Evaluation of Fire-Detection Systems Proposed for the Martin YP6M Airplane

By

Joseph Osman

Aircraft Division

TECHNICAL DEVELOPMENT REPORT NO. 302

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT CENTER
INDIANAPOLIS, INDIANA

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, Secretary

CIVIL AERONAUTICS ADMINISTRATION
James T. Pyle, Administrator
D. M. Stuart, Director, Technical Development Center

TABLE OF CONTENTS

EVALUATION OF FIRE-DETECTION SYSTEMS PROPOSED FOR THE MARTIN YP6M AIRPLANE*

INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, an evaluation was made of a continuous-type fire-detection system configuration proposed by the Glenn L. Martin Company for the YP6M airplane powerplant. A surveillance-type system configuration also was evaluated. In partial performance of Navy Contract NAer 01760, dated July 25, 1956, the test work was conducted during the period from July 1 to December 31, 1956, at the CAA Technical Development Center, Indianapolis, Indiana.

Previous testing at the Center had established requirements for both continuous- and surveillance-type system configurations for the XP6M airplane; however, major modifications incorporated in the Y-model powerplant necessitated revisions in the fire-detection systems and made a new evaluation desirable.

EQUIPMENT

The test nacelle used for these tests was a mockup of the XP6M No. 1 nacelle modified to conform to the YP6M configuration. The outer casing of a J71 engine, with the continuous-type detection systems mounted on it, was installed in the nacelle. Operational conditions of aircraft were simulated within the nacelle by providing ram air from a 1,750-hp blower at the forward end and by providing aspiration at the rear of the nacelle by two 100-hp blowers. Locations of fire nozzles used to provide test fires are shown in Fig. 1.

DESCRIPTION OF DETECTION SYSTEMS

Two continuous-type systems and one surveillance-type system were used in the tests. The detector elements of the continuous systems were mounted on the engine and were routed adjacent to each other. They were located as shown in Figs. 2 and 3. Elements of the surveillance system were mounted on the nacelle. They were located as shown in Figs. 4 and 5. The three systems used are described in this report.

Kidde Continuous System.

This system, manufactured by Walter Kidde & Company, Inc., consisted of a control unit, No. 871626; 30 feet (two 15-foot lengths) of element No. 809180; and 20 feet (two 10-foot lengths) of element No. 816120. All of the elements were connected in series. The control unit was set at 600 ohms which caused an alarm to occur if the entire length of low-temperature element (No. 809180) was heated slowly to 450° F. with the entire length of No. 816120 element at 425° F., or if the entire length of high-temperature element (No. 816120) was heated slowly to 710° F. with the entire length of No. 809180 element at 225° F. The 425° F. and 225° F. temperatures represent the expected ambient temperatures of the high- and low-temperature areas, respectively. The high-temperature element was installed on the aft section of the engine in the vicinity of test-fire locations O, P, T, U, V, W, X, Y, ZZ, and AA, shown in Fig. 1; the low-temperature elements were installed in the forward area.

Fenwal Continuous System.

This system, manufactured by Fenwal Incorporated, consisted of a control unit, No. 35000-0, and 50 feet of sensing element No. 35503-1. The Fenwal elements used in these tests were in various lengths and were similar to those used in bench tests which alarmed at 570° F. when heated slowly in an electric furnace. The control box was not adjustable.

---

*Reprinted for general distribution from a limited distribution report dated February 1957.

