

Appendix II

Fuel

While I specialized in the application of fuel to engines in the between-wars period, I do not claim to have any particular knowledge today; and while I have naturally mentioned fuel in this book, I thought a little more history would be valuable in view of the extreme importance of fuel to the piston engine in the war (see reference [a]).¹

When we heard of the American advances in the manufacture in quantity of 100 octane fuel by the hydrogenation and then the alkylation processes it was clear to many of us that this was obviously the fuel for the Royal Air Force. Already, in 1938, 90 per cent of the U.S. Government purchases were for 100 octane fuel, whereas British fuel for the R.A.F. was 87 octane grade, under Air Ministry specification DTD-230.

I gave a paper in London in January, 1937, and pleaded for the development of British military engines to take 100 octane fuel. It was criticised by a high oil company official on the grounds that we might not get 100 octane in war time and should therefore opt for 87 octane. Admittedly, 100 octane was only obtainable in the U.S. at the time; and if America was not in the war, her Neutrality Act could prevent supplies; though Anglo-Iranian, among other oil companies, was working on the alkylation process.

Fortunately, the critics were unheeded and in 1937 the Director of Technical Development of the British Air Ministry agreed to develop engines to run on 100 octane fuel. So by 1940 the Merlin's power was increased by this fuel from a combat rating of 1,000 (plus) bhp to over 1,300 bhp, and 100 octane became available to Fighter Command ready for the Battle of Britain through Roosevelt's 'cash and carry' compromise. It was the alkylation process, introduced in 1938, that met the rapidly rising needs for 100 octane fuel. While the paper mentioned in footnote (a) gives a lot more detail for those directly interested, it was the supply of 100 octane fuel for bench and flight tests which was very critical and important,

and to one man can be credited the foresight and the energy to get a tanker load of this fuel delivered to the U.K. This man, Dr Bill Sweeney of Esso, blended the constituents of the hydrogenated 100 octane fuel to meet the British requirements for good 'rich mixture response'. Sweeney's fuel blend was first tested at the Army Air Corps (later U.S.A.F.) experimental and test base at Wright Field in single cylinder units and later in our own air-cooled (Pegasus and Mercury) units, which were more sensitive than the water-cooled Merlin. 'Sweeney's Blend' was a great success and in June 1939, only three months before the start of World War Two, a company tanker, the *Beaconhill*, set sail across the Atlantic for the U.K. with a full cargo of 100 octane fuel. We began stockpiling this fuel, though the decision to use 100 octane for Fighter Command was not made until March 1940 and that for its use by Bomber Command came in 1941.

I had early manifestation of 'rich mixture response', quite accidentally I might say, when preparing the benzole-alcohol fuel for the 1931 Schneider engines. This is acknowledged in the Schlaifer and Heron Book, *The Development of Aircraft Engines and Fuels*.

There was, on occasions, a special fuel component blended into 100 octane for Merlin engines in the Mosquito, to accelerate away from enemy fighters over Berlin or to catch the VI flying bomb. This was mono-methyl aniline, of which about 8 per cent (plus) was added.

The aviation gas turbine engine is more catholic than the piston engine in the fuel it can use, though kerosine (paraffin) is its normal fuel (dewaxed to lower its freezing point to about minus 40°C). It has, however, been found that kerosene, having an aromatic content of 20 per cent and above, can cause an increase of 8°C (14°F) in combustion liner temperature compared with that of standard Jet A fuel of 15 per cent aromatics (see reference [b]).² There is, normally, no detonation problem in a continuous combustion process engine like the gas turbine.

For the benefit of those readers interested in a simple explanation of the subject, Ethyl Fluid consisted of tetraethyl lead $Pb(C_2H_5)_4$ and a halogen bearer such as ethylene dibromide or ethylene dichloride. The latter was added to the lead in amounts of 1 or 1.5 theories (one theory being the theoretical chemical amount of halogen bearer fully to convert the lead oxide formed during combustion to more volatile compounds (lead bromide or lead chloride) for the better evacuation from the engine cylinders, to reduce deposits.

Ethylene dibromide was favoured for the Ethyl Fluid used in aviation fuel since it was more effective (volatile), but more expensive than ethylene dichloride – which latter was used for many years in

MOTOR MIX with a half theory of ethylene dibromide for automotive gasoline – $1\frac{1}{2}$ T total. I-T AVIATION FLUID contained tetraethyl lead with one theory of ethylene dibromide. In recent years, tetramethyl lead (T.M.L.), a more volatile form of lead than T.E.L., has been used with the latter, to improve lead distribution and anti-knock effect throughout the fuel particularly in the lighter fuel ends.

Ethylene dibromide is manufactured by processing vast quantities of sea water. Bromine is present in sea water in the proportion of about seven thousandths of one per cent, but one cubic mile of sea water contains about 600,000,000 lb of bromine.

¹ [a] *Milestones in Aviation Fuels* by W. G. Dukek, D. P. Winans and A. R. Ogston. Paper given at A.I.A.A. Designers and Operators meeting, July, 1969, Los Angeles.

² [b] *Looking for Fuels in the Future* by William Dukek and Dr. John Langwell. *Petroleum Review*, April, 1978.