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ANTIKNOCK EFFECTIVENESS OF XYLIDINES IN SMALL-SCALE ENGINES

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MEMORANDUM REPORT

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SUMMARY

Tests were made to determine the effect of mixtures of xylidines and AN-F-28 fuel on the knock-limited performance of small-scale engines. AN-F-28 fuel with no xylidines added and with additions of 1 and 3 percent xylidines was tested in a 17.6 engine under supercharged conditions. Data were obtained on this engine at engine speeds of 1800 and 2700 rpm and at inlet-air temperatures of 150°, 250°, and 325° F. Ratings were obtained for all blends on standard rating engines for the 3-C, the 1-C, and the A.S.T.M. (Motor) Methods.

The results are summarized in the following tables:

TABLE I. - EFFECT OF INLET-AIR TEMPERATURE ON KNOCK-LIMITED INDICATED MEAN EFFECTIVE PRESSURE

[17.6 engine; engine speed, 2700 rpm]

Fuel \ Inlet-air temperature, °F	imep, lb/sq in.					
	F/A = 0.065			F/A = 0.10		
	150	250	325	150	250	325
AN-F-28	102	81	70	222	176	155
AN-F-28 + 1 percent xylidines	91	73	66	211	166	145
AN-F-28 + 3 percent xylidines	87	66	63	201	157	136

TABLE II. - EFFECT OF ENGINE SPEED ON KNOCK-LIMITED INDICATED MEAN EFFECTIVE PRESSURE

[17.6 engine; inlet-air temperature, 250° F]

Fuel \ Engine speed, rpm	imep, lb/sq in.			
	F/A = 0.065		F/A = 0.10	
	1800	2700	1800	2700
AN-F-28	71	81	156	176
AN-F-28 + 1 percent xylidines	67	73	159	166
AN-F-28 + 3 percent xylidines	63	66	174	157

TABLE III. - EFFECT OF XYLIDINES IN THE STANDARD RATING ENGINES

Fuel \ Rating method →	Modified 3-C		1-C	A.S.T.M. (Motor)
	Performance number			Octane number
	Rich	Lean	S-2+ml TEL	
AN-F-28	130	105	0.08	99.5
AN-F-28 + 1 percent xylidines	135	110	.06	99.2
AN-F-28 + 3 percent xylidines	145	105	.05	97.1

INTRODUCTION

The data presented in this report are part of a general program to determine the effects of xylidines on the knock-limited performance of currently used aviation fuels. This work has been requested by the Army Air Forces and is being conducted at the National Advisory Committee for Aeronautics, Aircraft Engine Research Laboratory, Cleveland, Ohio. The data were obtained during July 1943.

APPARATUS AND PROCEDURE

The tests were conducted on an engine of 17.6-cubic-inch displacement, and on three standard rating engines: a modified 3-C engine, a 1-C (Aviation) engine, and an A.S.T.M. (Motor) engine.

The 17.6 engine. - The 17.6 engine is a single-cylinder test engine with a stroke of $3\frac{1}{4}$ inches, a bore of $2\frac{5}{8}$ inches, and a compression ratio of 7.0. An AFD-3-C injection elbow was used. Fuel was injected during the inlet stroke into the inlet manifold parallel to the flow of air. Knock was detected by a cathode-ray oscilloscope in conjunction with a modified Stancal pickup unit.

The tests on the 17.6 engine were run at the following test conditions:

Engine speed, rpm 1800, 2700
Compression ratio 7.0

Inlet-coolant temperature, °F	250
Inlet-air temperature, °F	150, 250, 325
Spark advance, deg B.T.C. (optimum)	40
Injection timing, deg A.T.C.	60

The modified 3-C engine. - The modified 3-C engine installation conformed to CRC designation F-4-443, dated April 20, 1943, with the exception of the fuel system and the method of knock detection. In place of the refluxing fuel system, a cooling method was used in which the fuel was circulated through a primary pump, a fuel cooler, and back into the injection-pump gallery. Knock was detected by a modified Stancal pickup unit in conjunction with a cathode-ray oscilloscope. Incipient detonation was taken as the criterion of knock.

The 1-C (Aviation) engine. - The 1-C (Aviation) engine conformed to AN-VV-F-746 specification, amendment 1, dated November 5, 1940.

The A.S.T.M. (Motor) engine. - The A.S.T.M. (Motor) engine conformed to A.S.T.M. designation D 357-39-T.

DISCUSSION OF RESULTS

The 17.6 engine. - At an engine speed of 2700 rpm, the addition of xylidines to AN-F-28 fuel decreased the knock-limited indicated mean effective pressure 5 to 11 percent for a 1-percent addition and 9 to 15 percent for a 3-percent addition. (See table I in summary.) At an engine speed of 2700 rpm, the addition of xylidines to AN-F-28 fuel apparently had little or no effect on the temperature sensitivity of the fuel as measured by the percentage decrease in permissible power with a given increase in temperature.

At an engine speed of 1800 rpm (table II), the addition of 1 percent of xylidines to AN-F-28 fuel had little effect on permissible power. The tendency, however, was to decrease the lean-region power and to increase the rich-region power. The addition of 3 percent of xylidines to the AN-F-28 fuel decreased the permissible indicated mean effective pressure approximately 11 percent at a fuel-air ratio of 0.065 and increased it approximately 12 percent at a fuel-air ratio of 0.10.

The addition of xylidines to AN-F-28 fuel tended to increase the indicated specific fuel consumption. This increase was particularly noticeable at the higher inlet-air temperatures. (See figs. 1, 2, 3, and 4.)

When the engine was dismantled at the end of this series of tests, a rather heavy deposit was found on the intake valve.

Standard rating engines. - Modified 3-C ratings are presented in figures 5, 6, and 7. The rich ratings showed an increase in performance number directly proportional to the amount of xylidines. The indicated-specific-fuel-consumption curves coincided up to a fuel-air ratio of 0.10.

The 1-C ratings on the blends indicated that addition of xylidines progressively lowered the rating of AN-F-28 fuel; the differences shown by those ratings were, however, quite small. Two ratings were made on each blend and the average deviation was 0.03 ml tetraethyl lead.

A.S.T.M. (Motor) Method tests showed a decided decrease in octane number for the 3-percent xylidine blend. Five tests on each fuel were made; the average deviation was 0.4 octane number.

Results of the standard rating methods are presented in table III of the summary.