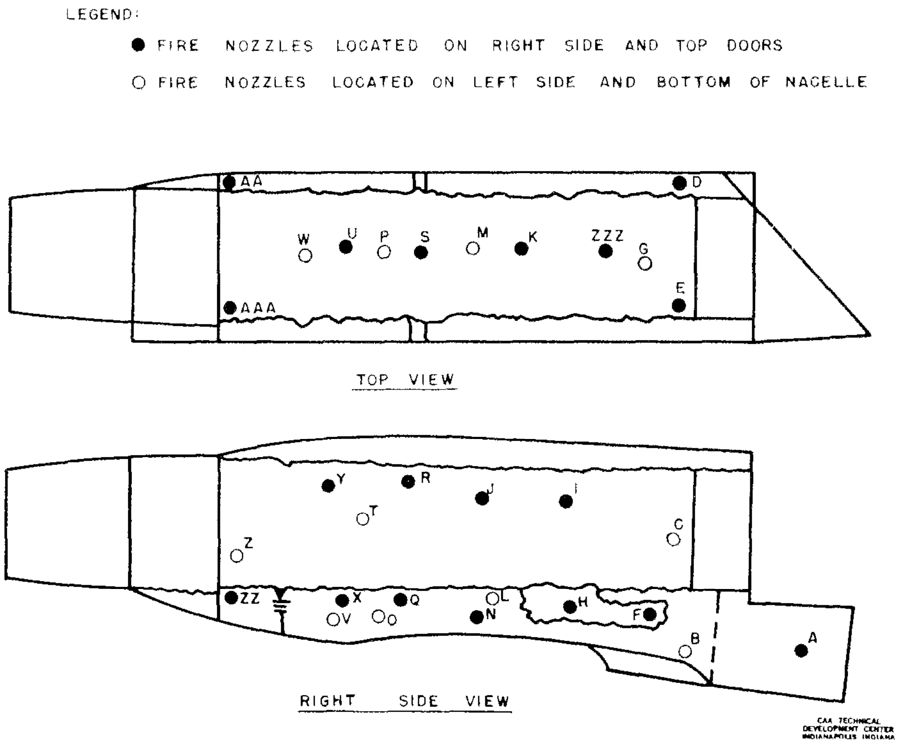

Fig. 1 Test Fire Locations

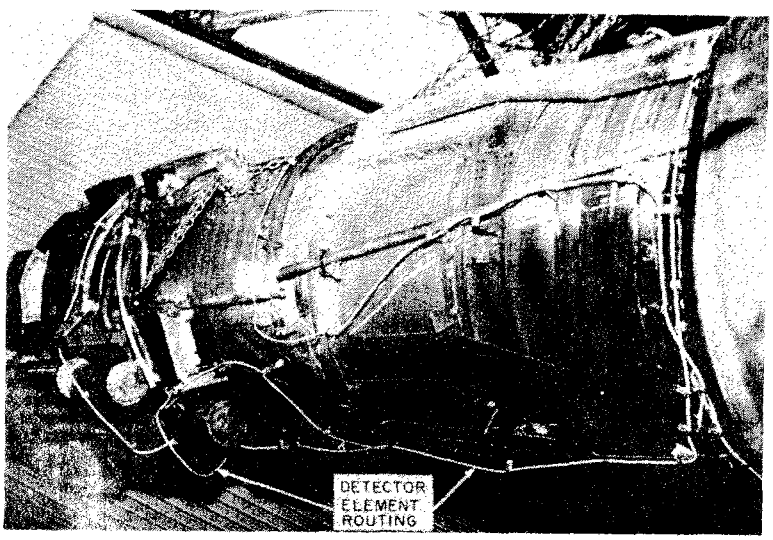

Fig. 2 Location of Continuous Sensing Elements - Left Side

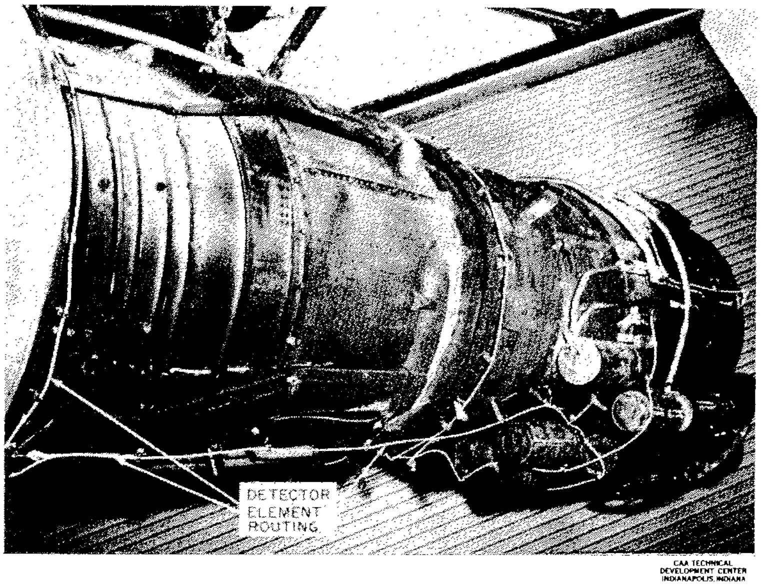

Fig. 3 Location of Continuous Sensing Elements - Right Side

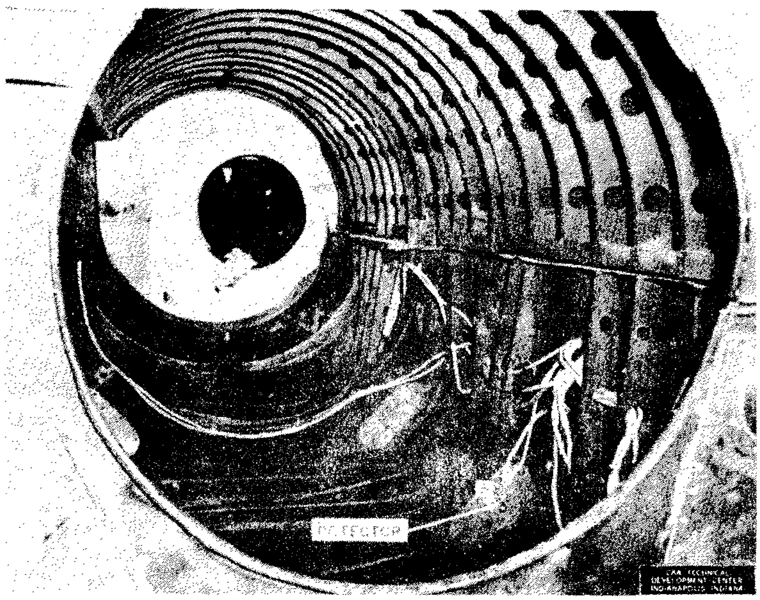

Fig. 4 Fireye Detector Locations - Forward View

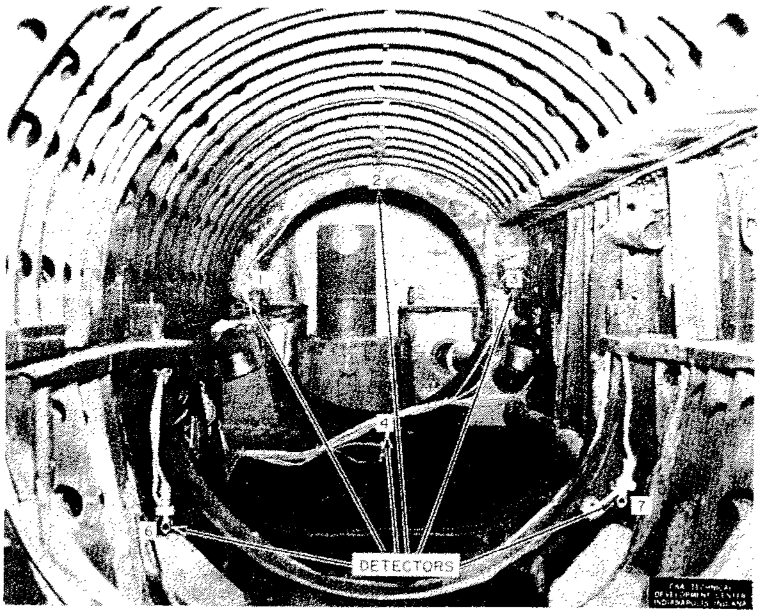

Fig. 5 Fireye Detector Locations - Rearward View

Fireye Surveillance System.

This system, manufactured by the Electronics Corporation of America, consisted of an amplifier unit, Type 72BA2, Model 1001; a test-switch assembly; and seven detector units, Type 47ST7, Model 1003.

TEST PROCEDURE

Evaluation of the detection systems was made by providing test fires at numerous locations throughout the nacelle under airflow conditions simulating those occurring during operation of the airplane, and recording the alarm reaction of the detection systems installed. The test fires were produced by spark ignition of gasoline released at a rate of 0.3 gallon per minute (gpm) for 10 seconds from locations shown in Fig. 1.

The airflows provided for each series of tests are shown in Tables I and II. They approximate estimates of the airflows under various conditions of operation. These estimates, provided by the Glenn L. Martin Company, were as follows:

