NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED

May 1946 as
Restricted Bulletin E6D22

THE KNOCK-LIMITED PERFORMANCE OF FUEL BLENDS CONTAINING SPIROPENTANE, METHYLENECYCLOBUTANE, DI-tert-BUTYL ETHER, METHYL tert-BUTYL ETHER, AND TRIPTANE

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INTRODUCTION

A general investigation is being conducted at the NACA Cleveland laboratory to determine the effectiveness of various compounds as antiknock agents for aviation fuels. As a part of this program, limited quantities of spiropentane, methylenecyclobutane, and di-*tert*-butyl ether were synthesized for exploratory tests. Methyl *tert*-butyl ether and triptane, which had been commercially obtained, were used for comparative purposes. Knock-limited tests were made in a 17.6 engine of blends containing each of the five compounds individually blended with S-4 reference fuel to a concentration of 20 percent by volume; the final blends contained 4 ml TEL per gallon. The data were obtained in August 1945.

APPARATUS AND TEST PROCEDURE

A description of the apparatus is given in reference 1. The tests were conducted with a 17.6 engine at the following engine conditions:

Engine speed, rpm	1800
Compression ratio	7.0
Outlet-coolant temperature, °F	212
Inlet-air temperature, °F	250, 100
Spark advance, deg B.T.C.	30

PRESENTATION AND DISCUSSION OF RESULTS

The knock-limited performance at an inlet-air temperature of 250° F of leaded blends containing spiropentane and methylenecyclobutane is presented in figure 1; the knock-limited performance at inlet-air temperatures of 250° F and 100° F of leaded blends containing di-tert-butyl ether, methyl tert-butyl ether, and triptane is presented in figure 2. All data at a given inlet-air temperature were obtained during a single operating day. The data of figures 1 and 2 are summarized in table I.

The 20-percent addition of spiropentane (fig. 1) decreased the knock-limited power of the base fuel at all fuel-air ratios below 0.085 but permitted gains at richer fuel-air mixtures. Methylenecyclobutane decreased the knock-limited power of the base fuel at all fuel-air ratios below 0.112. Because of the lack of material, knock-limited performance data were not obtained for the spiropentane blend at fuel-air ratios greater than 0.10; additional tests to determine the effect of a change in inlet-air temperature on the knock-limited performance of either of the two aforementioned blends were not possible for the same reason.

Di-tert-butyl ether, methyl tert-butyl ether, and triptane (fig. 2) increased the knock-limited power of the base fuel at all fuel-air ratios and at both inlet-air temperatures. Methyl tert-butyl ether was the most effective antiknock agent of the three compounds. Di-tert-butyl ether was more effective than triptane at fuel-air ratios below 0.07 at the higher inlet-air temperature and at all fuel-air ratios at the lower inlet-air temperature. (Under other test conditions, reference 2 showed that di-tert-butyl ether had better antiknock qualities than methyl tert-butyl ether at fuel-air ratios below about 0.065.) Blends containing the three compounds are more sensitive at fuel-air ratios of 0.065 and 0.07 to changes in inlet-air temperature (table I(b)) than the base fuel; methyl tert-butyl ether was the most sensitive in the aforementioned fuel-air-ratio range.

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REFERENCES

1. Meyer, Carl L., and Branstetter, J. Robert: The Knock-Limited Performance of Fuel Blends Containing Aromatics. Part I - Toluene, Ethylbenzene, and p-Xylene. NACA ARR No. E4J05, 1944.

2. Alquist, Henry E., and Tower, Leonard K.: Suitability of Ethers as Aviation Fuel Components. The Knock-Limited Performance of Several Ethers Blended with AN-F-28 Fuel. NACA CB No. E5A04, 1945.

TABLE I - SUMMARY OF TEST DATA

[17.6 engine; compression ratio, 7.0; engine speed, 1800 rpm; spark advance, 30° B.T.C.; outlet-coolant temperature, 212° F]

(a) Relative performance

Compound	Blend composition (percent by volume) Compound	S-4	Tetraethyl lead (ml/gal)	imep ratio[a] Fuel-air ratio 0.065	0.07	0.085	0.10	0.11
Inlet-air temperature, 250° F								
S-4 reference fuel	0	100	4	1.00	1.00	1.00	1.00	1.00
Spiropentane	20	80	4	0.84	0.86	1.00	1.09	----
Methylenecyclobutane				.77	.81	.89	.95	0.99
Di-*tert*-butyl ether				1.19	1.15	1.14	1.16	1.17
Methyl *tert*-butyl ether				1.26	1.25	1.37	1.45	1.47
Triptane				1.14	1.15	1.20	1.21	1.19
Inlet-air temperature, 100° F								
S-4 reference fuel	0	100	4	1.00	1.00	1.00	1.00	1.00
Di-*tert*-butyl ether	20	80	4	1.28	1.26	1.23	1.20	1.19
Methyl *tert*-butyl ether				1.40	1.42	1.41	1.41	1.40
Triptane				1.19	1.21	1.17	1.15	1.16

$$^{a}\text{imep ratio} = \frac{\text{imep (20 percent compound + 80 percent S-4 + 4 ml TEL/gal)}}{\text{imep (S-4 + 4 ml TEL/gal)}}$$