Aircraft Engine Research Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio, August 6, 1943.

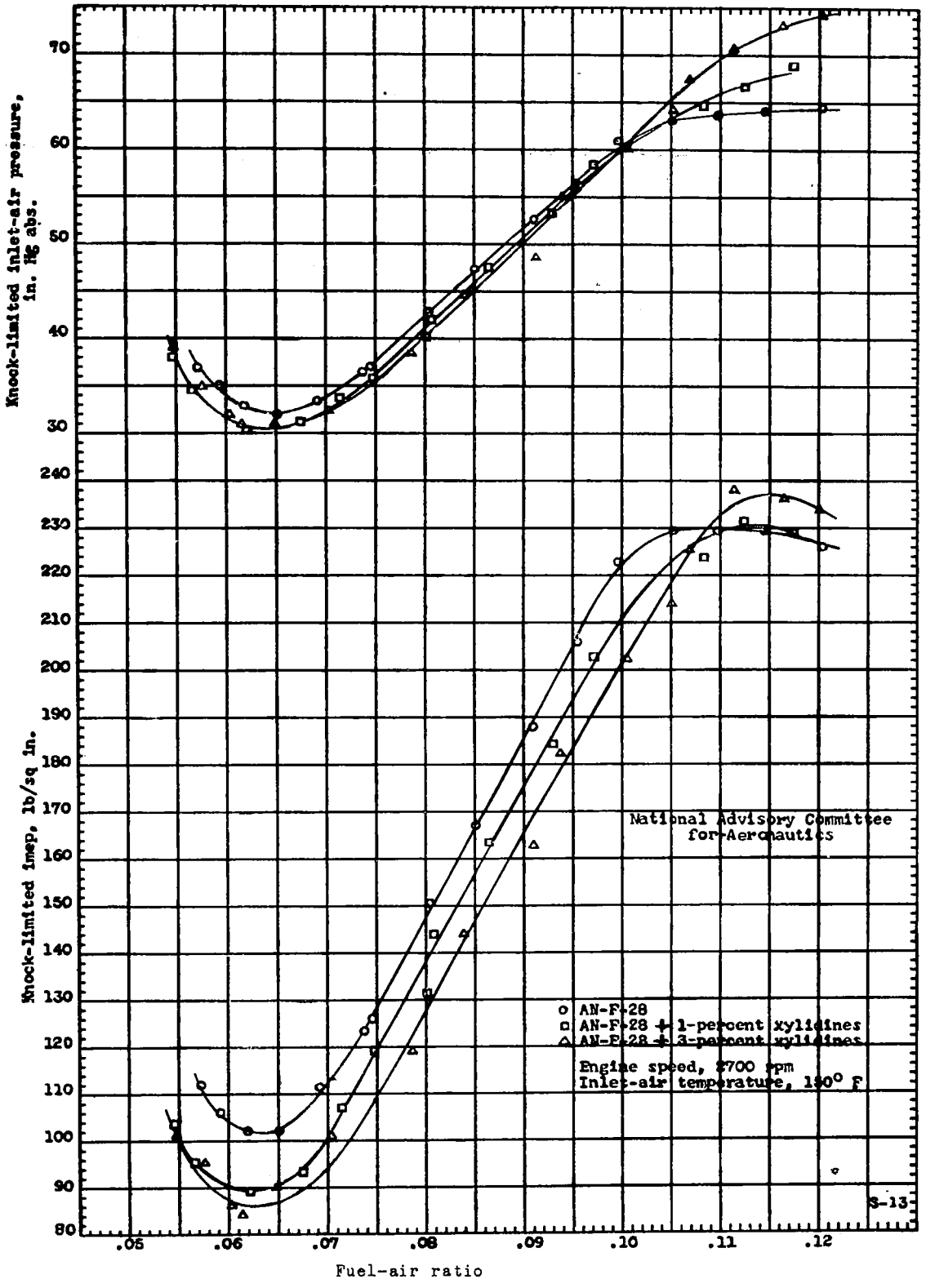

Figure 1. - Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 2700 rpm; inlet-air temperature, 150° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

