REPORT No. 52

TEMPERATURES IN SPARK PLUGS HAVING STEEL AND BRASS SHELLS

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

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BY

C. S. CRAGOE

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By C. S. Cragoe.

RÉSUMÉ.

This investigation was conducted at the Bureau of Standards for the National Advisory Committee for Aeronautics.

Brass has often been assumed superior to steel for spark plug shells because of its greater heat conductivity. The measurements described in this report prove the contrary, showing that the interior of a spark plug having a brass shell is from 50° to 150° C. (90° to 270° F.) hotter than that of a similar steel plug. Consistent results were obtained in both an aviation and a truck engine, and under conditions which eliminated all other sources of difference between the plugs. It is to be concluded that steel is to be preferred to brass for spark plug shells.

INTRODUCTION.

The measurements described below were undertaken to compare the temperatures attained in various portions of spark plugs having brass and steel shells. The plugs used were of the Rajah type. The porcelains were especially made with a hollow central (electrode) space of approximately 2 mm. (0.08 inch) diameter and sealed at the lower end. The temperature gradient along this central axis of the porcelain was measured with a movable copper constantan thermocouple. A brass tube about 2 cm. (0.8 inch) in diameter and 15 cm. (6 inches) in length was attached to the upper part of the shell of each plug to protect the thermocouple and to support it in any desired position.

MEASUREMENTS WITH PLUGS IN HALL-SCOTT MOTOR.

Two plugs with brass and two with steel shells were placed in the regular spark plug holes on the exhaust side of a four-cylinder Hall-Scott motor, type A–5a, running at a speed of about 1,500 revolutions per minute, and delivering about 110 horsepower to an airplane propeller. A separate run was made for each plug and the temperatures measured after sufficient time had elapsed (about a half hour) for the temperature to become constant. The temperature of the discharge water from the cylinders was about 70° C. (158° F.) in each case. The following table contains the results of the measurements. The first column gives the position of the thermocouple from the bottom of the porcelain. This was limited by the depth of the central space.

TABLE I.

Position.		Temperatures °C. in aviation engine.					
		In cylinder I.		In cylinder II.		In cylinder I.	
Cm.	Inches.	Brass A.	Steel A.	Brass A.	Steel	Brass B.	Steel B.
1.5	0.59	....	....	....	....	435	325
2.0	.79	380	220	375	225	395	290
2.5	.98	355	180	360	210	350	260
3.0	1.18	310	155	330	180	305	225
3.5	1.38	255	130	285	155	265	195
4.0	1.57	200	120	215	125	210	160

[1] This Report was confidentially circulated during the war as Bureau of Standards Aeronautic Power Plants Report No. 12.

These values are shown in plot 1.

The gas leakage on the above plugs was measured at 225 pounds pressure and 150° C. with the following results:

	Brass.	Steel.
A	0.01 cc. per sec.	0.05 cc. per sec.
B	0.36 cc. per sec.	0.45 cc. per sec.

The pitch diameters of the threads (in inches) were measured by choosing the two central threads and taking diameters at right angles.

Brass.		Steel.	
A.	B.	A.	B.
0.6680	0.6696	0.6663	0.6707
.6682	.6688	.6642	.6692
.6672	.6678	.6640	.6668
.6675	.6680	.6637	.6665
Mean. .6677	.6685	.6645	.6683

MEASUREMENTS IN A TRUCK MOTOR.

Similar measurements were made in a Waukesha truck motor with special cylinder heads which gave a maximum compression of about 115 pounds per square inch. This motor was connected with a dynamometer and loaded down with the throttle wide open to run at a speed of 1,000 revolutions per minute. There was no fan or radiator connected but the discharge water was thermostated at a temperature of 63° C. (145° F.). Each plug was placed separately in the second cylinder and in the same spark plug hole, which was specially drilled and tapped in a position originally used for a priming cup. The bottom of the plugs lacked about 2.5 cm. (1 inch) of being flush with the inside cylinder wall. The temperature gradients along the central axis of the porcelains were measured as before. An additional thermocouple was placed about 2 mm. (0.08 inch) within the metal of the shell of each plug and level with the copper gasket below the shoulder of the porcelain.

