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KNOCK-LIMITED PERFORMANCE OF BLENDS OF AN-F-28 FUEL
CONTAINING 4 PERCENT ALIPHATIC AMINES

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RESTRICTED BULLETIN

KNOCK-LIMITED PERFORMANCE OF BLENDS OF AN-F-28 FUEL

CONTAINING 4 PERCENT ALIPHATIC AMINES

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INTRODUCTION

Tests conducted by the NACA and other laboratories have shown that several of the aromatic amines are of interest as aviation-fuel additives for improving knock-limited power. Although aliphatic amines have in the past appeared to be less effective than aromatic amines as antiknock compounds (reference 1), recent investigations of the knock-limited performance of internal coolants have indicated that the use of certain aliphatic amines in water solutions as internal coolants resulted in extremely high knock-limited power. The antiknock effectiveness of some of the aliphatic amines when mixed either directly with the fuel or in water solutions as internal coolants is therefore being investigated at the Cleveland laboratory of the NACA.

The present paper reports knock-limited performance data on fuel blends containing 96 percent by volume of AN-F-28, Amendment-2, fuel and 4 percent by volume of each of the following aliphatic amines: diethylamine, triethylamine, butylamine, isobutylamine, diisopropylamine, and sec-butylamine. The data were obtained during the summer of 1944.

APPARATUS AND TEST PROCEDURE

The tests were conducted with a high-speed, supercharged CFR engine coupled to a 100-horsepower, direct-current, cradle-type, dynamometer. The engine was equipped with an aluminum piston, a sodium-cooled exhaust valve, two independent fuel systems, and a four-hole cylinder equipped with dual ignition. Knock was detected by a magnetostriction pickup unit in conjunction with a cathode-ray oscilloscope. Champion RJ-2 spark plugs were used throughout the tests. The engine operating conditions were as follows:

Engine speed, rpm	2500
Inlet-air temperature, °F	250
Coolant temperature, °F	250
Compression ratio	7.0
Spark advance, degrees B.T.C.	30
Inlet-oil temperature, °F	150

The amines, as purchased, were estimated to be 98 percent pure and were added to the base stock without further treatment. The final blend of amine and base stock was leaded to 4.6 ml TEL per gallon.

RESULTS AND DISCUSSION

Figure 1 presents the curves of knock-limited performance for the six aliphatic amines blended with AN-F-28, Amendment-2, fuel and for the base fuel alone. Each part of figure 1 (that is, figs. 1(a), 1(b), and 1(c)) presents data taken on a single day. The discrepancies between the three base-fuel curves therefore indicate the daily variations in the knock-limited engine performance. No significance was attributed to differences in the indicated specific fuel consumptions of the blends and the base fuel. A comparison of the knock-limited indicated mean effective pressures afforded by each of the aliphatic amines relative to that of AN-F-28, Amendment-2, fuel is presented in table I.

Of the six amines tested, isobutylamine gave the highest knock-limited performance at fuel-air ratios above about 0.08. At a fuel-air ratio of 0.115, a 4-percent addition of this compound to the base fuel resulted in an improvement of about 10 percent in the knock-limited indicated mean effective pressure. Because of insufficient material, no data points were recorded at fuel-air ratios below 0.07. sec-Butylamine caused some improvements in the knock-limited performance of the base fuel over the normal range of fuel-air ratios. Both diethylamine and diisopropylamine promoted knock except in the very rich-mixture region; butylamine and triethylamine acted as proknock agents at all fuel-air ratios tested.