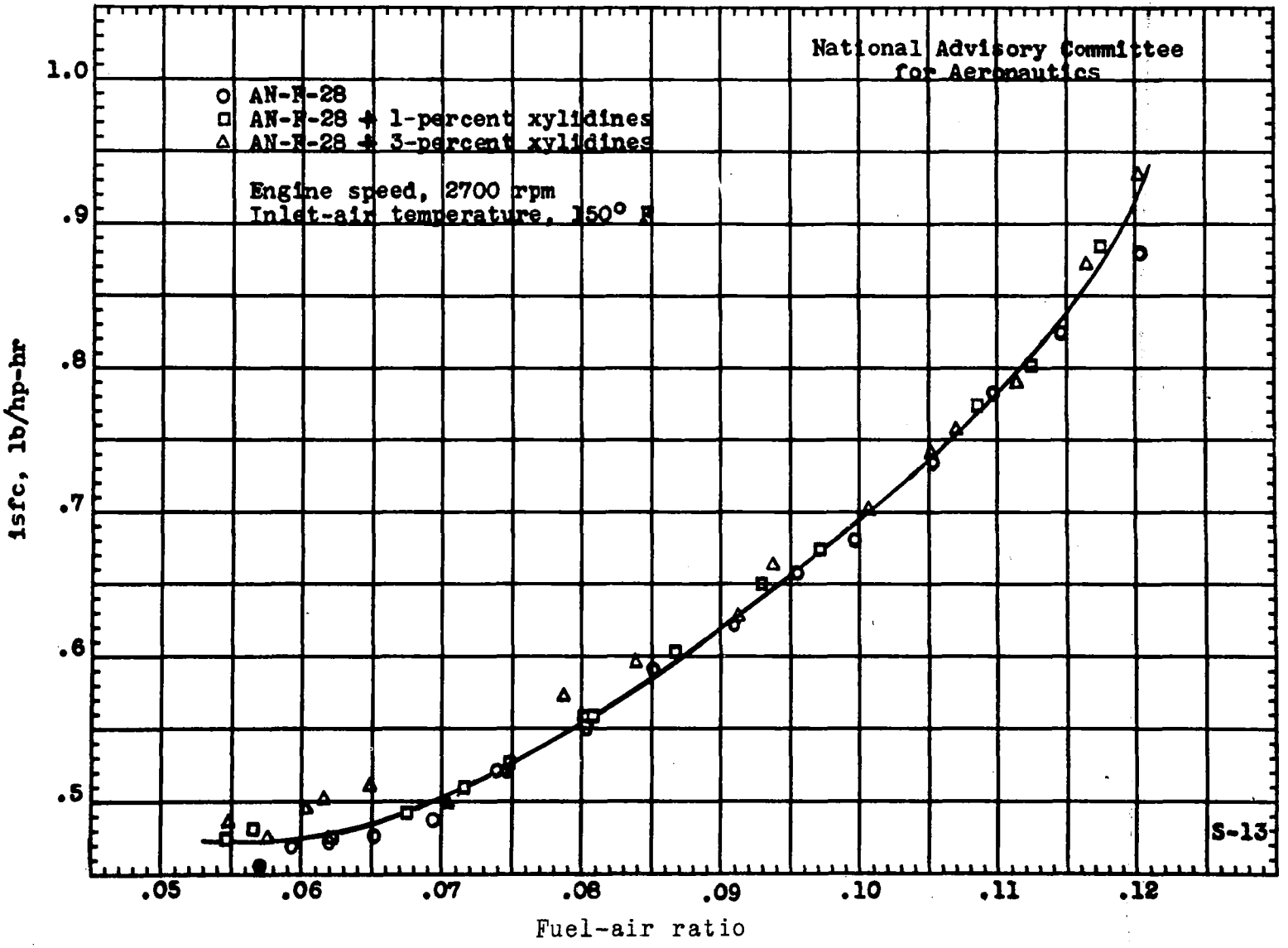

Figure 1. - Concluded. Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 2700 rpm; inlet-air temperature, 150° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

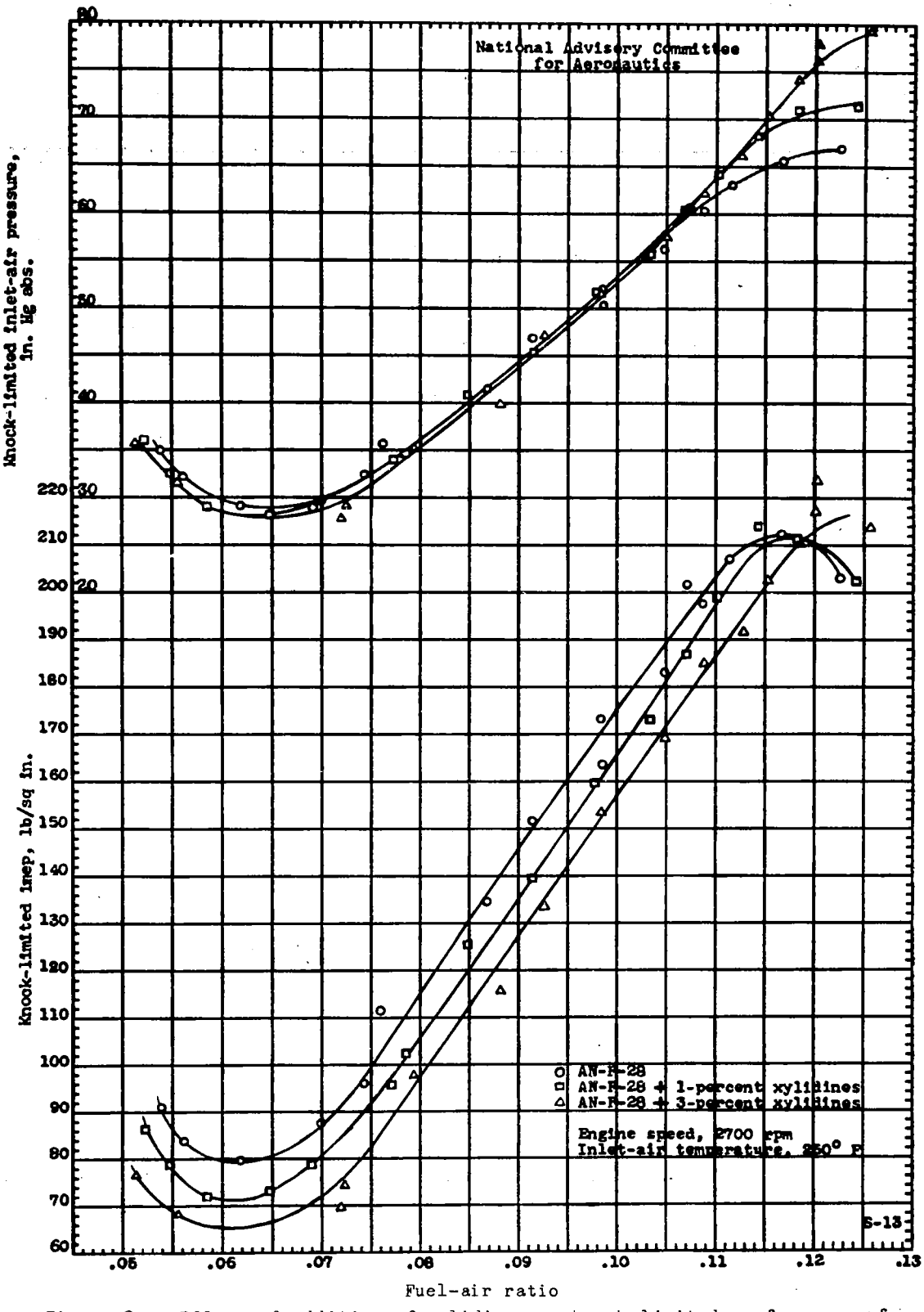

Figure 2. - Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 2700 rpm; inlet-air temperature, 250° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

