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RESEARCH MEMORANDUM

KNOCK-LIMITED PERFORMANCE OF TRIPTANE AND 28-R FUEL BLENDS AS AFFECTED BY CHANGES IN COMPRESSION RATIO AND IN ENGINE OPERATING VARIABLES

By Rinaldo J. Brun, Melvin S. Feder, and
William F. Fisher

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KNOCK-LIMITED PERFORMANCE OF TRIPTANE AND 28-R FUEL BLENDS AS AFFECTED BY CHANGES IN COMPRESSION RATIO AND IN ENGINE OPERATING VARIABLES

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SUMMARY

A knock-limited performance investigation was conducted on blends of triptane and 28-R fuel with a 12-cylinder, V-type, liquid-cooled aircraft engine of 1710-cubic-inch displacement at three compression ratios: 6.65, 7.93, and 9.68. At each compression ratio, the effect of changes in temperature of the inlet air to the auxiliary-stage supercharger and in fuel-air ratio were investigated at engine speeds of 2280 and 3000 rpm.

The results show that knock-limited engine performance, as improved by the use of triptane, allowed operation at both take-off and cruising power at a compression ratio of 9.68. At an inlet-air temperature of 60° F, an engine speed of 3000 rpm, and a fuel-air ratio of 0.095 (approximately take-off conditions), a knock-limited engine output of 1500 brake horsepower was possible with 100-percent 28-R fuel at a compression ratio of 6.65; 20-percent triptane was required for the same power output at a compression ratio of 7.93, and 75 percent at a compression ratio of 9.68 allowed an output of 1480 brake horsepower.

Knock-limited power output was more sensitive to changes in fuel-air ratio as the engine speed was increased from 2280 to 3000 rpm, as the compression ratio is raised from 6.65 to 9.68, or as the inlet-air temperature is raised from 0° to 120° F.

INTRODUCTION

Among the methods of utilizing high-performance fuels is that of increasing fuel economy through use of increased compression ratio and advanced spark settings; high-performance fuel allows these changes without interference from knock. Data have been obtained on a 12-cylinder, V-type, liquid-cooled aircraft engine of 1710-cubic-inch engine displacement to determine the relations among cruising fuel economy, engine operating conditions, compression ratio, and knock-free take-off power available with high-performance fuels. The results of this investigation have been divided into two parts: (1) fuel economy at various compression ratios (reference 1), and (2) the knock-limited data presented in this report.

The effects of change in inlet-air temperature and in fuel-air ratio on the knock-limited performance obtainable with blends of triptane and 28-R fuel were investigated at three compression ratios, 6.65, 7.93, and 9.68 at engine speeds of 2280 and 3000 rpm. In order to aid in the evaluation of engine mechanical endurance, peak cylinder pressures were measured in a single-cylinder engine but only at an engine speed of 3000 rpm.

APPARATUS

The investigation was conducted with a 12-cylinder, V-type, liquid-cooled aircraft engine of 1710-cubic-inch displacement. The engine has two stages of supercharging (an engine-stage supercharger and an auxiliary-stage supercharger driven by the engine through a hydraulic coupling) with interstage carburetion. Compression ratio was varied by using three different pistons described in reference 1. The compression ratios as measured on the engine with these pistons installed were 6.65, 7.93, and 9.68.

The engine was set up on a dynamometer stand equipped with an absorbing capacity of 3100 horsepower and a motoring capacity of 500 horsepower.

Vibration-type pickup units were used for knock detection. Knock was indicated by an amplifier-oscilloscope combination.

Inlet-air temperature was measured by five thermocouples connected in parallel and arranged to indicate an average temperature of the air stream in the air stack leading to the auxiliary-stage-supercharger entrance elbow. Mixture-temperature data presented were obtained using an unshielded thermocouple installed in the central manifold approximately 9 inches downstream of the flange of the engine-stage-supercharger outlet just upstream of the central-manifold venturi. The mixture temperature at this point closely checked the temperature measured by a shielded thermocouple located 3 inches downstream of the central-manifold venturi and averaged about 10° F lower than the temperature measured in the side manifolds.

The manifold-pressure tap was located in the central manifold approximately $6\frac{1}{2}$ inches downstream of the flange of the engine-stage supercharger outlet. The pressure at this point averaged about 0.7 inch higher than the pressure at either the right- or left-rear manifolds.

Peak cylinder pressure was measured on a multicylinder block adapted to a CUE crankcase for single-cylinder operation. A pressure pickup utilizing the balanced-pressure principle applied on a diaphragm, together with an electronic instrument to determine when the cylinder pressure was equal to the applied pressure, was used in the measurements of peak cylinder pressure. The balancing pressure was observed on a calibrated Bourdon gage.

The apparatus used to obtain the data is the same as that used for the investigation reported in reference 1 and is described in more detail there.

CONDITIONS AND PROCEDURE

The following engine conditions were maintained during the runs:

Engine speed, rpm	2280 ±3, 3000 ±5
Spark advance, degrees B.T.C.:	
Exhaust	34
Intake	28
Outlet-coolant temperature, °F	250 ±5
Inlet-oil temperature, °F	180 ±5
Inlet-air pressure to auxiliary-stage supercharger, inches mercury absolute	29.9 ±0.1

Atmospheric exhaust pressure was maintained.

The following fuel blends, all leaded to 4.6 ml TEL per gallon and made on a percentage-volume basis, were used:

28-R
80-percent 28-R, 20-percent triptane
50-percent 28-R, 50-percent triptane
25-percent 28-R, 75-percent triptane

Knock-limited performance curves were obtained with these fuels under each of the conditions listed in table I. Engine reliability limited the conditions at which some of the high-performance fuels could be operated. No data were obtained on any of the fuels under conditions at which the knock-limited manifold pressure was less than 30 inches of mercury absolute.

The necessary manifold pressures were obtained with the auxiliary-stage supercharger operating at maximum slip in the hydraulic coupling except when the throttle was wide open and auxiliary-stage supercharging was necessary, in which case the desired manifold pressure was obtained by adjusting the speed of the auxiliary-stage supercharger. The data were taken at medium knock intensity, that is, when three or four cylinders were observed to be knocking.

The engine was motored with the dynamometer to measure motoring horsepower. After firing conditions had been established, the fuel and the ignition were cut off and the engine was immediately driven automatically by the dynamometer and the motoring horsepower was measured.

RESULTS AND DISCUSSION

The knock-limit data obtained from the multicylinder engine with blends of 28-R fuel and triptane leaded to 4.6 ml TEL per gallon are presented in figures 1 and 2 as the effect of fuel-air ratio on several engine variables. At a given engine speed and inlet-air temperature to the auxiliary-stage supercharger, data at the three compression ratios investigated are presented in each figure. Most of the data curves were checked, in some cases by the same engine used to obtain the original curves and in other cases by another engine. These check data, shown on the curve sheets as tailed symbols, indicate good data reproducibility.

Indicated horsepower, shown by the dashed curves in figures 1 and 2, is defined as the brake horsepower plus the motoring horsepower. The motoring horsepower was a measure of the losses caused by engine friction, supercharger, induction system, and the oil- and coolant-pumping system. A more complete discussion of indicated horsepower is presented in reference 1. Mechanical efficiency of the engine may be obtained by dividing the brake horsepower by the corresponding value of indicated horsepower.

Curves of observed mixture temperature plotted against fuel-air ratio are included in figures 1 and 2. With this engine, mixture temperature is a function not only of fuel-air ratio for a given inlet-air temperature and engine speed but is also affected by the speed of the auxiliary-stage supercharger.

No data were obtained at manifold pressures below 30 inches of mercury absolute because the knock limit dropped suddenly as the fuel-air mixture was leaned when the manifold pressure was nearly equal to exhaust pressure. This effect is particularly evident at high inlet-air temperature with high compression ratio. A discussion of the effect of exhaust back pressure on knock limit is presented in reference 2.

Knock-limited performance at take-off and cruising conditions. - Restrictive fuel requirements prevented the use of high compression ratios in engines. The use of triptane increases knock-limited performance and permits the use of high compression ratios. Knock-limited engine performance as improved by the use of triptane allows operation at both take-off and cruising power at a compression ratio of 9.68, as shown in figures 1 and 2. Knock-limited power output is more sensitive to changes in fuel-air ratio as the compression ratio is increased from 6.65 to 9.68. This effect can be seen in figures 1 and 2 by the increase in the slope of the knock curves as the compression ratio is increased. As either engine speed or inlet-air temperature is increased from 2280 to 3000 rpm or from 0° to 120° F, respectively, knock-limited power output becomes more sensitive to changes in fuel-air ratio.

The data presented in figures 1 and 2 are summarized in tables II and III. The data showing knock-limited brake horsepower output obtained at the three compression ratios and three inlet-air temperatures with the blends of 28-R fuel and triptane at an engine speed of 3000 rpm and a fuel-air ratio of 0.095 (approximately the values for take-off conditions) are presented in table II. Data obtained at 2280 rpm and a fuel-air ratio of 0.063 are given in table III. This value of fuel-air ratio was chosen because the minimum brake specific fuel consumption at cruising operations occurred at a fuel-air ratio of approximately 0.063 (reference 1).

The knock-limited brake horsepower obtainable from the engine at three compression ratios (6.65, 7.93, and 9.68) with blends of triptane and 28-R fuel is shown in figures 3 and 4. The curves in figure 3 are for an engine speed of 3000 rpm and a fuel-air ratio of 0.095. In figure 3(a) are shown the data obtained at an inlet-air temperature of 60° F (cross-plotted from fig. 1(b)); the variation in mixture temperature is also shown in the figure. Curves are shown in figure 3(b) that permit evaluation of the fuels at a constant mixture temperature of 200° F (cross-plotted from fig. 1). The curves of figure 4 represent data obtained at an engine speed of 2280 rpm cross-plotted at a fuel-air ratio of 0.063. In figure 4(a) the data are shown at an inlet-air temperature of 60° F (cross-plotted from fig. 2(b)); in figure 4(b) the data are shown at a constant mixture temperature of 140° F (cross-plotted from fig. 2).

A comparison of the performance of the fuels at an inlet-air temperature of 60° F, an engine speed of 3000 rpm, and a fuel-air ratio of 0.095 (approximately take-off conditions) may be made from the curves in figure 3(a). A knock-limited engine output of 1500 brake horsepower is possible with 100-percent 28-R fuel at a compression ratio of 6.65, 20-percent triptane is required for the same power output at a compression ratio of 7.93, and 75-percent triptane at a compression ratio of 9.68 will allow a knock-limited brake horsepower of 1480. A similar comparison can be made at cruising conditions by the use of figure 4.

