RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

FLIGHT INVESTIGATION OF THE KNOCK-LIMITED PERFORMANCE OF A TRIPTANE BLEND, A TOLUENE BLEND, AND 28-R FUEL IN AN R-1830-75 ENGINE

By

Calvin C. Blackman

Aircraft Engine Research Laboratory
Cleveland, Ohio

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

SEP 27 1946

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

FLIGHT INVESTIGATION OF THE KNOCK-LIMITED PERFORMANCE OF A TRIPTANE BLEND, A TOLUENE BLEND, AND 28-R FUEL IN AN R-1830-75 ENGINE

By Calvin C. Blackman

SUMMARY

Knock-limited performance data were obtained for three fuels on an R-1830-75 engine in a B-24D airplane at engine speeds of 1800, 2250, and 2600 rpm, a spark advance of 25° B.T.C., and carburetor-air temperatures of 85° F for 1800 and 2250 rpm and 100° F for 2600 rpm. The test fuels were a blend of 80 percent 28-R plus 20 percent triptane (leaded to 4.5 ml TEL/gal), a blend of 85 percent 28-R plus 15 percent toluene (leaded to 4.5 ml TEL/gal), and 28-R fuel.

The knock-limited manifold pressure of the toluene blend depreciated more in the lean region than the triptane blend or 28-R fuel. The knock-limited brake horsepower for the triptane blend varied from 16 to 25 percent higher than 28-R in the lean region and 18 to 30 percent higher in the rich region. The knock-limited brake horsepower of the toluene blend was approximately 15 percent higher than that of 28-R in the rich region and varied from 2 to 10 percent higher in the lean region.

Knock limits of the triptane blend and 28-R fuel tested in the R-1830-75 engine agreed with limits for the same fuels determined with the R-1830-94 engine for engine speeds of 1800 and 2250 rpm.

INTRODUCTION

As a part of the general program requested by the Army Air Forces, Air Materiel Command, to evaluate triptane as an aviation fuel component, a flight investigation was previously conducted on an R-1830-94 engine in a B-24D airplane to determine the knock limits of 28-R and

33-R fuels, a blend of 20 percent triptane with 80 percent 28-R, and a blend of 3 percent xylidines with 97 percent 28-R (references 1 to 3). In order to supplement these data, additional knock tests were made at the NACA Cleveland laboratory on an R-1830-75 engine testing a blend of 20 percent triptane with 80 percent 28-R, a blend of 15 percent toluene with 85 percent 28-R, and 28-R fuel by increasing engine speed and thereby extending the tests to a more severe engine condition. The toluene blend was selected to have a fuel sensitivity intermediate between that of the triptane blend and the xylidines blend of reference 2. This sensitivity was measured by the difference between the F-3 and F-4 ratings, as shown in the following table:

Fuels	Difference between F-3 and F-4 performance numbers
28-R	30
Triptane blend	38
Toluene blend	42
Xylidines blend	50

APPARATUS AND TEST PROCEDURE

An R-1830-75 engine (Mfr. No. 600884) was used for these tests because the R-1830-94 engine failed in the tests of reference 2 and no replacement was available. Several design changes exist between the R-1830-94 and the R-1830-75 engine (references 4 and 5). The change from flat to domed pistons may have changed the knock characteristics of the engine. Instrumentation and flight procedure for the tests were the same as in the previous tests (references 1 to 3). The three fuels were tested under the following conditions:

Fuel	Engine speed (rpm)	Approximate carburetor-air temperature (°F)
Triptane blend	1800	85
	2250	85
	2600	100
Toluene blend	1800	85
	2250	85
	2600	100
28-R	1800	85
	2250	85
	2600	100

The spark setting was maintained at 25° B.T.C. and the impeller gear ratio was 7.15:1 for all the tests. The F-3 and F-4 ratings obtained for the three fuels are:

Fuel (1)	Army-Navy performance number	
	F-3 rating (lean)	F-4 rating (rich)
Triptane blend, 80 percent 28-R and 20 percent triptane (leaded to 4.5 ml TEL/gal)	109	147
Toluene blend, 85 percent 28-R and 15 percent toluene (leaded to 4.5 ml TEL/gal)	103	145
28-R	100	130

[1]Compositions determined on volume basis.