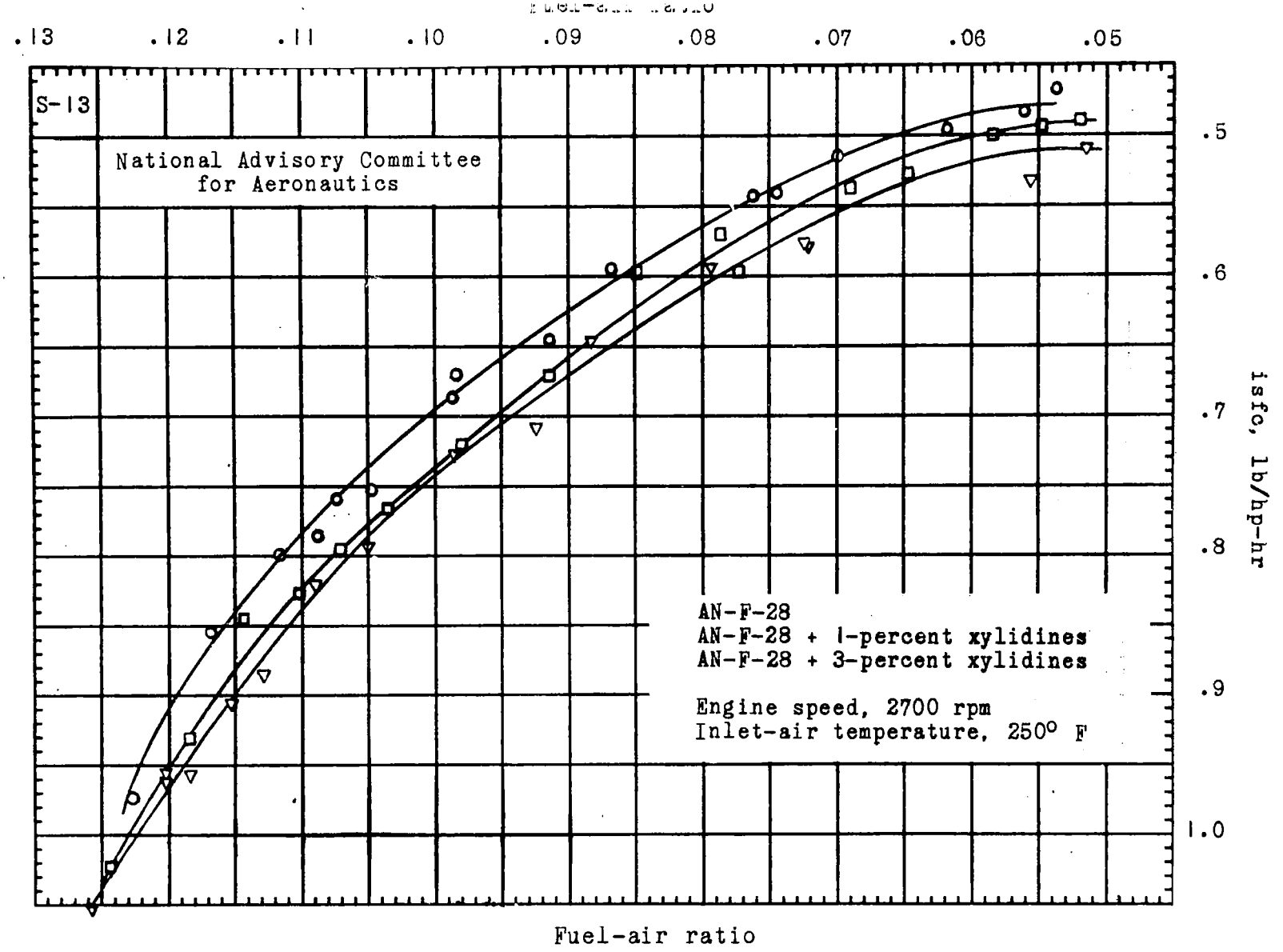

Figure 2. - Concluded. Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 2700 rpm; inlet-air temperature, 250° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