The only fuel investigated over the complete range of compression ratio was the 20-percent triptane blend (figs. 3 and 4). With either constant inlet-air temperature or constant mixture temperature, the knock limit of this fuel blend is more sensitive to a change in compression ratio in the region of high compression ratio than to a corresponding change in the region of low compression ratio. This characteristic can be seen in figures 3 and 4 by the greater drop in brake horsepower per unit change in compression ratio as the compression ratio is raised from 7.93 to 9.68 than the drop in brake horsepower as the compression ratio is raised from 6.65 to 7.93.

Relation between fuel-performance requirements and cruising fuel economy. - In reference 1 is presented an analysis of improvements in cruising fuel economy that are possible with the use of high compression ratios and advanced spark settings and also shown is the amount of triptane blended with 28-R fuel necessary for knock-free operation at cruising conditions with high compression ratios. A more complete analysis of the economic advantages of the use of high compression ratios must also consider the fuel requirements for a given take-off power at different compression ratios. The advantage, in regard to fuel economy, of operating at high compression ratio (at a cruising power output of 750 bhp) is shown in figure 5. In addition, the percentage triptane required for knock-free operation at a take-off power of 1400 brake horsepower as compared to the percentage triptane required for knock-free operation at the 750 cruising horsepower output is shown. The cruising data in figure 5 were taken from reference 1; the data were obtained at an engine speed of 2280 rpm, an inlet-air temperature of 60° F, and the fuel-air ratio for minimum specific fuel consumption. The spark settings for these data were the spark settings that permitted maximum torque at a fuel-air ratio of 0.06, an engine speed of 2280 rpm, a mixture temperature of 200° F, and a manifold pressure of 35 inches of mercury absolute. The take-off power data in figure 5 were cross-plotted from figure 3(a) at a fuel-air ratio of 0.095, an engine speed of 3000 rpm, an inlet-air temperature of 60° F, and a spark setting of 34° B.T.C. for the exhaust spark plug and 28° B.T.C. for the intake spark plug.

As is shown in figure 5, the brake specific fuel consumption decreases from 0.450 to 0.405 pound per horsepower-hour, a decrease of approximately 10 percent, with an increase in compression ratio from 6.65 to 9.68. A 32-percent triptane blend will allow knock-free cruising operation with a compression ratio of 9.68, whereas a 75-percent triptane blend is required for knock-free operation at the take-off power level with a compression ratio of 9.68. At a compression ratio less than 7.3, 28-R fuel is satisfactory for both the take-off and the cruising conditions. Similar comparisons using other values of cruising horsepower can be made with the aid of data from reference 1.

Peak cylinder pressures. - Engine durability was considerably reduced in these runs with engine operation at high compression ratio and power output. Several engine failures were caused by cylinder-gas leakage into the coolant system. The gas leakage was severe enough to cause the coolant-pumping system to fail. Except for one case in which the cylinder head was cracked in cylinders 1 and 2 of the right block, visual inspection showed no signs of damage to the cylinder blocks; it was therefore concluded that the leakage occurred between the cylinder liner and the cylinder head. This leakage is attributed to high peak cylinder pressures.

In figure 6 are shown the values of peak cylinder pressure that can be expected over the range of compression ratio and indicated mean effective pressure in which the multicylinder engine was operated. The magnitudes of peak cylinder pressures that were obtained from the single-cylinder engine are shown with the solid lines, which were extrapolated to cover the range of compression ratio and of indicated mean effective pressure in which the multicylinder engine was operated. Other single-cylinder engine data (unpublished) justify a straight-line extrapolation of peak cylinder pressures against indicated mean effective pressure. These data were taken at an engine speed of 3000 rpm, a fuel-air ratio of 0.10, and a mixture temperature of 200° F. Variations in the cycles caused the peak pressure of some of the cycles to be higher than that of others; the surface in figure 6 represents the mean values.

The ratio of peak pressure to indicated mean effective pressure is greater at a compression ratio of 9.68 than at a compression ratio of 6.65. Peak cylinder pressures above 1800 pounds per square inch can be expected at a compression ratio of 9.68 and at an indicated mean effective pressure of 320 pounds per square inch. Further discussion of peak cylinder pressure in the engine used for this investigation is presented in reference 1.

SUMMARY OF RESULTS

The following results were obtained from the investigation of knock-limited performance of blends of 28-R and triptane on a 12-cylinder, V-type, liquid-cooled aircraft engine of 1710-cubic-inch displacement at compression ratios of 6.65, 7.93, and 9.68:

1. The use of triptane allowed knock-free operation at take-off operating conditions at a compression ratio of 9.68. At an inlet-air temperature of 60° F, an engine speed of 3000 rpm, and a fuel-air ratio of 0.095, a knock-limited power output of 1500 brake horsepower was possible with 100-percent 28-R fuel at a compression ratio of 6.65; 20-percent triptane was required for the same power output at a compression ratio of 7.93, and 75-percent triptane at a compression ratio of 9.68 allowed a knock-limited brake horsepower of 1480.

2. Knock-limited power output was more sensitive to changes in fuel-air ratio as the engine speed was increased from 2280 to 3000 rpm, the compression ratio was raised from 6.65 to 9.68, or the inlet-air temperature was raised from 0° to 120° F.

3. The effect of change in compression ratio on the knock-limited performance of the fuels was obtained over the complete range of compression ratio investigated with only the 20-percent triptane blend because low knock-limited performance of other fuels or engine reliability limited the conditions at which data could be obtained. The knock limit of this fuel blend was more sensitive to a change in compression ratio in the region of high compression ratio than to the same change in the region of low compression ratio.

4. Peak cylinder pressures above 1800 pounds per square inch could be expected at a compression ratio of 9.68 and at an indicated

mean effective pressure of 320 pounds per square inch. Engine durability was considerably reduced by operation at these conditions.

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1. Brun, Rinaldo J., Feder, Melvin S., and Harries, Myron L.: Minimum Specific Fuel Consumption of a Liquid-Cooled Multicylinder Aircraft Engine as Affected by Compression Ratio and Engine Operating Conditions. NACA RM No. E6L31, 1946.

2. Cook, Harvey A., Held, Louis F., and Pritchard, Ernest I.: The Influence of Exhaust Pressure on Knock-Limited Performance. NACA MR No. E5A05, 1945.

TABLE I. - OPERATING CONDITIONS FOR KNOCK-LIMITED INVESTIGATION ON BLENDS OF TRIPTANE AND 28-R FUEL

Engine speed (rpm)	Compression ratio	Fuel (a)			
		28-R	80-percent 28-R, 20-percent triptane	50-percent 28-R, 50-percent triptane	25-percent 28-R, 75-percent triptane
		Inlet-air temperature (°F)			
2280	6.65	0	0	(b)	(b)
		60	60	(b)	(b)
		120	120	(b)	(b)
	7.93	0	0	(b)	(b)
		60	60	60	(b)
		120	120	120	(b)
	9.68	(c)	0	0	(b)
		(c)	60	60	60
		(c)	(c)	120	120
3000	6.65	0	0	(b)	(b)
		60	60	(b)	(b)
		120	120	(b)	(b)
	7.93	0	(b)	(b)	(b)
		60	60	60	(b)
		120	120	120	(b)
	9.68	(c)	0	0	(b)
		(c)	60	60	60
		(c)	(c)	(c)	120

[a] All fuel blends made on a percentage-volume basis and leaded to 4.6 ml TEL/gal.

[b] Limited by engine reliability; no data taken.

[c] Knock-limited manifold pressure less than 30 in. Hg absolute; no data taken.

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TABLE II. - KNOCK-LIMITED BRAKE HORSEPOWER OF TRIPTANE BLENDS WITH 28-R FUEL AT ENGINE SPEED OF 3000 RPM AND FUEL-AIR RATIO OF 0.095

	Knock-limited brake horsepower								
Compression ratio →	6.65			7.93			9.68		
Inlet-air temperature (°F)→	120	60	0	120	60	0	120	60	0
Fuel (a)↓									
28-R	1270	1500	1655	1195	1310	1430	----	----	----
80-percent 28-R 20-precent triptane	1425	1750	1890	1450	1520	----	----	895	1260
50-percent 28-R 50-percent triptane	----	----	----	1675	1750	----	----	1137	1695
25-percent 28-R 75-percent triptane	----	----	----	----	----	----	1275	1480	----

[a] Blends of 28-R and triptane shown on a percentage-volume basis. All fuel contained 4.6 ml TEL/gal.

TABLE III. - KNOCK-LIMITED BRAKE HORSEPOWER OF TRIPTANE BLENDS WITH 28-R FUEL AT ENGINE SPEED OF 2280 RPM AND FUEL-AIR RATIO OF 0.063

	Knock-limited brake horsepower								
Compression ratio →	6.65			7.93			9.68		
Inlet-air temperature (°F)→	120	60	0	120	60	0	120	60	0
Fuel ↓									
28-R	420	1080	1195	760	930	1030	----	----	----
80-percent 28-R 20-percent triptane	1000	1270	1415	950	1125	1245	----	765	950
50-percent 28-R 50-percent triptane	----	----	----	1080	1330	----	----	1020	1370
25-percent 28-R 75-percent triptane	----	----	----	----	----	----	1040	1210	----