RESULTS AND DISCUSSION

The knock data obtained with the three fuels are presented in figures 1(a) to 1(c) in the order of increasing severity of engine conditions as indicated by engine speed. Each figure shows knock-limited manifold pressure, knock-limited brake horsepower, brake specific fuel consumption, and mixture temperature plotted against fuel-air ratio.

When the engine speed was increased from 1800 to 2250 rpm (figs. 1(a) and 1(b)), the knock curves became steeper with a greater lean-mixture depreciation of the knock-limited manifold pressure for the toluene blend than for the triptane blend or 28-R fuel. A further increase in engine speed to 2600 rpm (fig. 1(c)) resulted in a still greater depreciation of the lean-mixture knock-limited manifold pressure of the toluene blend relative to the other two fuels. The following table presents the ratio of the knock-limited brake horsepower for the test fuels relative to 28-R:

Engine speed (rpm)	Carburetor-air temperature (°F)	Ratio of knock-limited brake horsepower			
		Fuel-air ratio of triptane blend		Fuel-air ratio of toluene blend	
		0.065	0.08	0.065	0.08
1800	85	1.17	1.21	1.10	1.16
2250	85	1.16	1.18	1.09	1.13
2600	100	1.25	1.30	1.02	1.16

The knock limits on the R-1830-75 engine with the triptane blend and 28-R fuel at 1800 and 2250 rpm (figs. 1(a) and 1(b)) are approximately the same as those determined in the R-1830-94 engine (reference 2) for the same fuels.

SUMMARY OF RESULTS

Tests of a triptane blend, a toluene blend, and 28-R fuel in an R-1830-75 engine installed in a B-24D airplane gave the following results:

1. The knock-limited manifold pressure of the toluene blend depreciated more in the lean region for the more severe conditions of 2250 and 2600 rpm than the triptane blend and 28-R fuel.

2. The knock-limited brake horsepower for the triptane blend fuel was 16 to 25 percent higher than 28-R in the lean region and 18 to 30 percent higher in the rich region over the speed range examined. The knock-limited brake horsepower of the toluene blend fuel was approximately 15 percent higher in the rich region and varied from 2 to 10 percent higher in the lean region.

3. The knock limits of the triptane blend and 28-R fuel tested in the R-1830-75 engine agreed with limits determined with the R-1830-94 engine for engine speeds of 1800 and 2250 rpm.

Aircraft Engine Research Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio.

Calvin C. Blackman,
Mechanical Engineer.

Approved:
for Joseph R. Vensel,
Engineer Test Pilot.

Abe Silverstein,
Aeronautical Engineer.