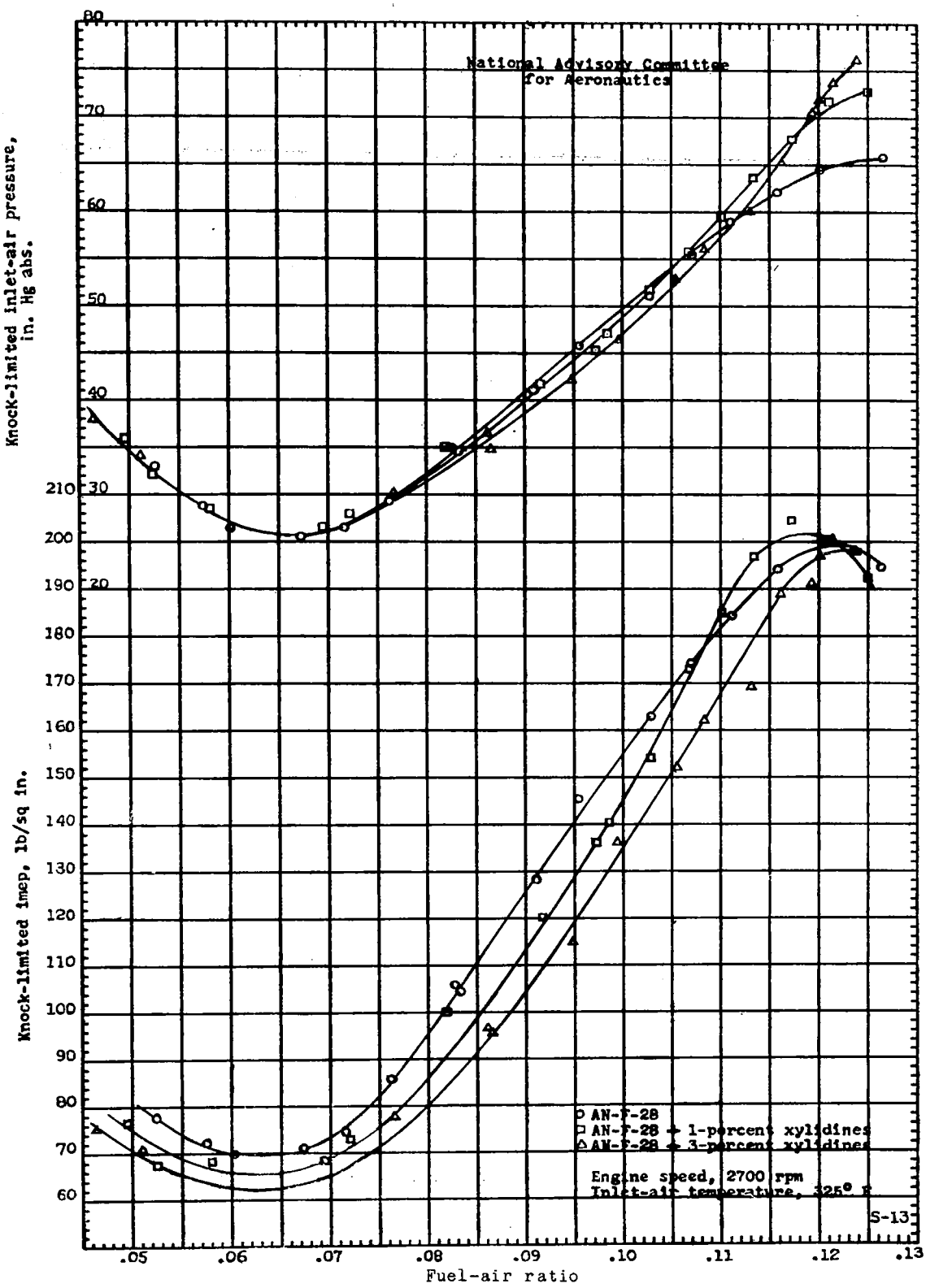

Figure 3. - Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 2700 rpm; inlet-air temperature, 325° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

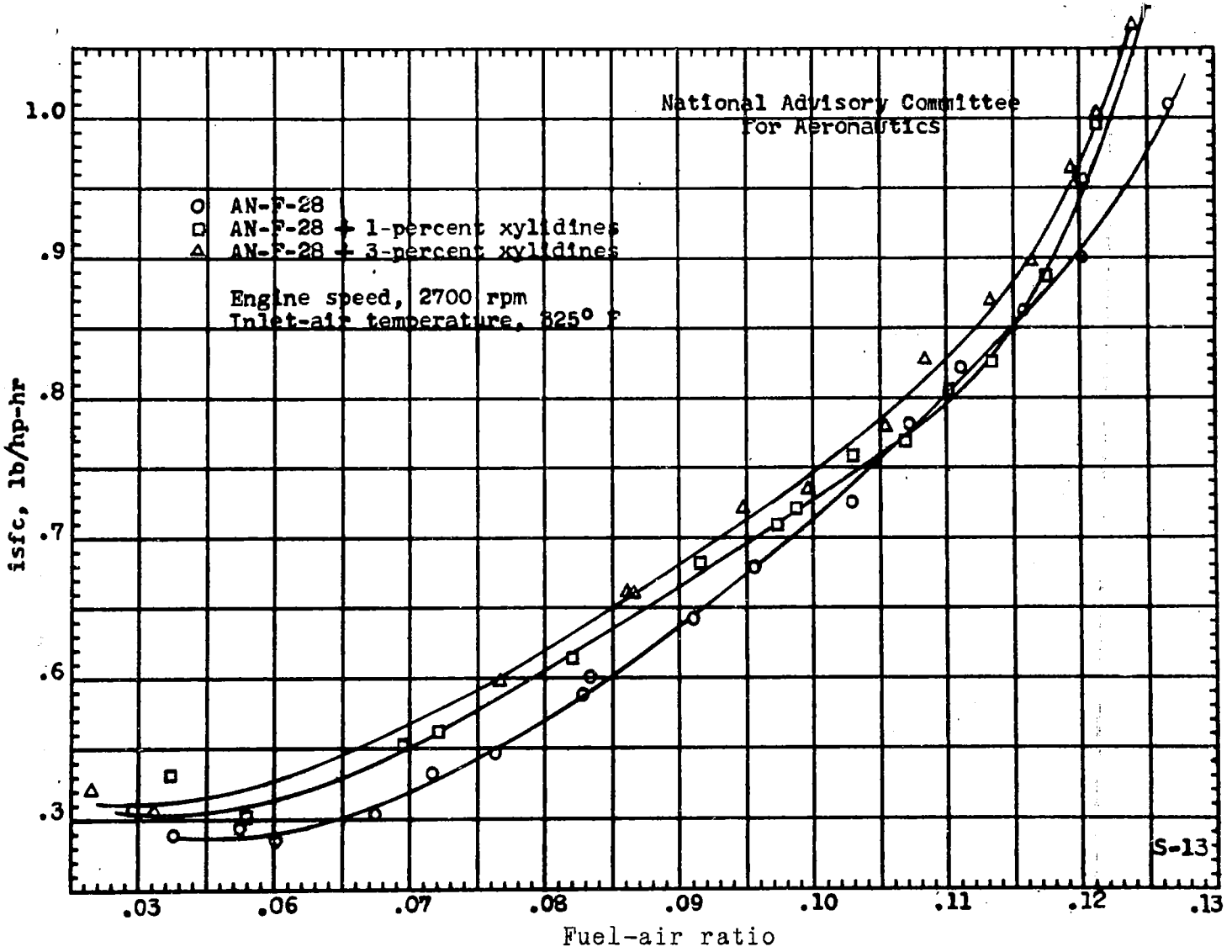

Figure 3. - Concluded. Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 2700 rpm; inlet-air temperature, 325° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