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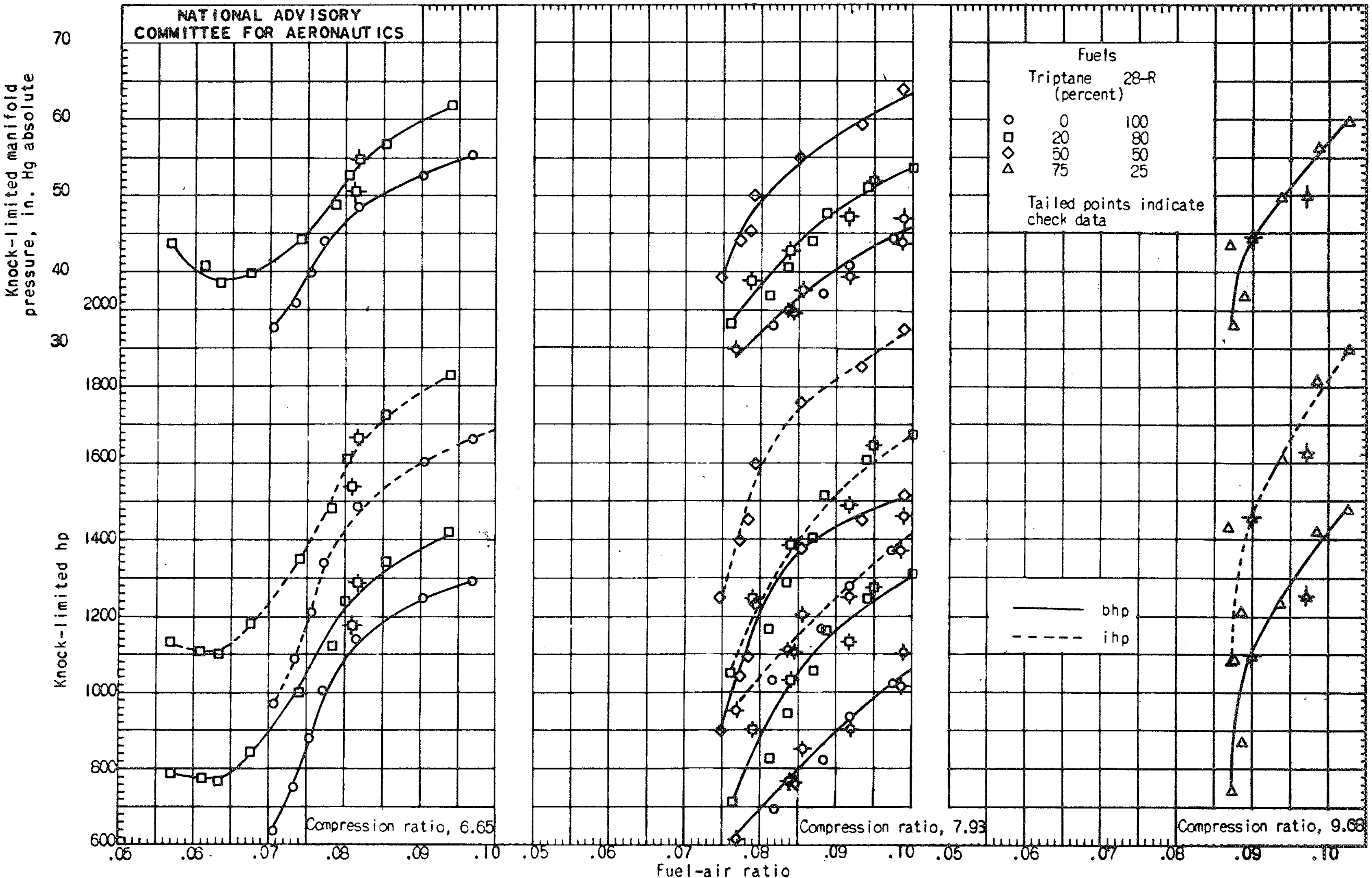
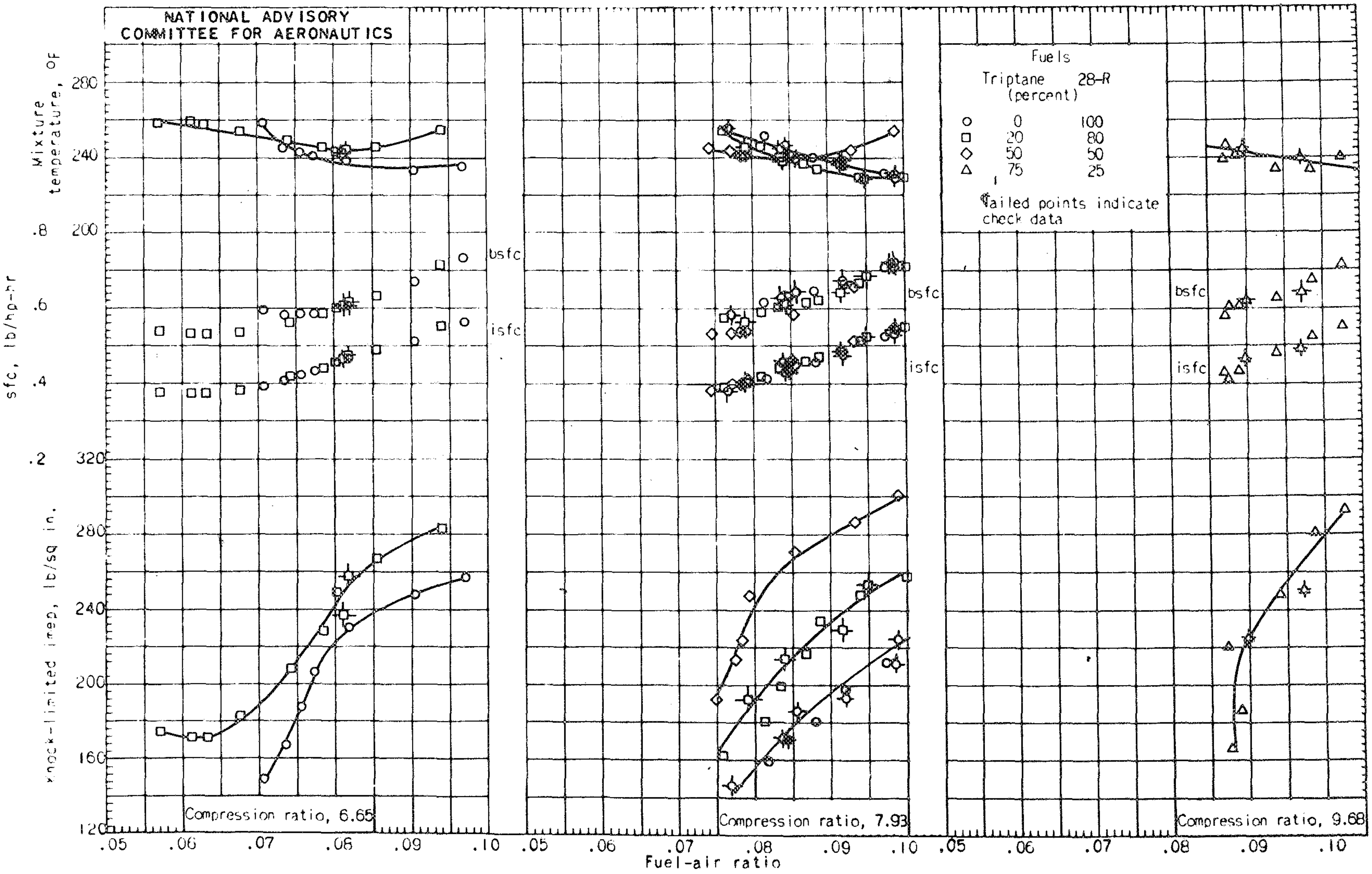


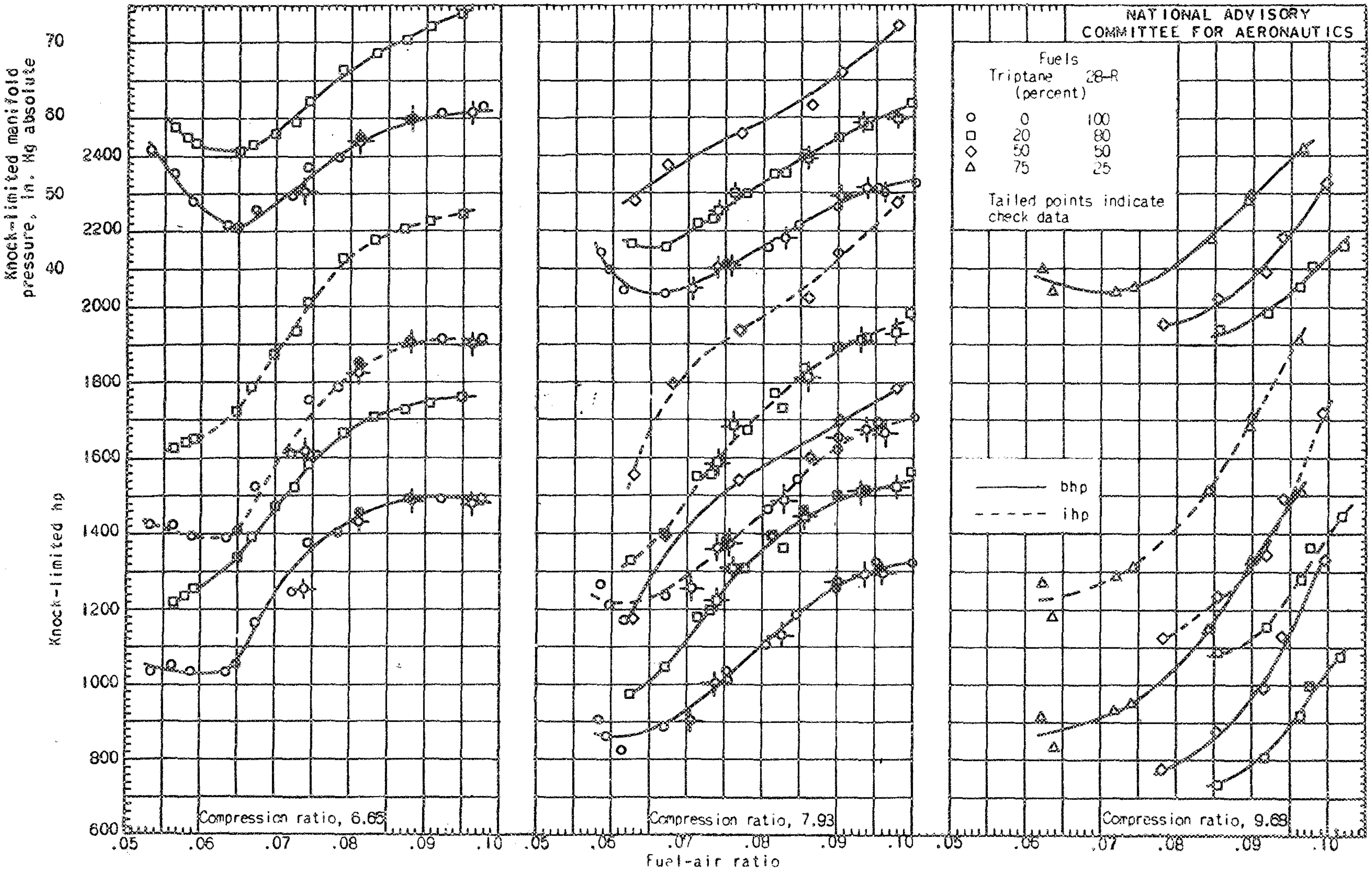
(a) Inlet-air temperature, 120° F.