TABLE II.

Position (from bottom of porcelain).		Temperatures °C. in truck engine.					
Cm.	In.	Brass A.	Steel C.	Brass C.	Steel D.	Brass A.	Steel C.
2.0	0.79	227	158	245	173	230	156
2.5	.98	169	133	173	141	171	135
3.0	1.18	147	120	149	125	149	120
3.5	1.38	135	111	135	114	137	116
4.0	1.57	128	104	126	108	130	108
4.5	1.77	121	100	121	103	123	101
Thermocouple in shell		135	112	135	116		

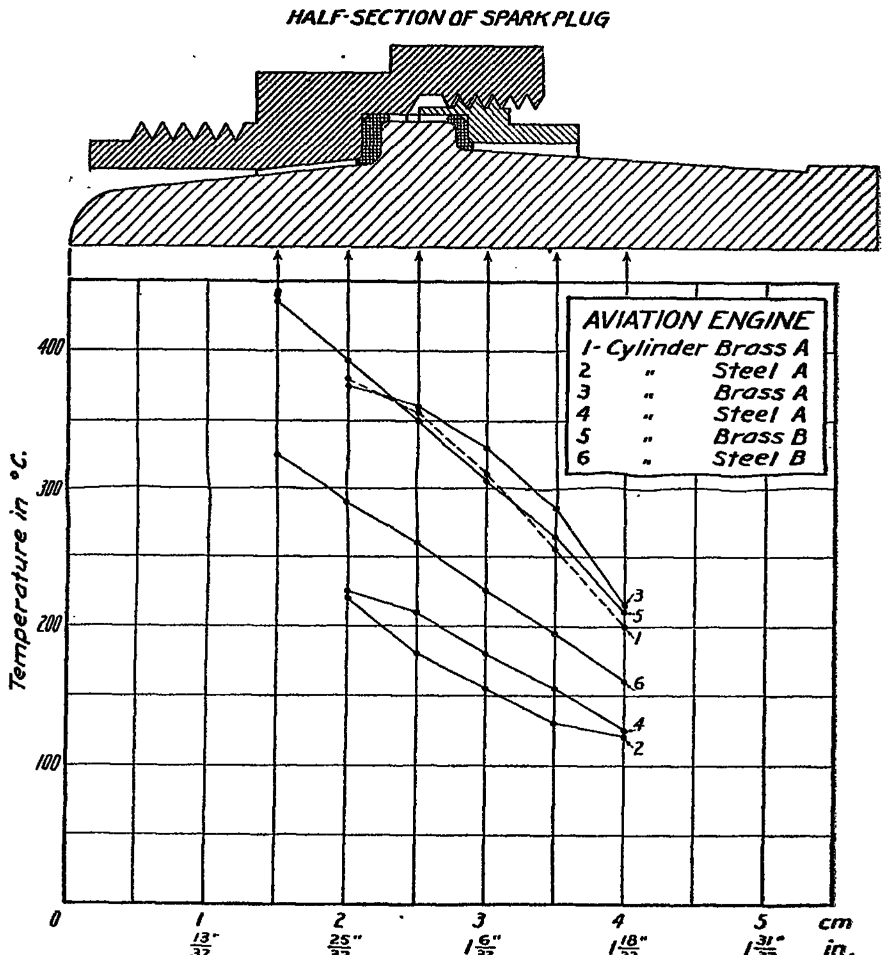
These values are shown in plot 2.

The gas leakage was carefully measured at 220 pounds pressure and 155° C. and plugs purposely chosen having wide variations.