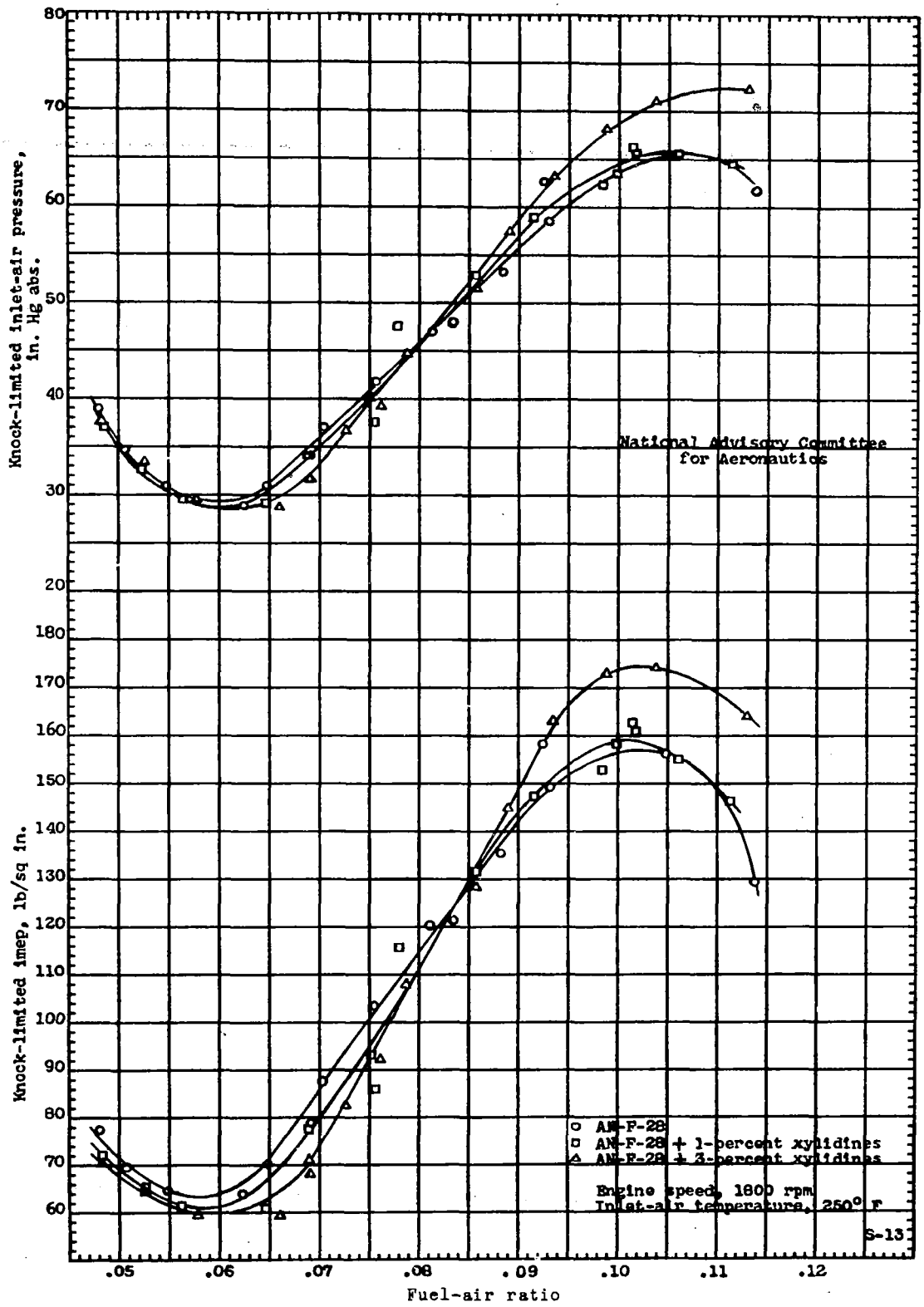

Figure 4. - Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 1800 rpm; inlet-air temperature, 250° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

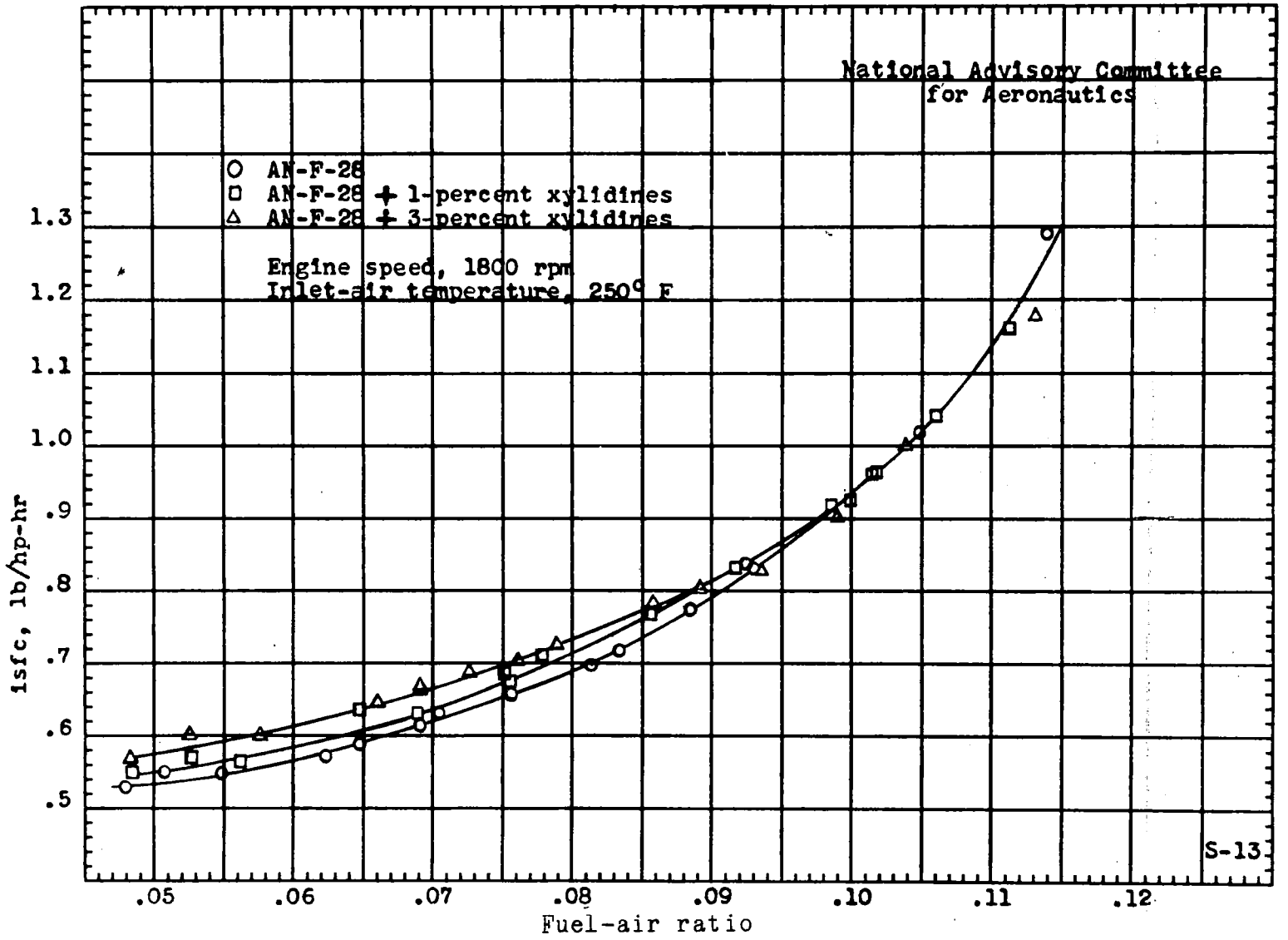

Figure 4. - Concluded. Effect of addition of xylidines on knock-limited performance of AN-F-28 fuel in a 17.6 engine. Compression ratio, 7.0; engine speed, 1800 rpm; inlet-air temperature, 250° F; spark advance, 40° B.T.C.; inlet-coolant temperature, 250° F.