Figure 1. - Knock-limited performance of several fuels at take-off engine speed. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



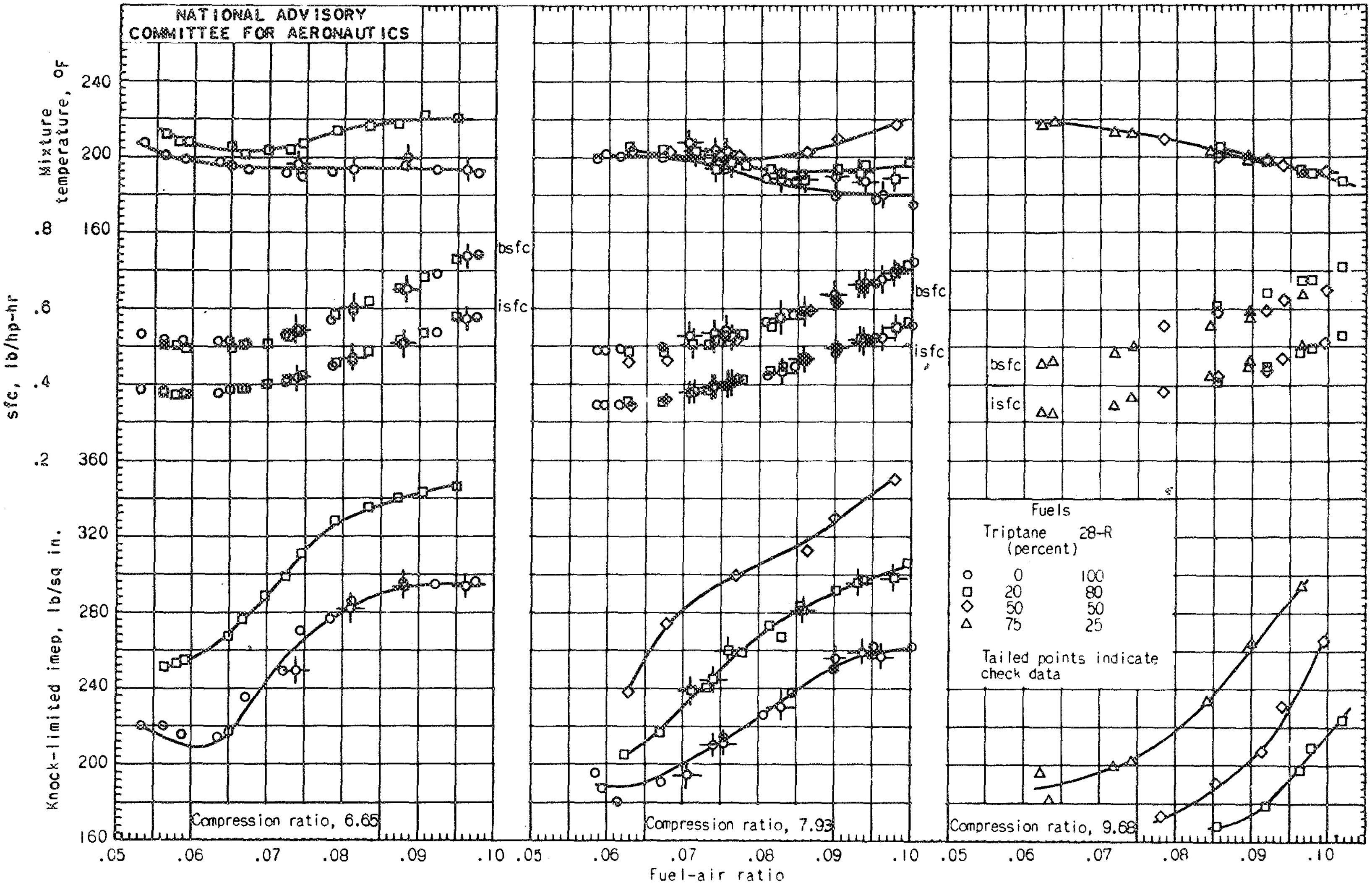
(a) Concluded. Inlet-air temperature, 120° F.

Figure 1. - Continued. Knock-limited performance of several fuels at take-off engine speed. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(b) Inlet-air temperature, 60° F.

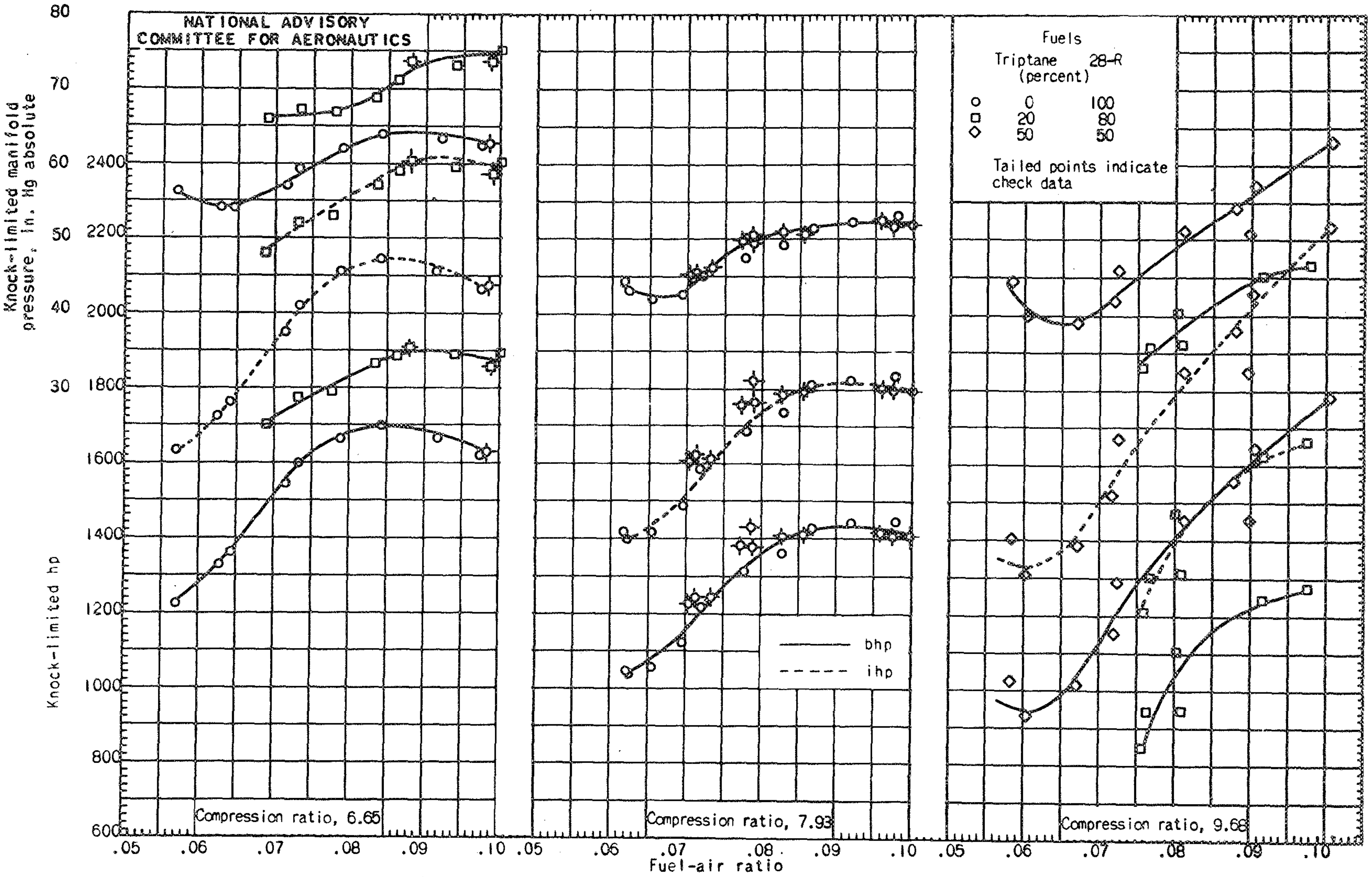
Figure 1. - Continued. Knock-limited performance of several fuels at take-off engine speed. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(b) Concluded. Inlet-air temperature, 60° F.

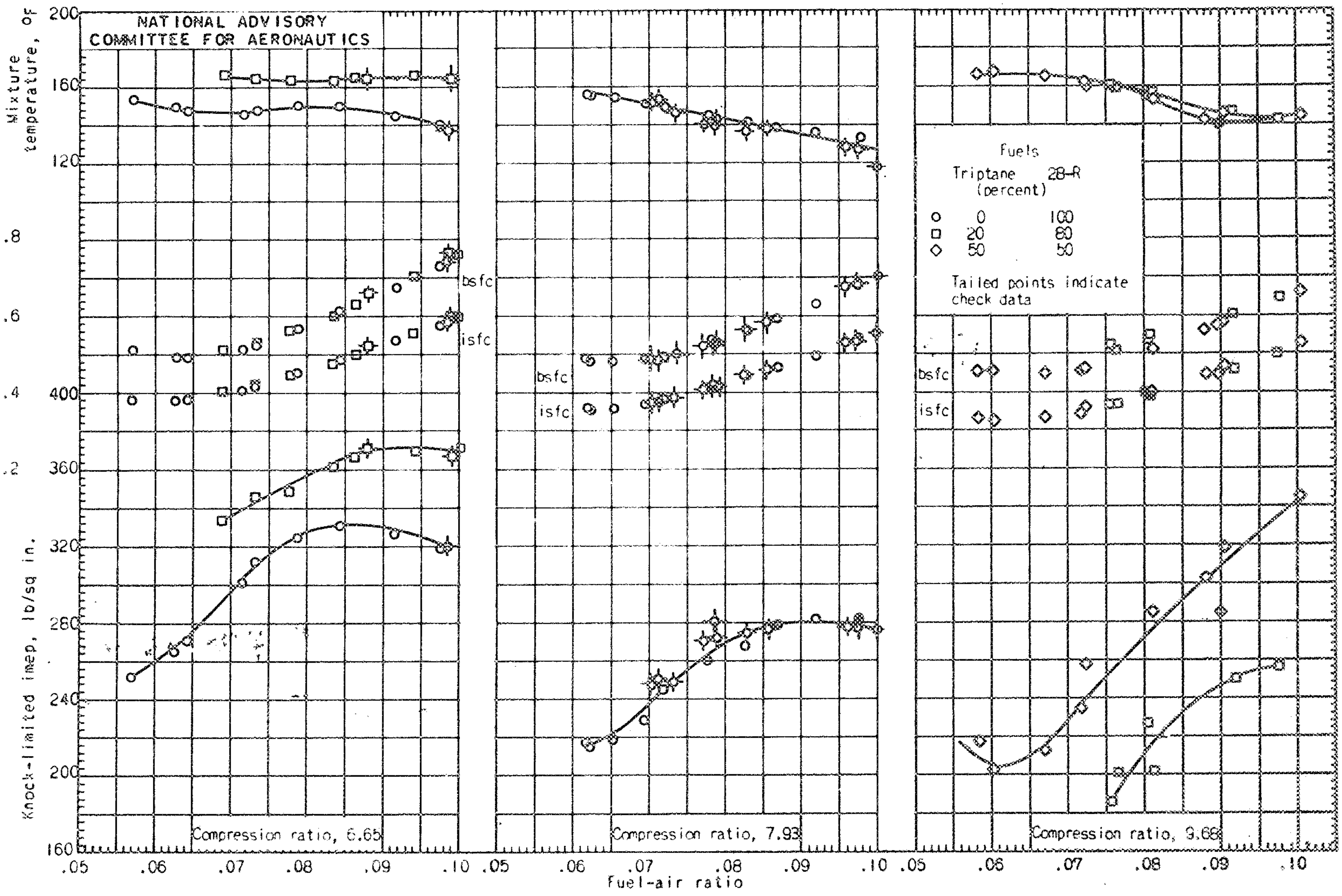
Figure 1. - Continued. Knock-limited performance of several fuels at take-off engine speed. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.