lrp

REFERENCES

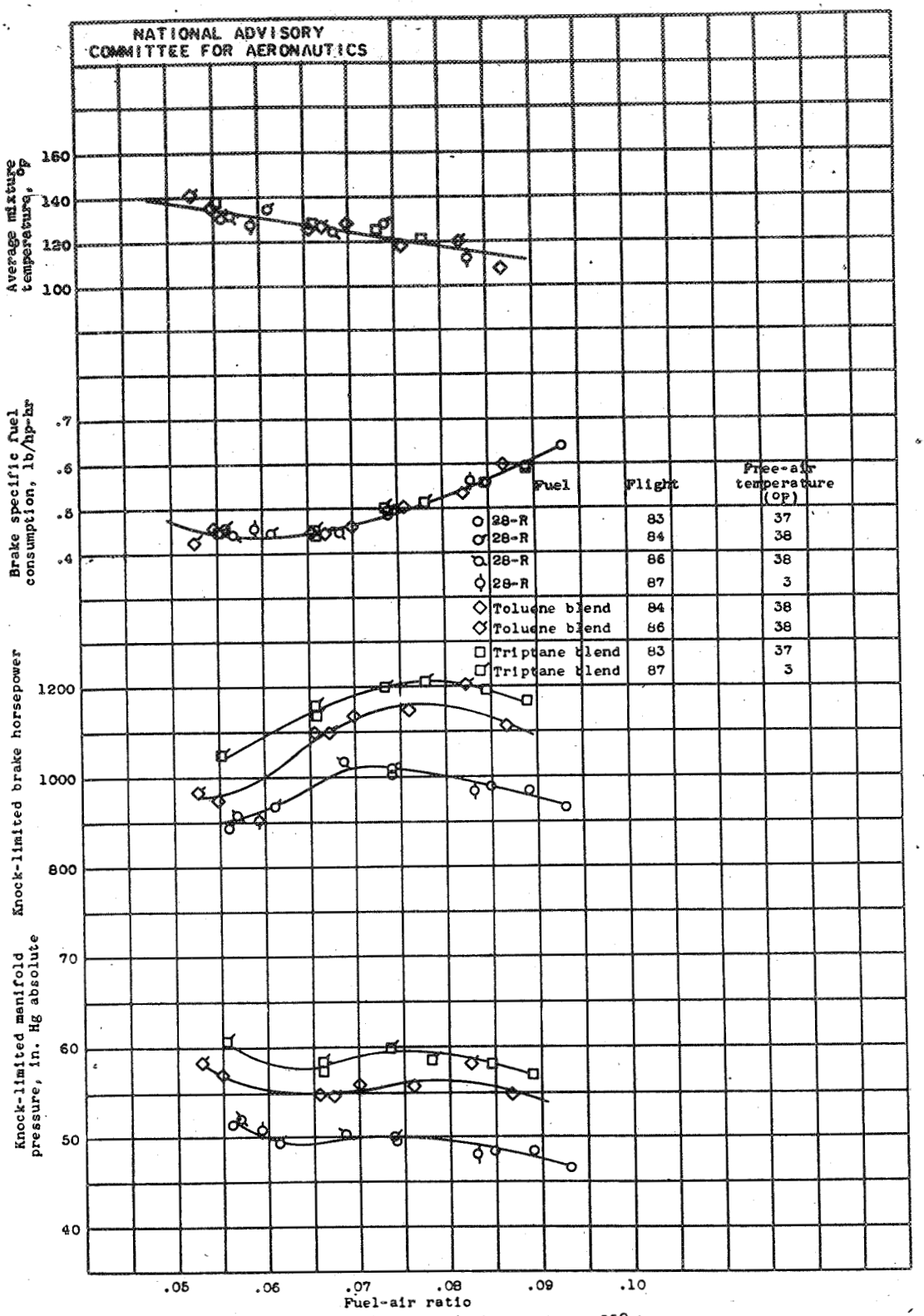
1. Werner, Milton, Blackman, Calvin C., and White, H. Jack: Flight and Test-Stand Investigation of High-Performance Fuels in Pratt & Whitney R-1830-94 Engines. I - Determination of Cooling Characteristics of the Flight Engine. NACA MR No. E5G09, Army Air Forces, 1945.

2. White, H. Jack, Pragliola, Philip C., and Blackman, Calvin C.: Flight and Test-Stand Investigation of High-Performance Fuels in Pratt & Whitney R-1830-94 Engines. II - Flight Knock Data and Comparison of Fuel Knock Limits with Engine Cooling Limits in Flight. NACA MR No. E5H04, Army Air Forces, 1945.

3. Blackman, Calvin C., and White, H. Jack: Flight and Test-Stand Investigation of High-Performance Fuels in Pratt & Whitney R-1830-94 Engines. III - Knock-Limited Performance of 33-R as Compared with a Triptane Blend and 28-R in Flight. NACA MR No. E5H08, Army Air Forces, 1945.

