation engines are of the direct injection type, and it is claimed that this arrangement results, among other things, in good mixture distribution to all cylinders and the absence of difficulties by ice formation. In order to increase the quantity of aviation fuel, tests have been carried out to prepare a fuel which would dispense with the DHD process, which operates with high gas make. Addition of 2% methylaniline and 7.5 cc TEL/gallon to hydrogenation gasoline and use of this fuel in conjunction with methanol/water injection as well as change of the injection cycle appeared to give the desired result. The tests were carried out by Junkers on the regular BMW test engine. Daimler-Benz and BMW, however, claimed that they could not get their maximum output (2400 HP) with this type of fuel. It seems desirable to mention that the Junkers motor JuMo 213A had an output of 2800 HP with the fighter grade aviation fuel.

<u>Nomenclature of Aviation Fuels:</u>

The following nomenclature was used in Germany for the various grades of aviation fuel components and finished blends. This list does not include identifications for all German plants but only the code numbers obtained during the interview with Dr.Ester.

B Fuels	hydrogenation gasoline, leaded
C Fuels	high efficiency fuel
ET 110	technical iso-octane (96 octane no.)
ET 120	alkylate (94 " ")
VT 702	hydrogenation gasoline from Leuna + 4.5 cc. TEL/gal. (90 octane no.)

VT 705	hydrogenation gasoline from Scholven, leaded as above.
VT 706	hydrogenation gasoline from Pölitz, leaded as above.
VT 708	" " from Gelsenberg, leaded as above.
VT 810	" " from Böhlen, leaded as above
VT 812	" " from Brüx, leaded as above.
VT 342	hydro-formed hydrogenation gasoline (DHD gasoline)
D 1000	pure iso-octane reference fuel.

The sulphur content fom all aviation fuels and components was specified to be 0,005%. A stability test was included in the specification according to which 200 cc. of gasoline were kept at 103 lbs. (7 atm) oxygen pressure and 212°F for 2 hours; the gasoline was passed without further testing if no pressure drop took place during this period. In case of a pressure drop, the gum formed was determined and the permissible gum content was set at 5 mg/100 cc of gasoline.