Fig. 1b concl.



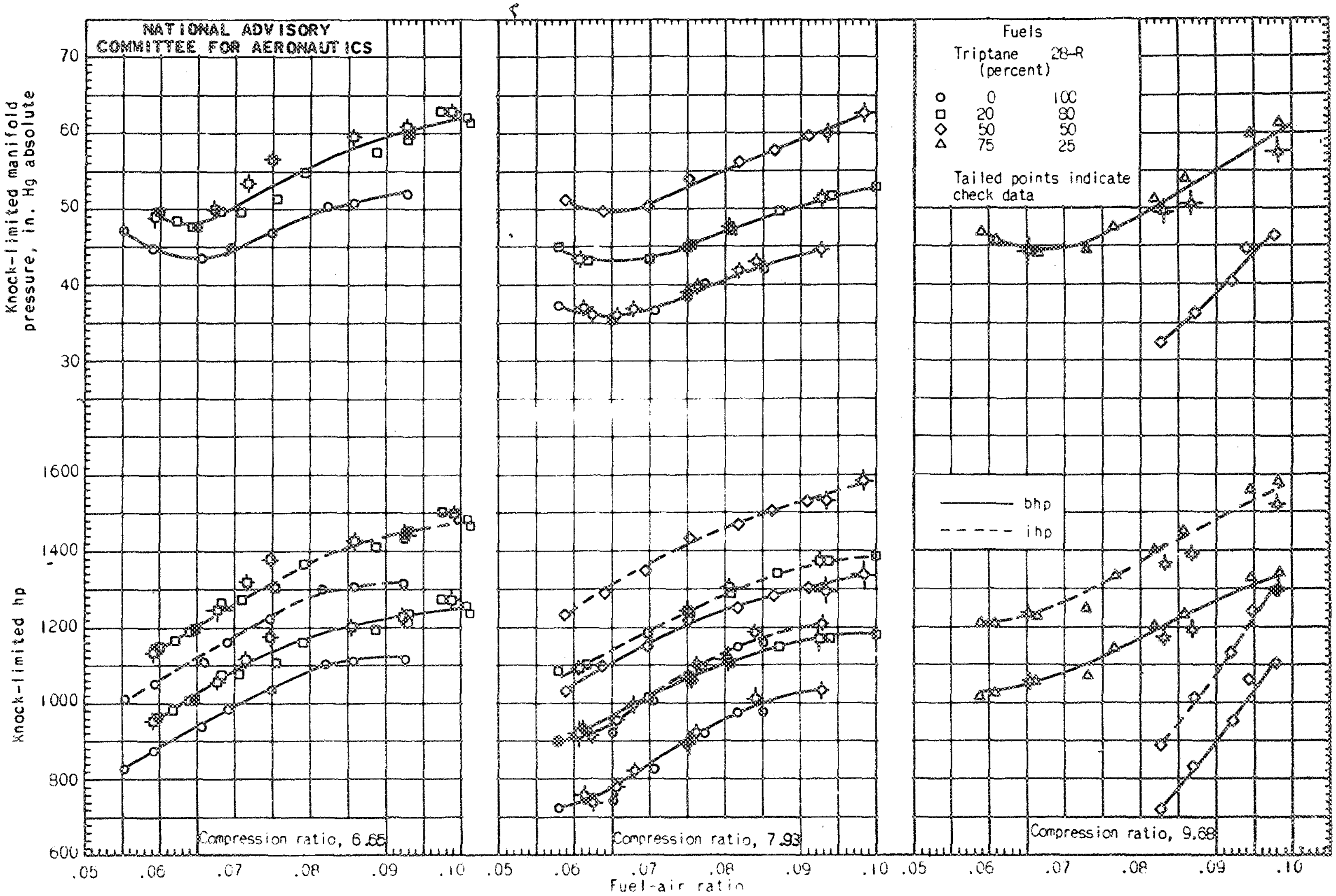
(c) Inlet-air temperature, 0° F.

Figure 1. - Continued. Knock-limited performance of several fuels at take-off engine speed. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



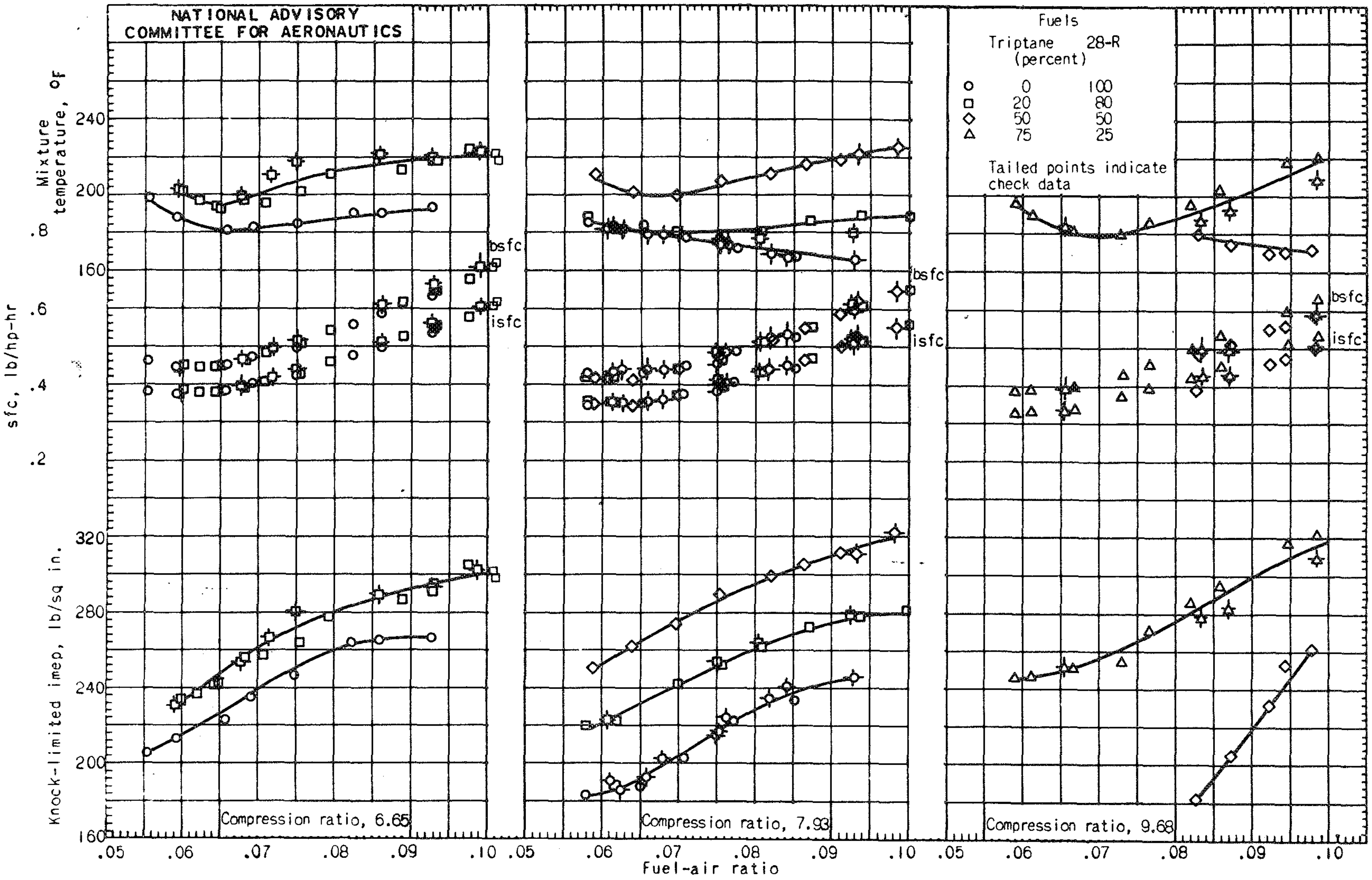
(c) Concluded. Inlet-air temperature, 0° F.