(b) Relative temperature sensitivity

Compound	Blend composition (percent by volume) Compound	S-4	Tetraethyl lead (ml/gal)	Relative temperature sensitivity[a] Fuel-air ratio 0.065	0.07	0.085	0.10	0.11
S-4 reference fuel	0	100	4	1.00	1.00	1.00	1.00	1.00
Di-*tert*-butyl ether	20	80	4	1.08	1.10	1.08	1.03	1.02
Methyl *tert*-butyl ether				1.11	1.14	1.03	.97	.95
Triptane				1.04	1.05	.98	.95	.97

[a]Relative temperature

$$\text{sensitivity} = \frac{\text{imep ratio (inlet-air temperature, 100° F)}}{\text{imep ratio (inlet-air temperature, 250° F)}}$$

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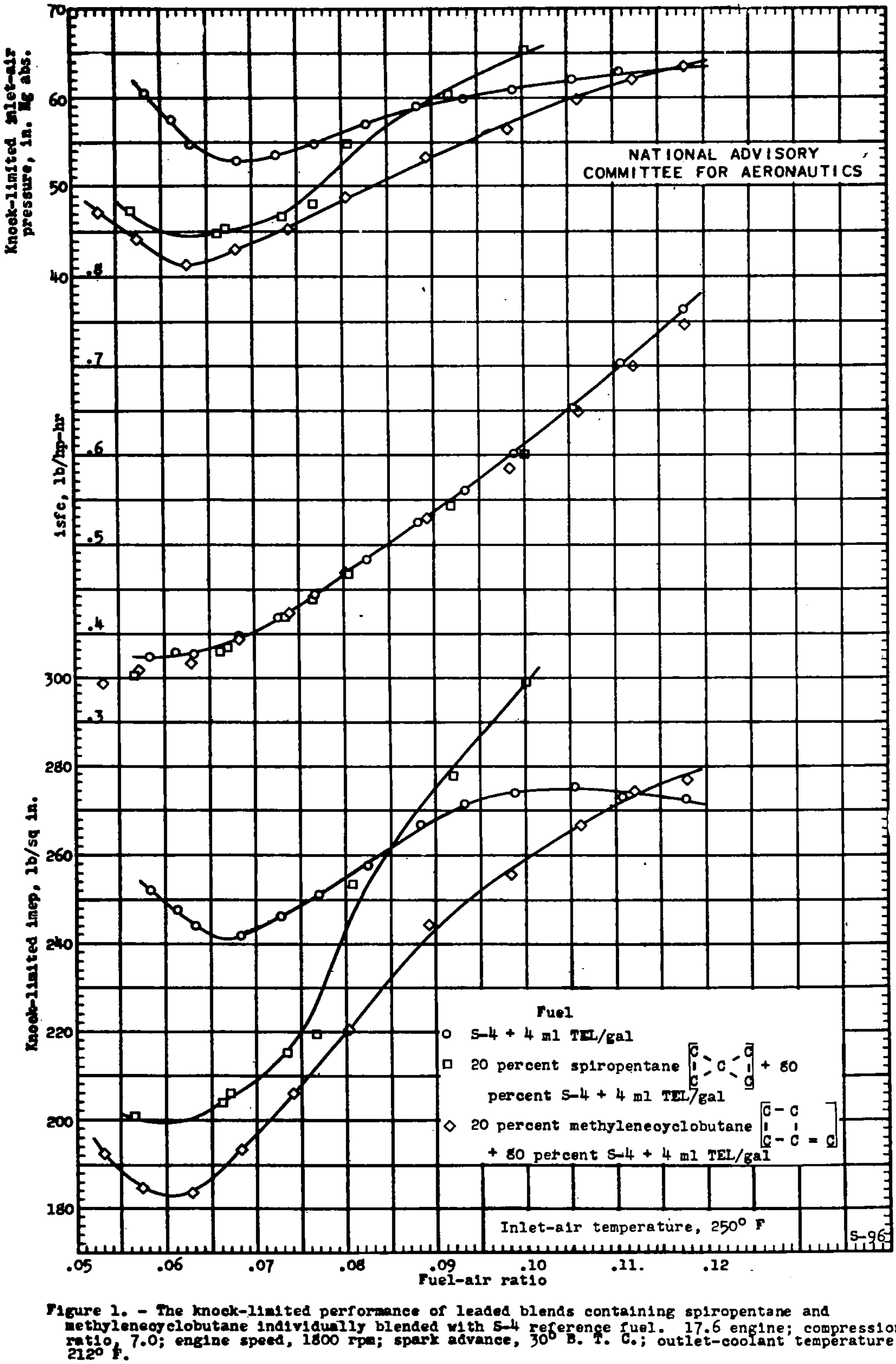

Figure 1. - The knock-limited performance of leaded blends containing spiropentane and methylenecyclobutane individually blended with S-4 reference fuel. 17.6 engine; compression ratio, 7.0; engine speed, 1800 rpm; spark advance, 30° B. T. C.; outlet-coolant temperature, 212° F.