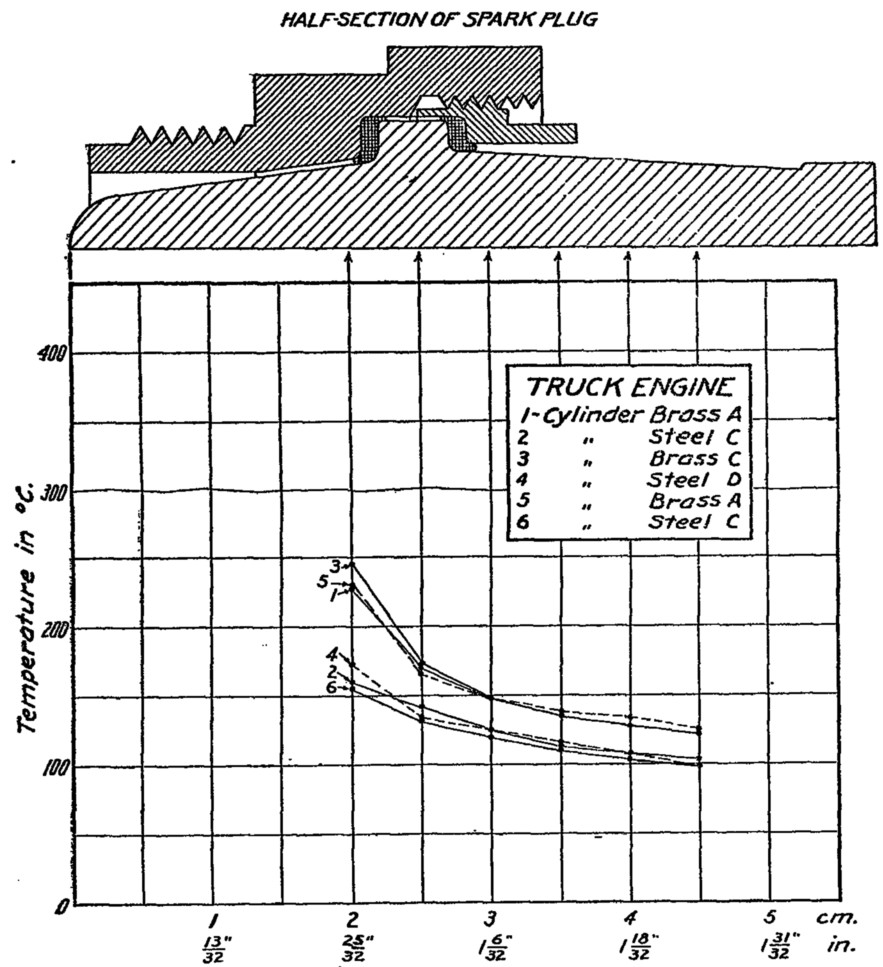
	Brass.		Steel.
A	0.009 cc. per sec.	C	0.03 cc. per sec.
C	1.5 cc. per sec.	D	1.6 cc. per sec.

The pitch diameters of the threads in inches were:

Brass.		Steel.	
A.	C.	C.	D.
0.6680	0.6697	0.6692	0.6668
.6682	.6686	.6684	.6668
.6672	.6676	.6674	.6659
.6675	.6678	.6670	.6661
Mean .6677	.6684	.6681	.6664



Plot No. 1



Plot No. 2.

CONCLUSIONS.

The measurements indicate that the temperatures of the brass shells are considerably higher than the steel in each case. Also, the temperatures in the center of the porcelain are higher in the case of brass shells. This difference can not be attributed to difference in gas leakage, since plugs of the same material differing quite widely in leakage gave practically identical results. Also, the thread dimensions were so nearly the same that the difference in temperature can not be due to difference in the contact between the plug and the jacket, and is apparently due to the difference in the material of the shell. This effect is apparently due to the greater thermal conductivity of brass (0.22 c. g. s. units) as compared with steel (0.11 c. g. s. units). The heat received from the hot gases in the cylinder by the inner end of the brass plug is more readily conducted longitudinally to the upper part of the shell, which is thus maintained at a relatively higher temperature in spite of the loss of heat from the upper portions of the shell and insulator by radiation and convection. Since the contact between the porcelain and the plug is above the plane of the engine water jacket, the porcelain is less effectively cooled in the case of the brass plug where the upper part of the metal is hotter, and consequently shows a higher temperature throughout its length.

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