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REFERENCES

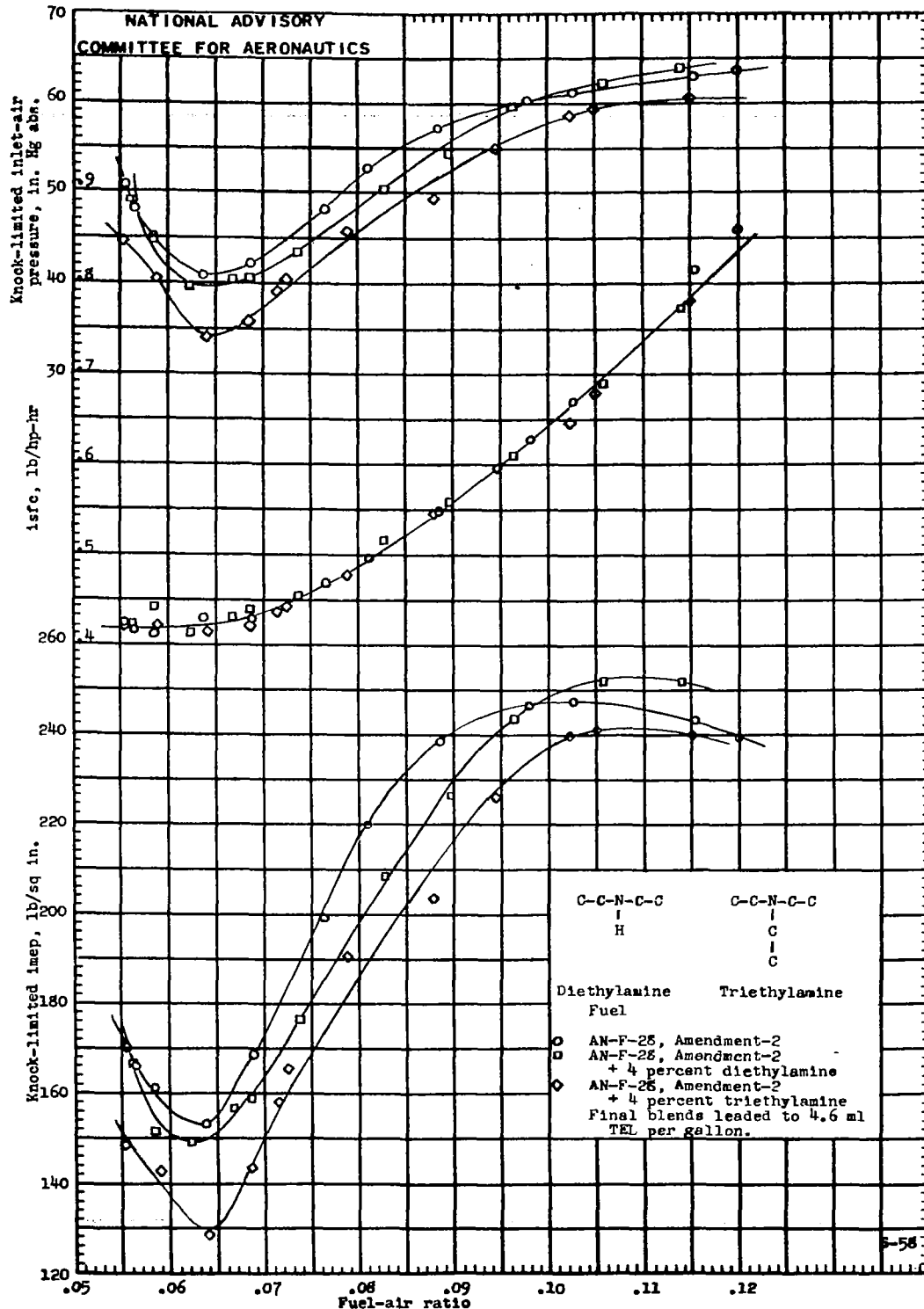
1. Boyd, T. A.: Relative Effects of Some Nitrogen Compounds upon Detonation in Engines. Ind. and Eng. Chem., vol. 16, no. 9, Sept. 1, 1924, pp. 893-895.

TABLE I - SUMMARY OF ANTIKNOCK EFFECTIVENESS OF ALIPHATIC-AMINE
ADDITIONS TO AN-F-28, AMENDMENT-2, FUEL

Aliphatic amine (4-percent addition to AN-F-28 fuel) ^a	imep ratio = $\frac{\text{imep}(\text{aliphatic amine} + \text{AN-F-28 fuel})}{\text{imep}(\text{AN-F-28 fuel})}$			
	F/A = 0.062	F/A = 0.070	F/A = 0.090	F/A = 0.110
Diethylamine	0.97	0.95	0.96	1.03
Triethylamine	.86	.87	.90	.98
Butylamine	.98	.97	.94	1.00
Isobutylamine	-----	1.05	1.03	1.09
Diisopropylamine	.94	.93	.93	.98
sec-Butylamine	1.02	1.08	1.01	1.02