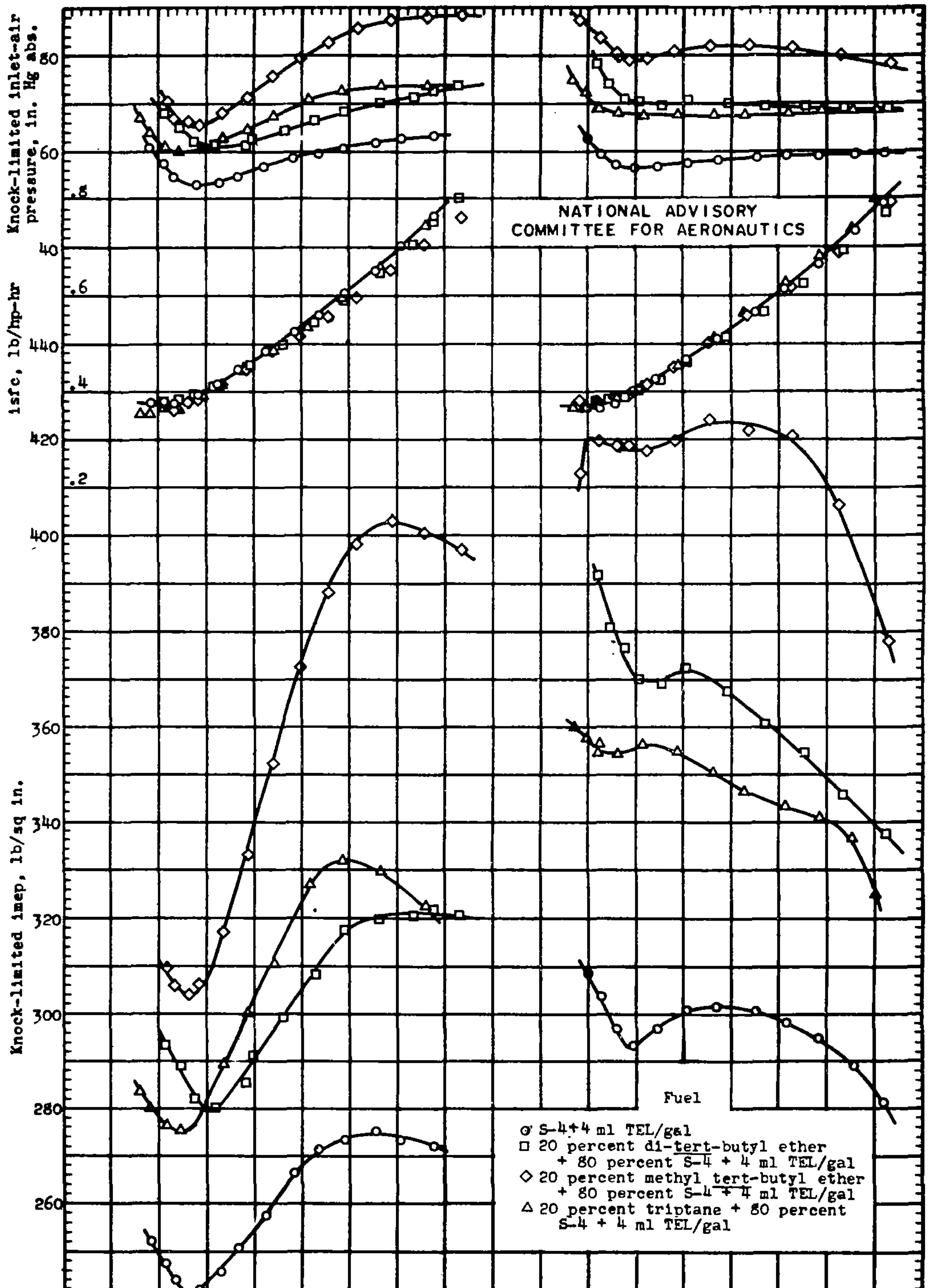

Figure 2. - The knock-limited performance of leaded blends containing di-tert-butyl ether, methyl tert-butyl ether, and triptane individually blended with S-4 reference fuel. 17.6 engine; compression ratio, 7.0; engine speed, 1800 rpm; spark advance, 30° B. T. C.; outlet-coolant temperature, 212° F.