Figure 1. - Concluded. Knock-limited performance of several fuels at take-off engine speed. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



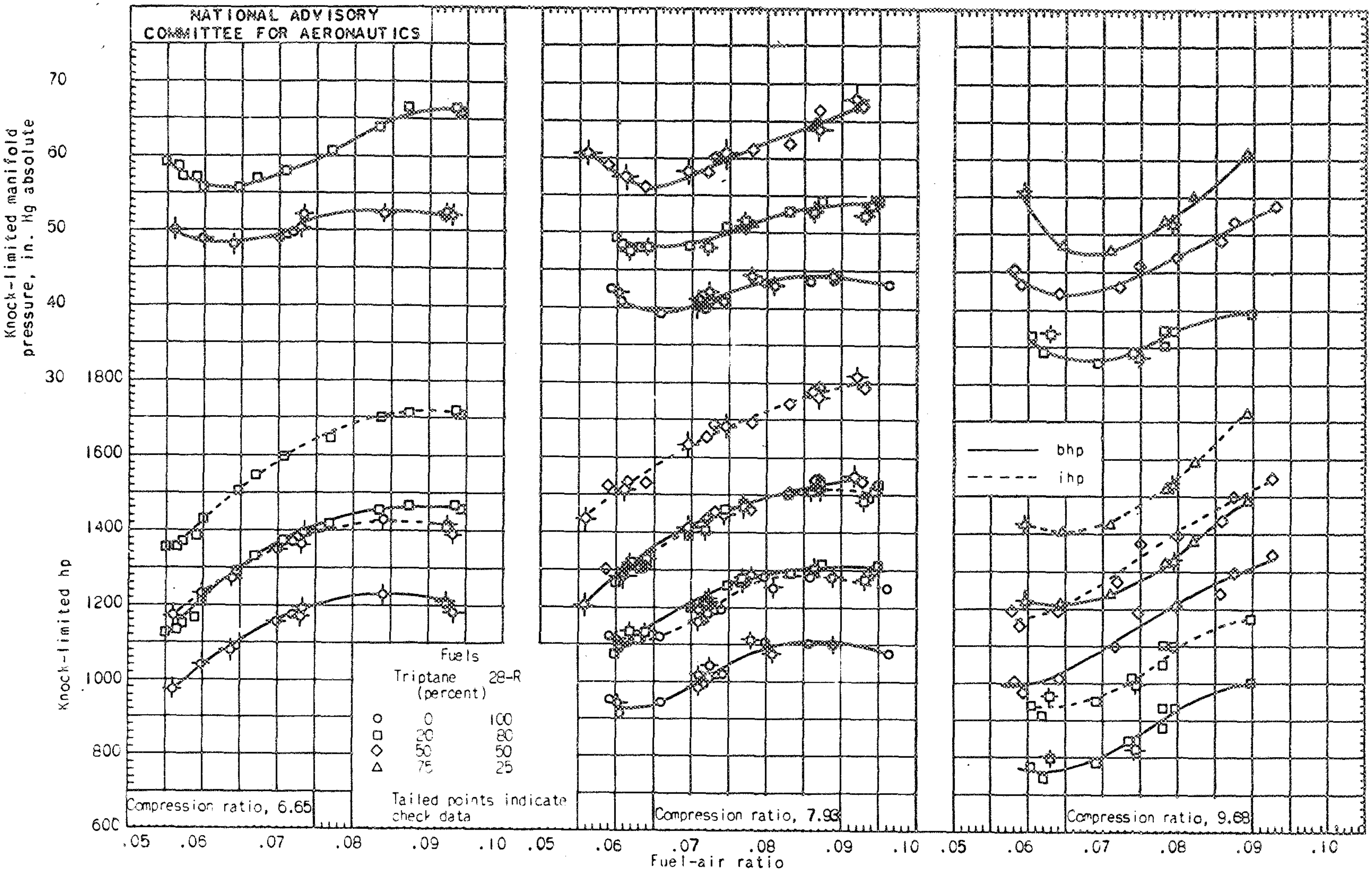
(a) Inlet-air temperature, 120° F.

Figure 2. - Knock-limited performance of several fuels at cruising engine speed. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(a) Concluded. Inlet-air temperature, 120° F.

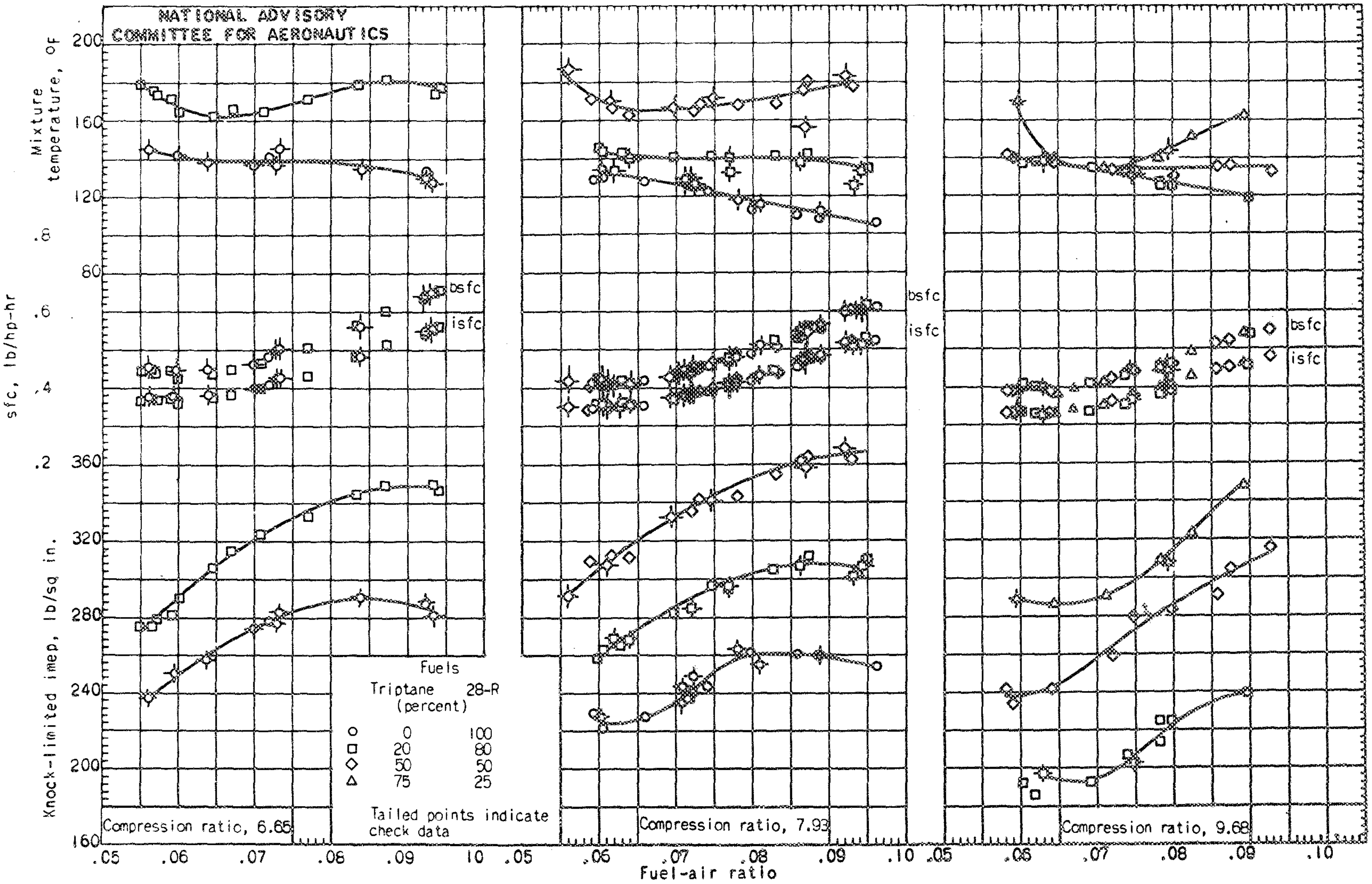
Figure 2. - Continued. Knock-limited performance of several fuels at cruising engine speed. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(b) Inlet-air temperature, 60° F.

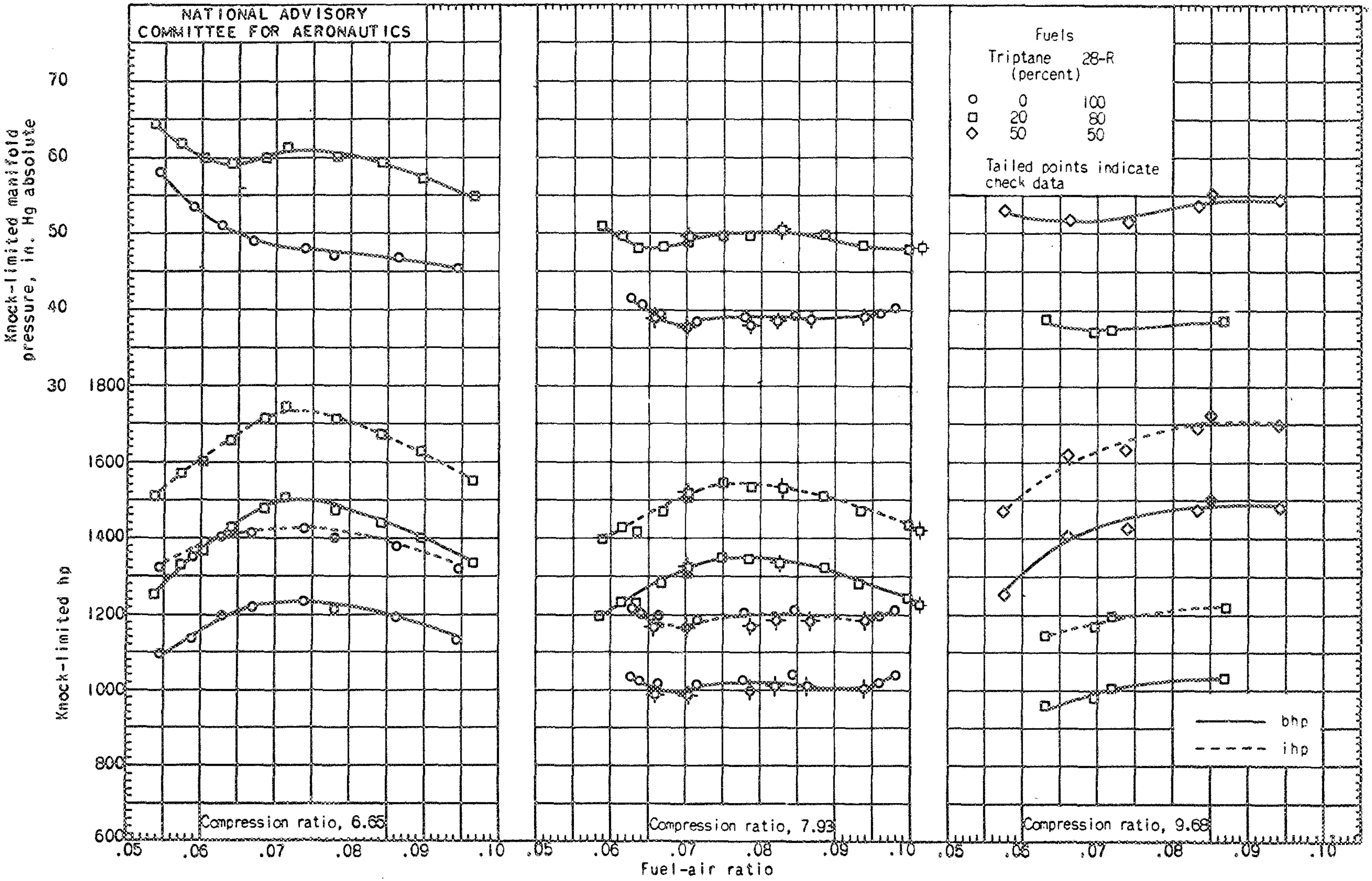
Figure 2. - Continued. Knock-limited performance of several fuels at cruising engine speed. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.