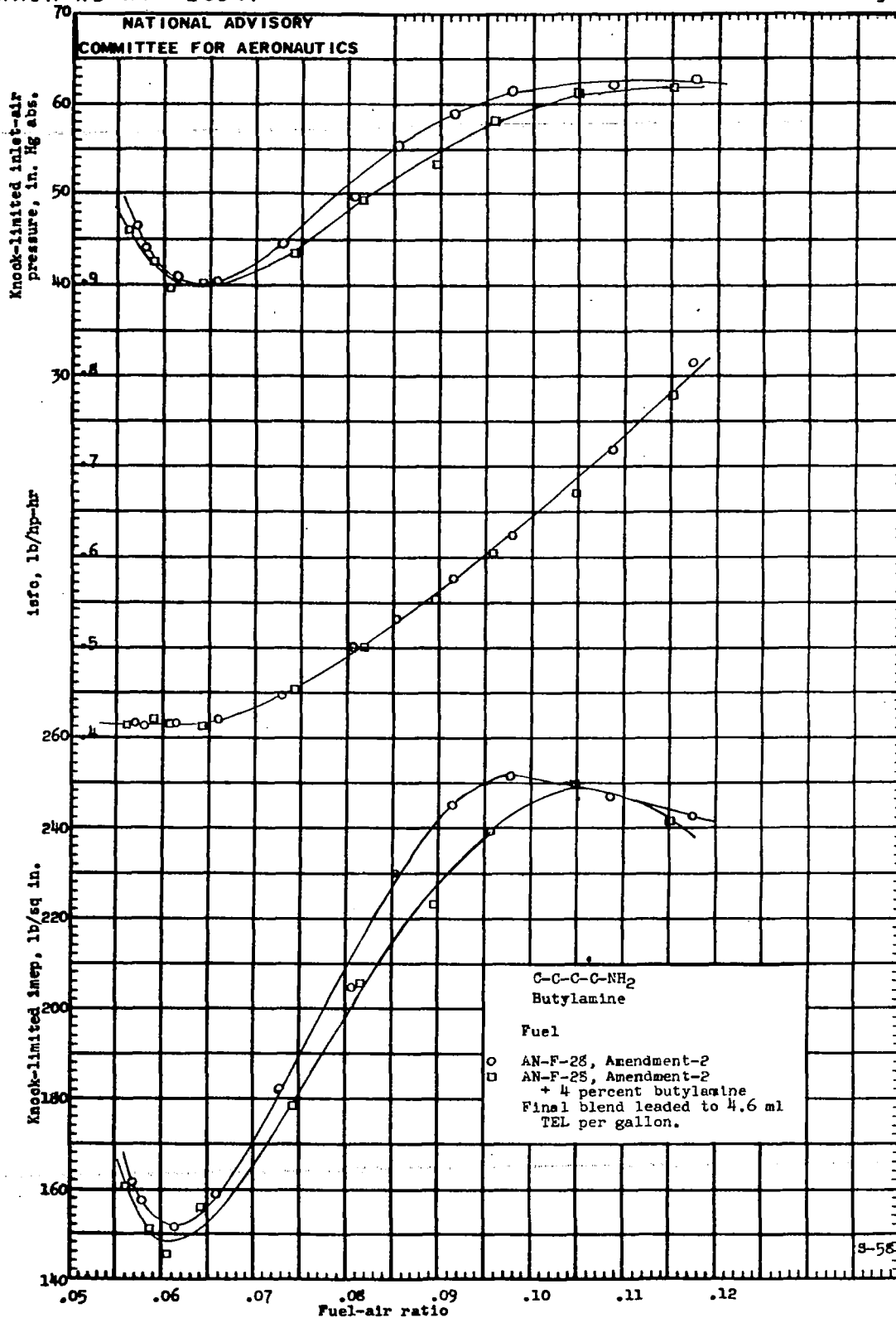
^aFinal blend leaded to 4.6 ml TEL/gal.