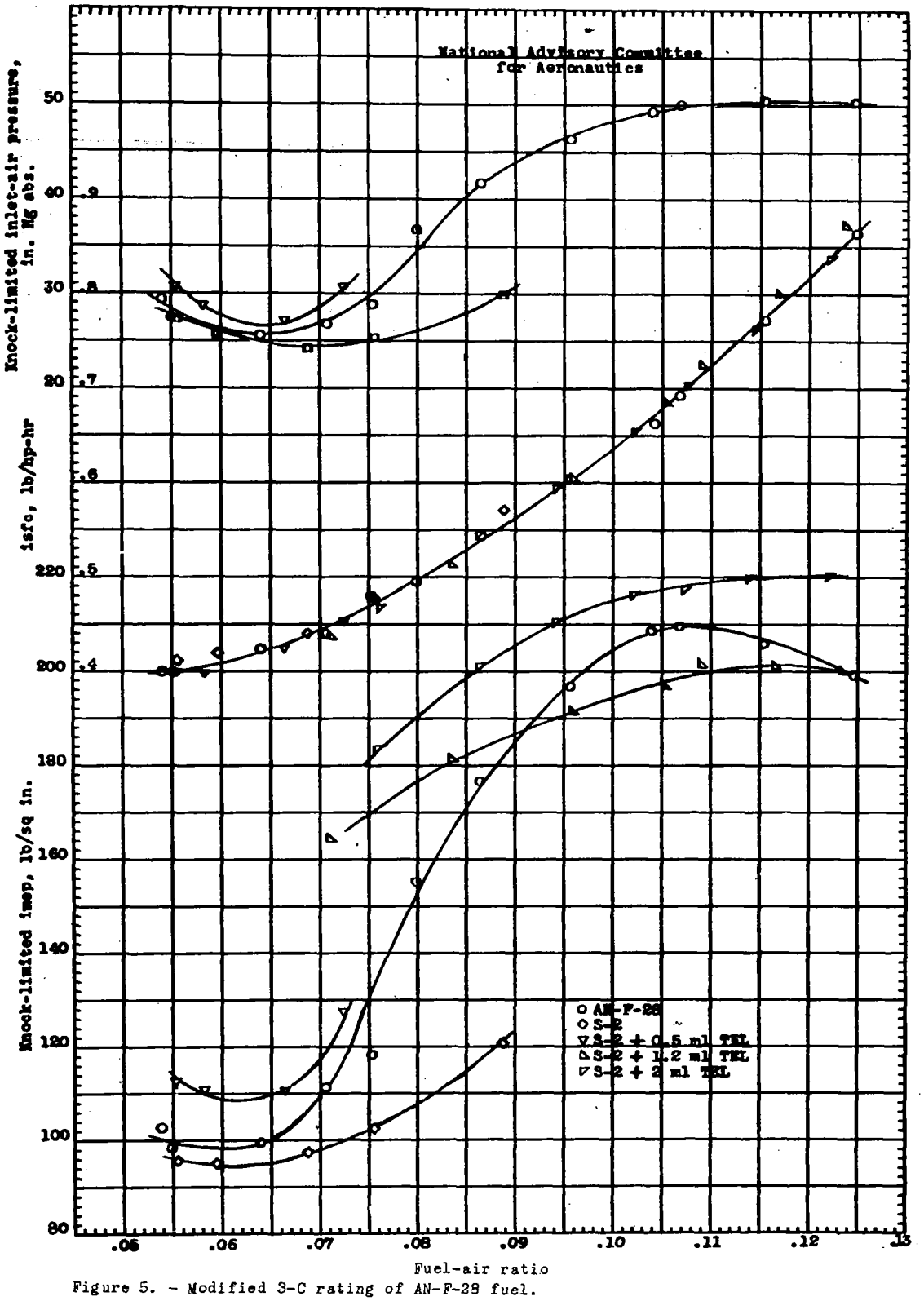

Figure 5. - Modified 3-C rating of AN-F-28 fuel.

Rich-mixture rating: S-2 + 1.43 ml TEL (130 Performance Number)
Lean-mixture rating: S-2 + 0.10 ml TEL (105 Performance Number)