Fig. 2b



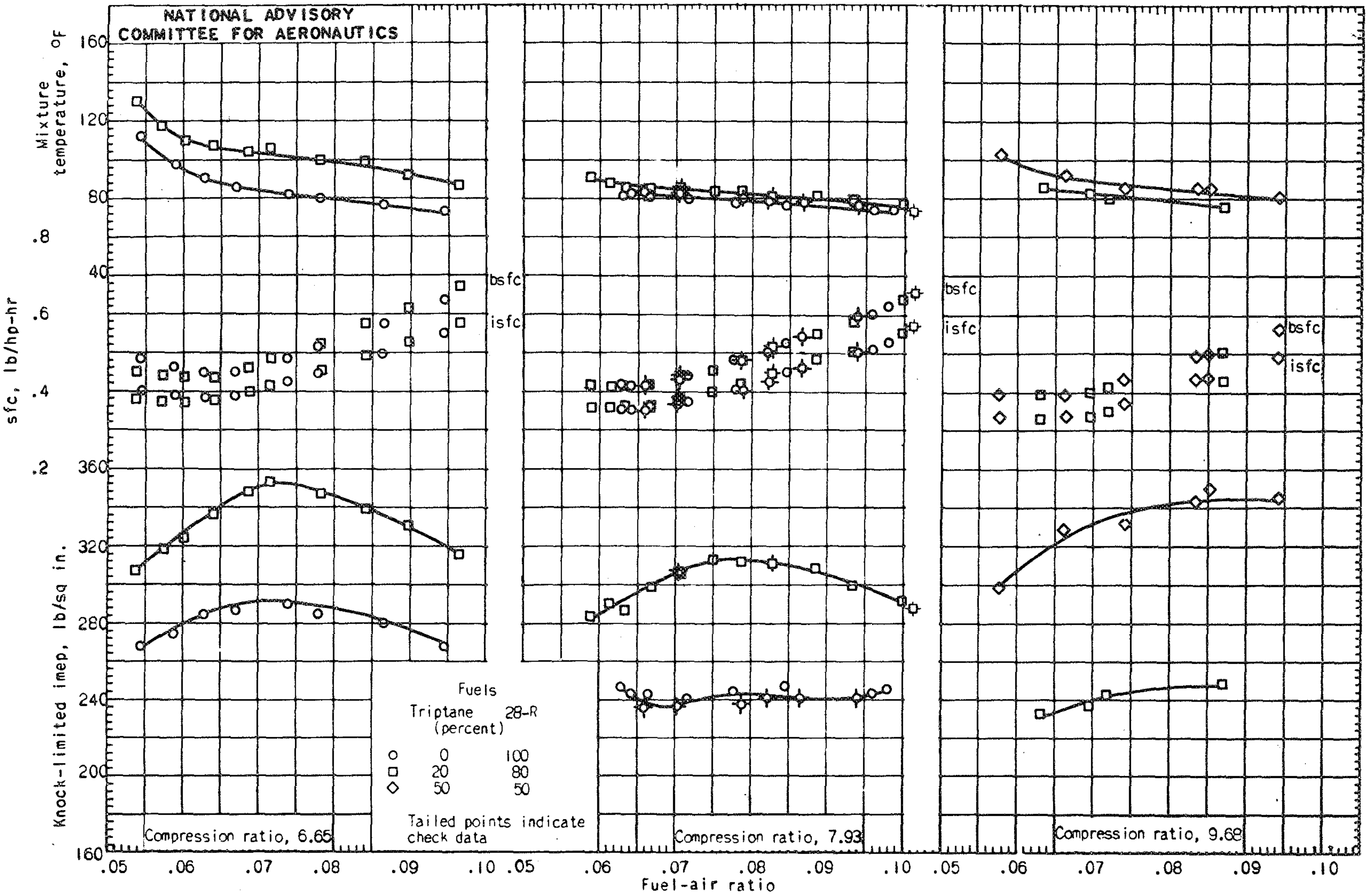
(b) Concluded. Inlet-air temperature, 60° F.

Figure 2. - Continued. Knock-limited performance of several fuels at cruising engine speed. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



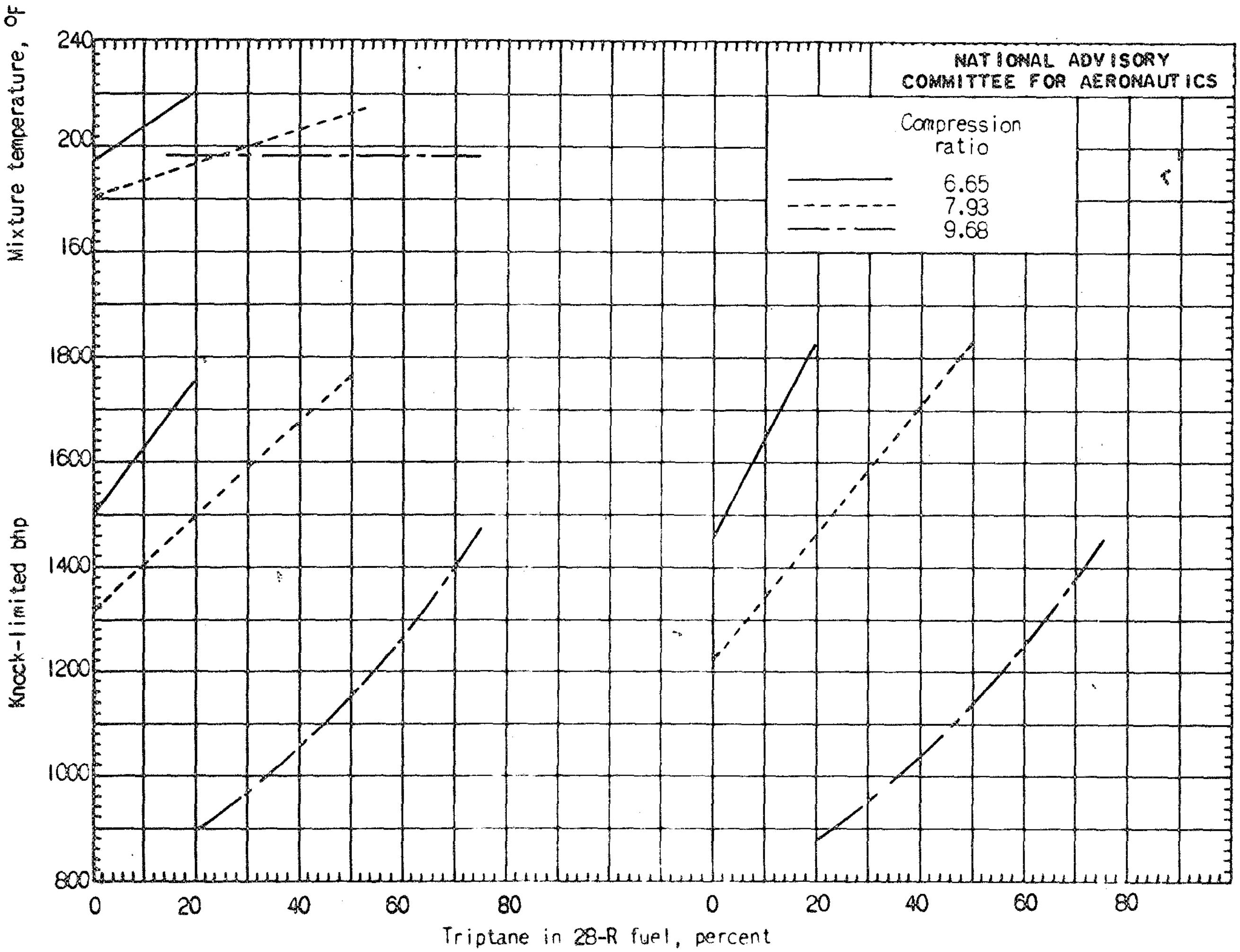
(c) Inlet-air temperature, 0° F.

Figure 2. - Continued. Knock-limited performance of several fuels at cruising engine speed. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(c) Concluded. Inlet-air temperature, 0° F.

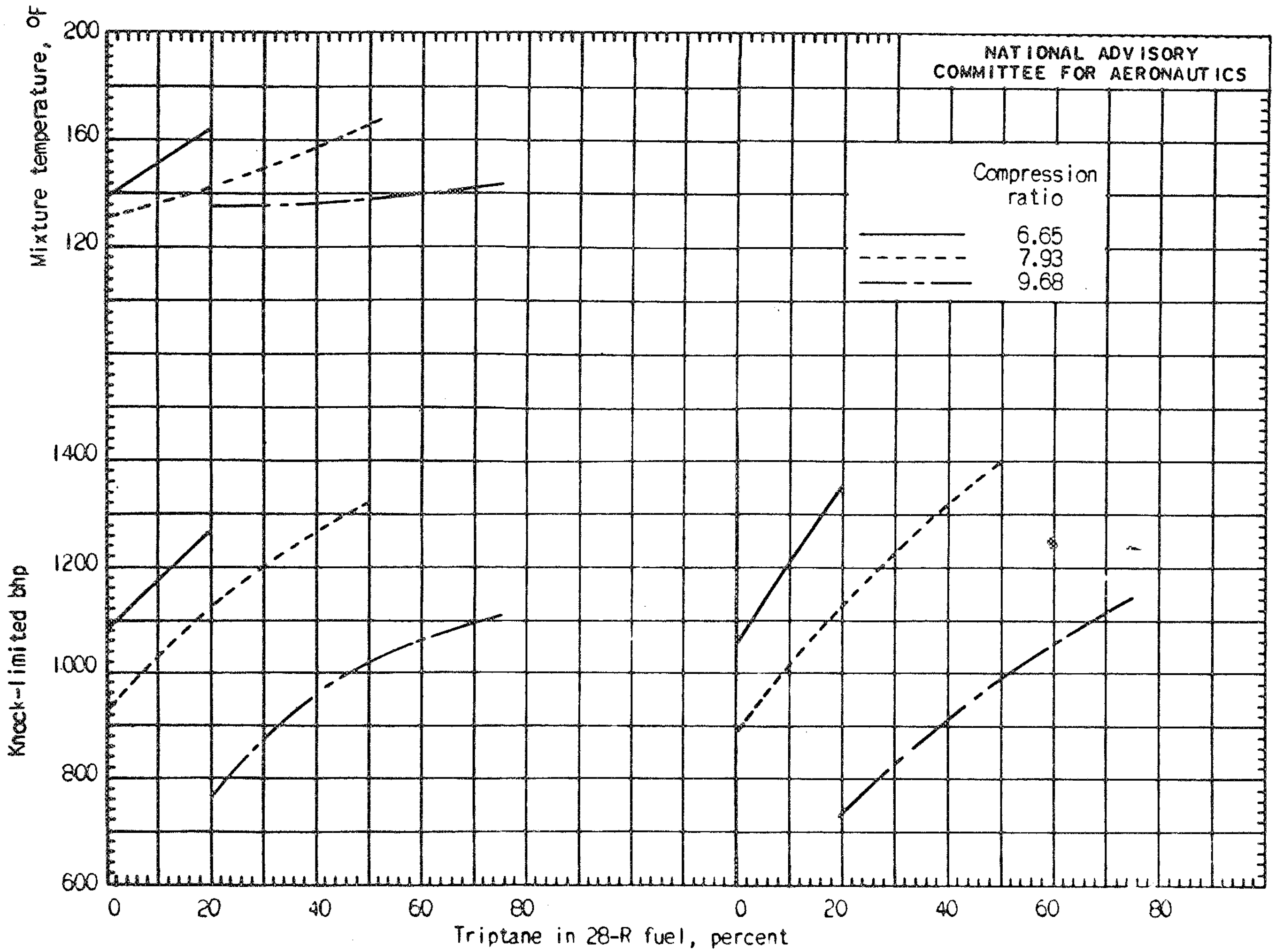
Figure 2. - Concluded. Knock-limited performance of several fuels at cruising engine speed. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; standard sea-level inlet and exhaust pressures; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(a) Inlet-air temperature, 60° F. (Cross-plotted from fig. 1(b).)