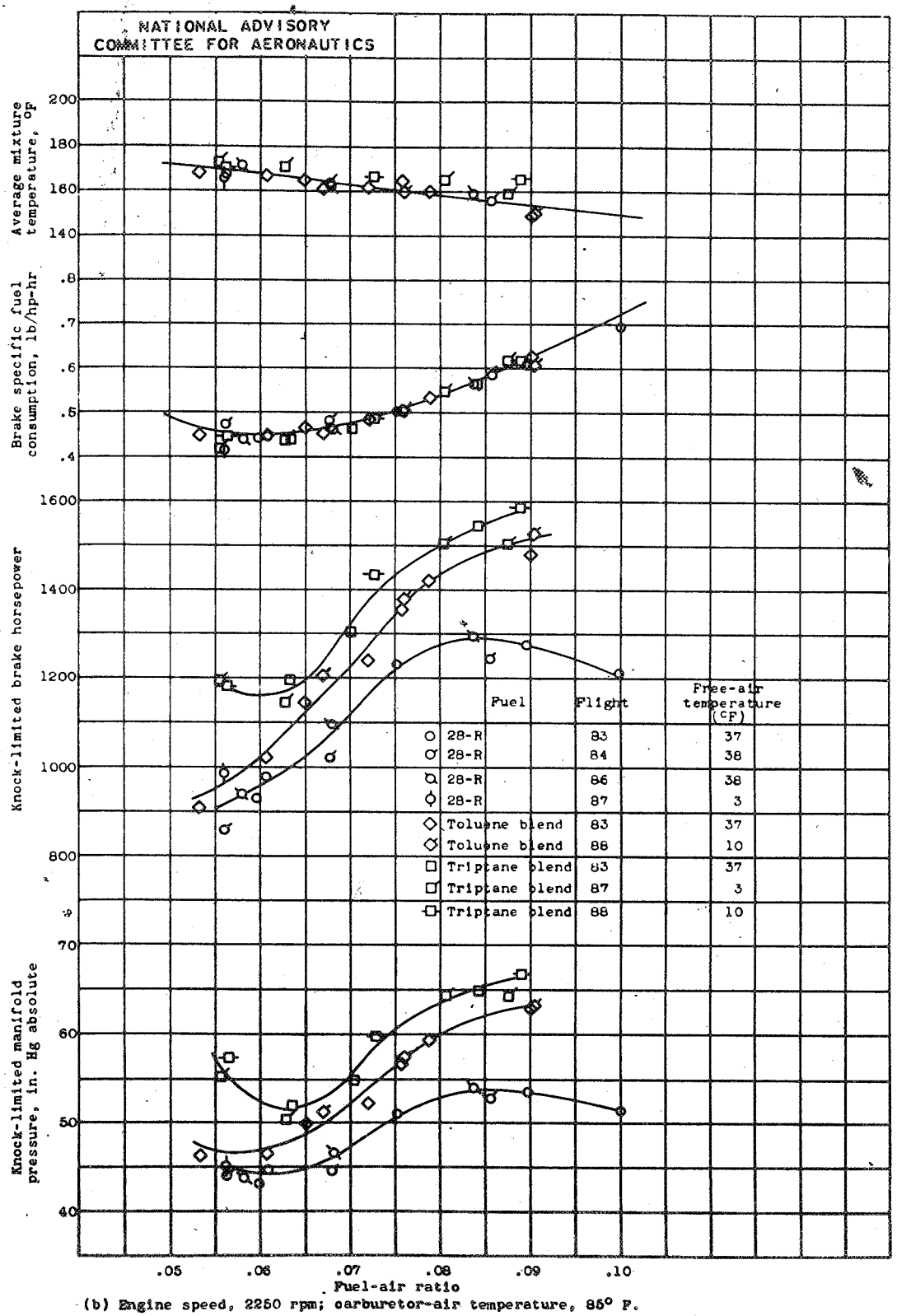
4. Anon.: Specific Operating Instructions, R-1830-94 Engine. PWA.OI.48B, Pratt & Whitney Aircraft, June 18, 1945.