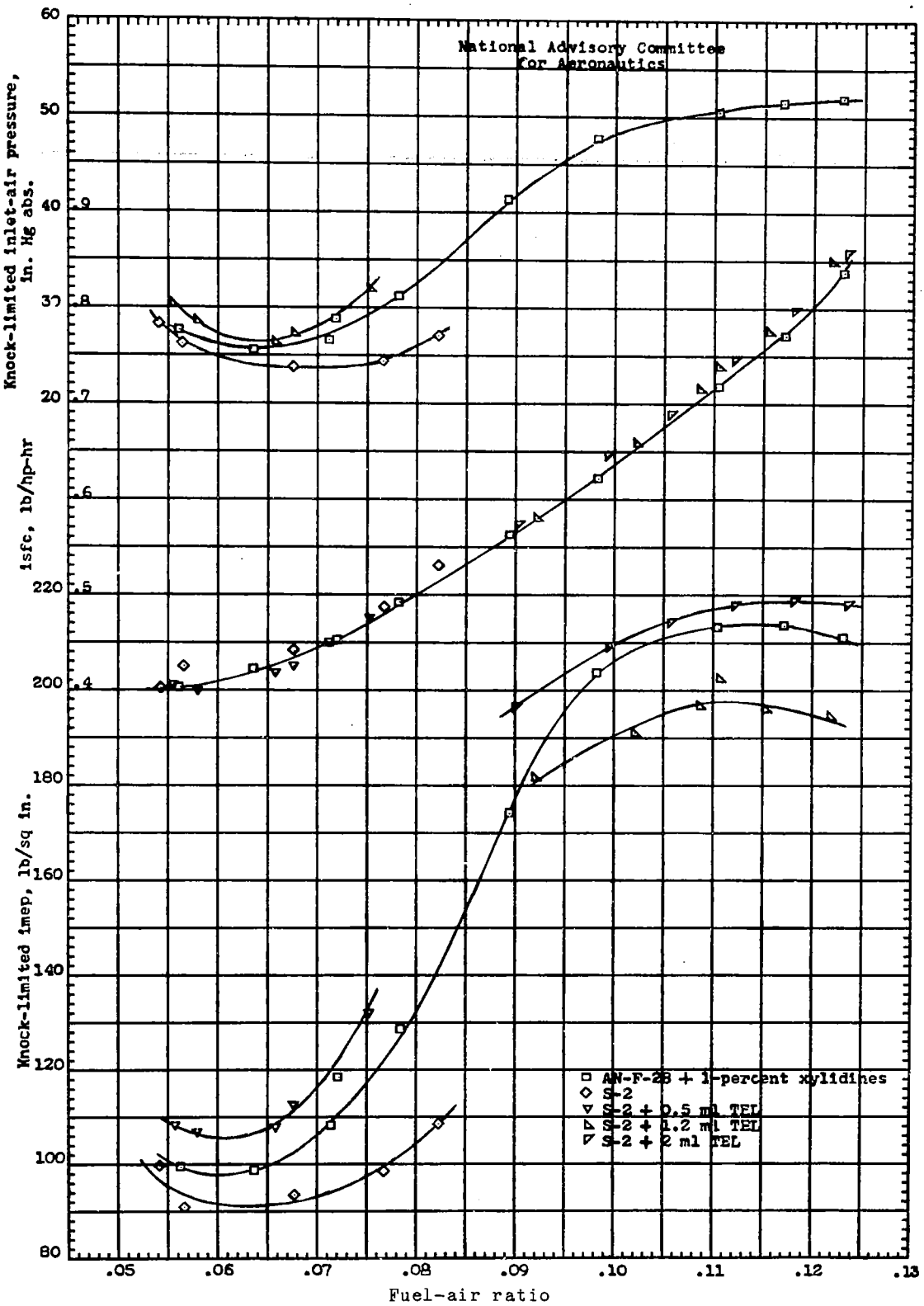

Figure 6. - Modified 3-C rating of AN-F-28 fuel plus 1-percent xylidines.

Rich-mixture rating: S-2 + 1.84 ml TEL (135 Pefformance Number)
Lean-mixture rating: S-2 + 0.23 ml TEL (110 Performance Number)

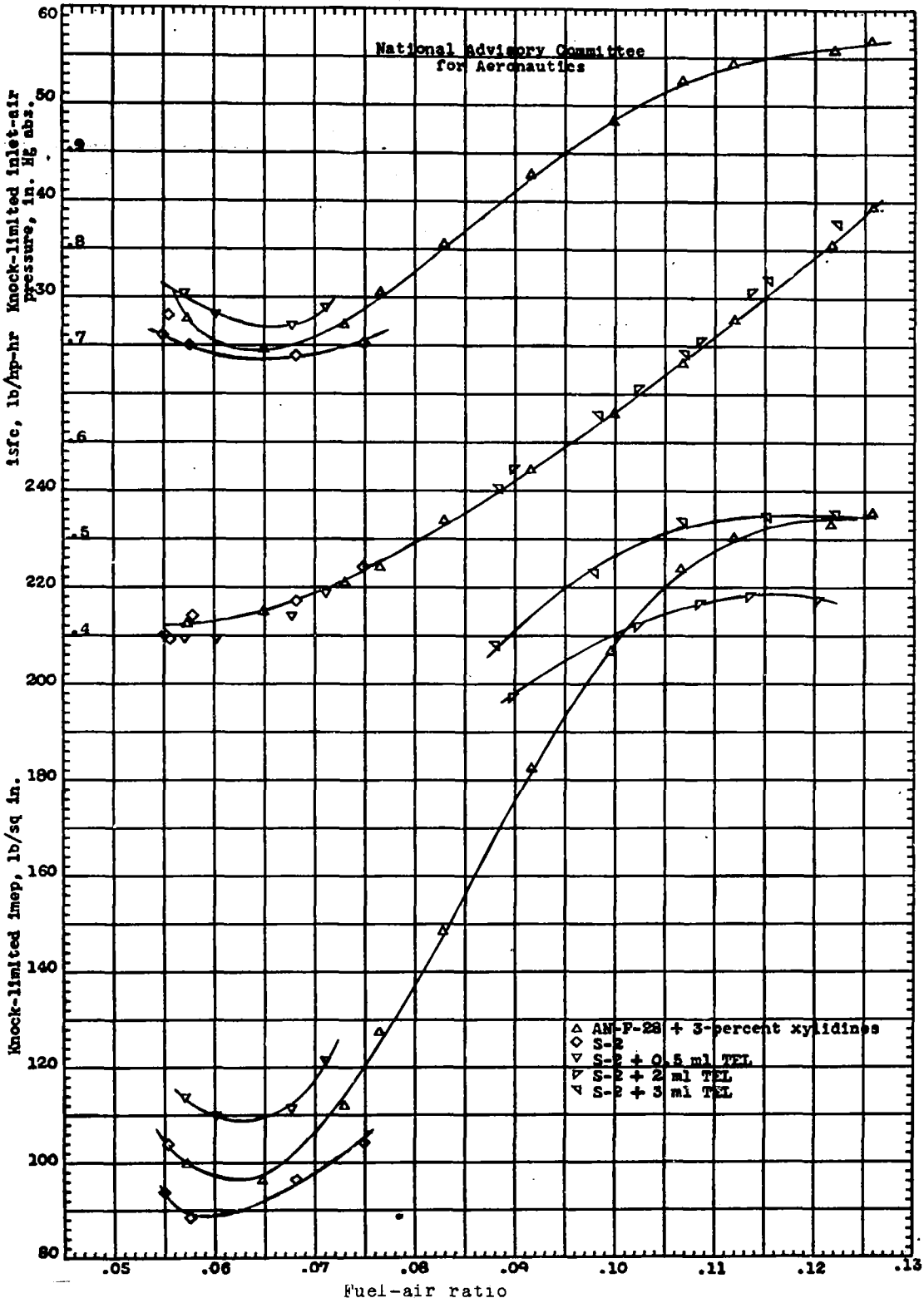

Figure 7. - Modified 3-C rating of AN-F-28 fuel plus 3-percent xylidines.

Rich-mixture rating: S-2 + 2.88 ml TEL (145 Performance Number)
Lean-mixture rating: S-2 + 0.13 ml TEL (105 Performance Number)