(b) Mixture temperature, 200° F. (Cross-plotted from fig. 1.)

Figure 3. - Knock-limited take-off-speed performance obtained with various percentages of triptane in 28-R fuel at several compression ratios. Engine displacement, 1710 cubic inches; engine speed, 3000 rpm; fuel-air ratio, 0.095; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.



(a) Inlet-air temperature, 60° F. (Cross-plotted from fig. 2(b).)

(b) Mixture temperature, 140° F. (Cross-plotted from fig. 2.)

Figure 4. - Knock-limited cruising-speed performance obtained with various percentages of triptane in 28-R fuel at several compression ratios. Engine displacement, 1710 cubic inches; engine speed, 2280 rpm; fuel-air ratio, 0.063; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.

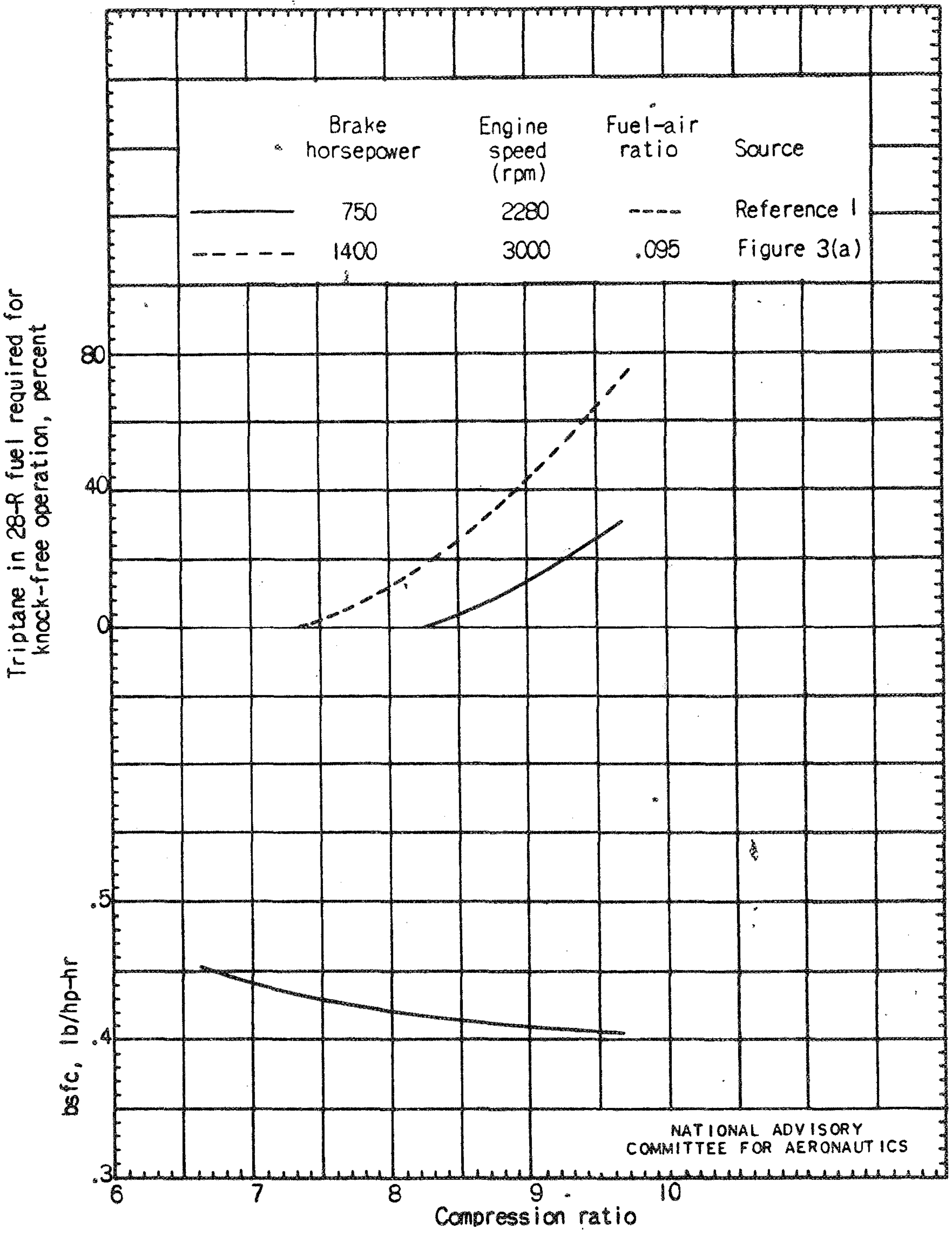


Figure 5. - Comparison of percentage of triptane required at assumed take-off conditions with that at assumed cruising conditions as affected by increase in compression ratio; also effect of increasing compression ratio on brake specific fuel consumption at cruising conditions. Engine displacement, 1710 cubic inches; inlet-air temperature, 60° F. (Cruising conditions at fuel-air ratio for minimum brake specific fuel consumption.)

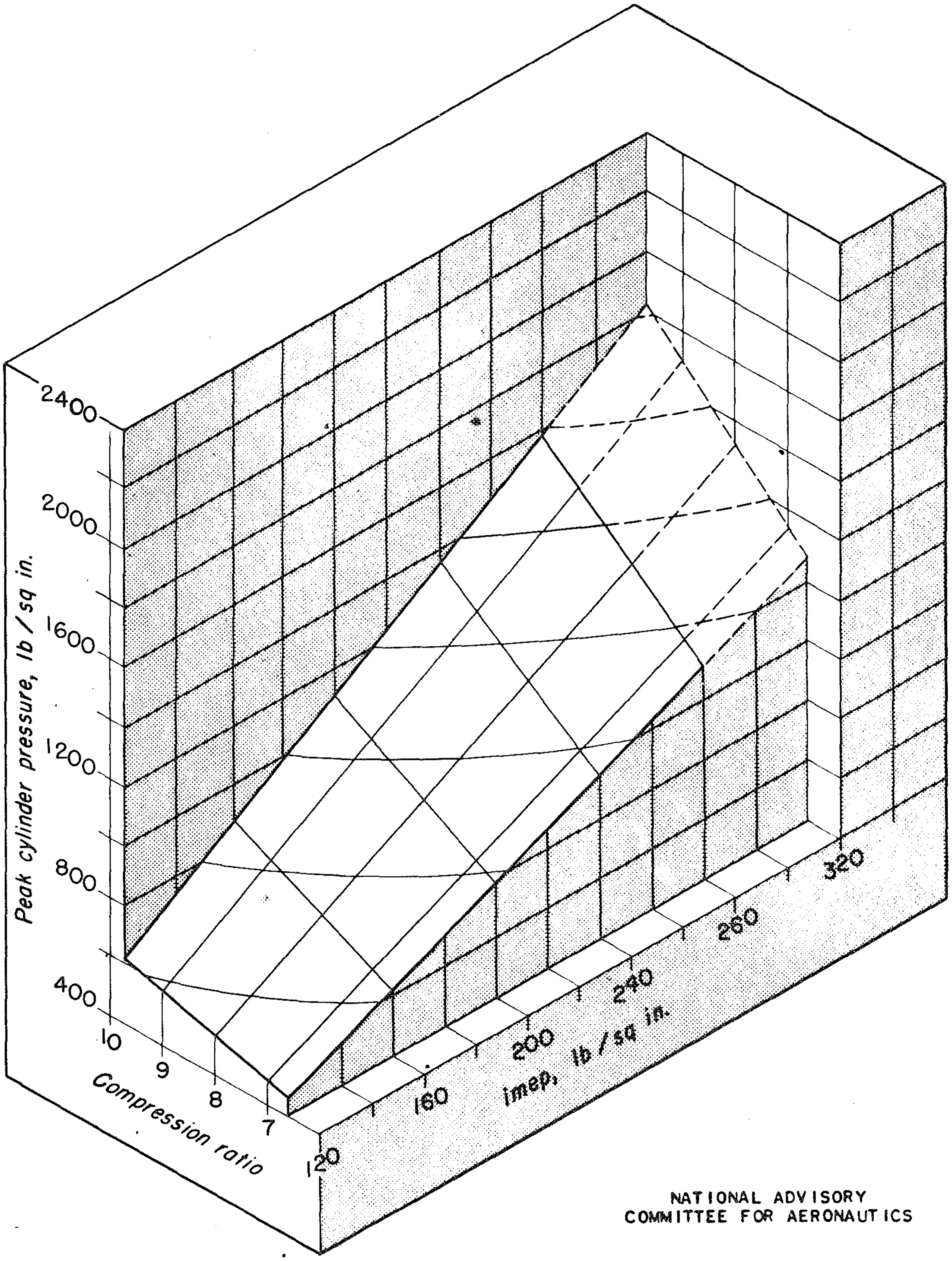


Figure 6. - Peak cylinder pressures as affected by compression ratio and indicated mean effective pressure. Single-cylinder adaptation of multicylinder block to CUE crankcase; engine speed, 3000 rpm; fuel-air ratio, 0.10; mixture temperature, 200° F; spark setting: exhaust, 34° B.T.C.; inlet, 28° B.T.C.