5. Anon.: Preliminary Operating Instructions for R-1830-75 Engines. PWA.OI.55A, Pratt & Whitney Aircraft, Feb. 12, 1946.



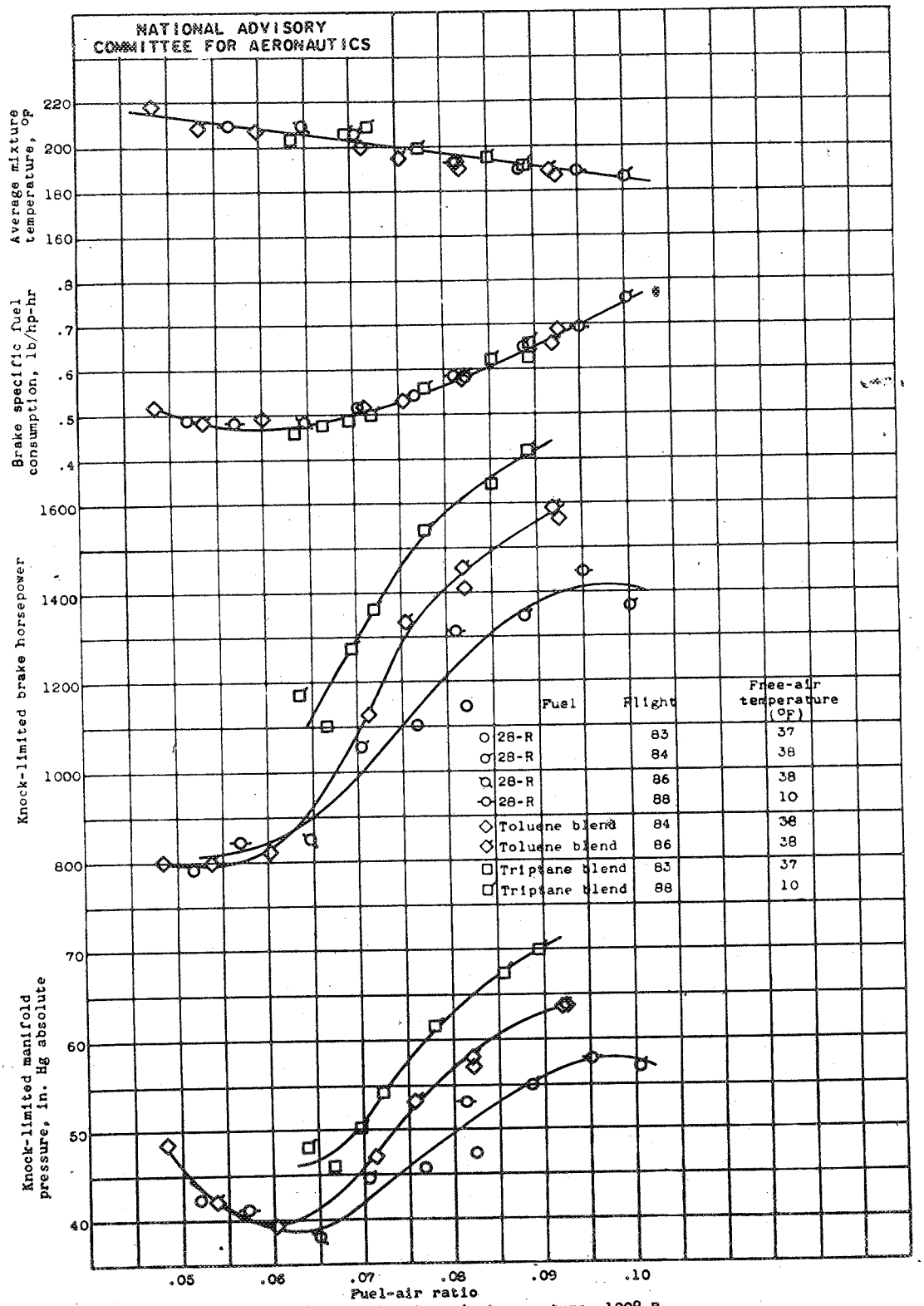
(a) Engine speed, 1800 rpm; carburetor-air temperature, 85° F.

Figure 1. - Performance of R-1830-75 engine in B-24D airplane as limited by knock characteristics of three fuels. Blower ratio, 7.15:1; spark advance, 25° B.T.C.



(b) Engine speed, 2250 rpm; carburetor-air temperature, 85° F.

Figure 1. - Continued. Performance of R-1830-75 engine in B-24D airplane as limited by knock characteristics of three fuels. Blower ratio, 7.15:1; spark advance, 25° B.T.C.



(c) Engine speed, 2600 rpm; carburetor-air temperature, 100° F.

Figure 1. - Concluded. Performance of R-1830-75 engine in B-24D airplane as limited by knock characteristics of three fuels. Blower ratio, 7.15:1; spark advance, 26° B.T.C.