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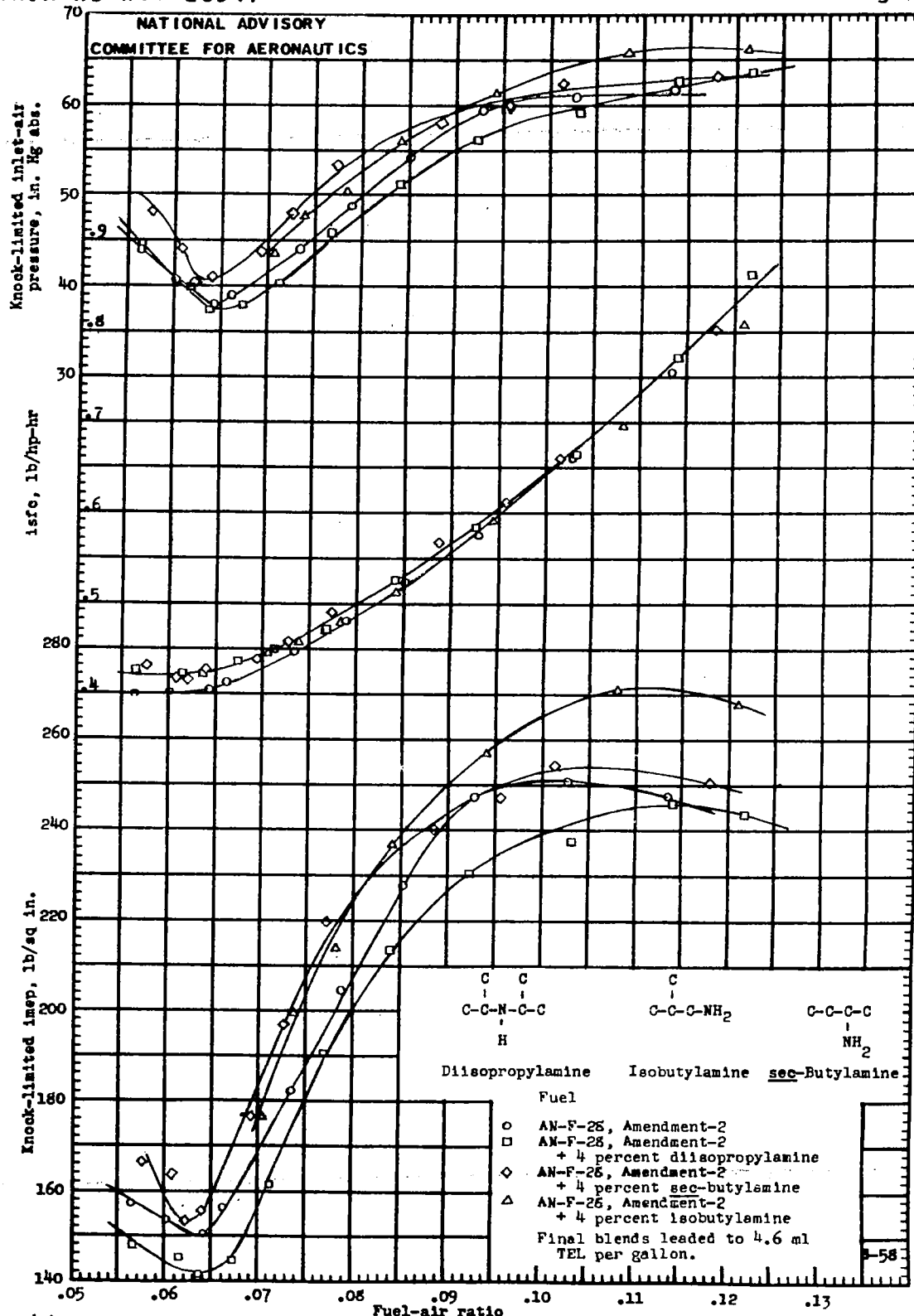


(a) Diethylamine and triethylamine.

Figure 1. - The effect of the addition of 4 percent aliphatic amines to AN-F-28, Amendment-2 fuel on the knock-limited performance of a CFR engine. Inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.; engine speed, 2500 rpm; compression ratio, 7.0; inlet-oil temperature, 150° F.



(b) Butylamine.
Figure 1.-Continued.



(c) Diisopropylamine, sec-butylamine, and isobutylamine.
Figure 1. - Concluded.

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ABSTRACT

Highest knock-limited performance at fuel/air ratios above 0.08 are obtainable with isobutyl amine. At fuel/air ratio of 0.115, 4% of this amine produces a 10% improvement in the knock-limited indicated mean effective pressure. Secondary butylamine causes some improvement in the knock-limited performance of the base fuel over the normal range of fuel/air ratios. Diethylamine and diisopropylamine are ineffective in very rich-mixture region. Butylamine and triethylamine act as proknocks.

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