Condition	Nacelle Airflow (pounds per second)
Military power, sea level, 560 K speed	11.3
Military or normal power, 35,000 feet altitude, Mach 0.8 speed	3.0 to 3.03
Afterburner power, sea level, static or zero speed	7.06
Military power, sea level, static or zero speed	2.8

Tests conducted under simulated flight conditions, Table I, were made with secondary cooling-air ducts open. Those conducted under simulated surface operation, Table II, were made with the ducts closed.

Alarm reaction of the detection systems was measured from the instant of fuel release.

TABLE I

RESULTS OF TESTS CONDUCTED ON FIRE-DETECTION SYSTEMS IN YP6M TEST NACELLE UNDER SIMULATED FLIGHT CONDITIONS (Test-Fire Fuel Rate, 0.3-gpm Aviation Gasoline)

Test-Fire Position	Test No. 1[1] Detection Time (seconds) Fireye	Fenwal	Kidde	Test-Fire Position	Test No. 2[2] Detection Time (seconds) Fireye	Fenwal	Kidde
A	1.0	XX	XX	A	1.0	XX	XX
B[3]		XX	XX	B	1.0	XX	XX
C	1.0	XX	XX	C	0.8	XX	XX
D[3]	10.0	XX	XX	D	1.0	XX	XX
E[3]		XX	XX	E	1.3	XX	XX
F[3]		XX	XX	F	1.4	7.7	4.7
G	1.2	4.0	3.0	G	1.8	6.8	4.8
H	0.8	7.0	4.2	H	1.0	3.7	3.0
I	1.1	3.2	2.9	I	1.0	2.0	2.1
J	1.0	4.0	3.3	J	1.0	6.5	5.2
K	1.0	2.3	2.0	K	1.0	2.9	2.3
L	0.7	8.5	4.0	L	1.0	5.6	4.0
M	1.0	5.2	3.0	M	0.9	4.2	3.0
N	0.9	8.5	4.5	N	1.1	3.1	3.0
O	1.4	3.9	4.0	O	1.0	5.5	5.8
P	1.0	4.0	X	P	1.5	8.6	9.0
Q	0.8	7.0	X	Q	1.0	4.0	6.0
R	0.7	3.2	3.0	R	4.8	5.3	6.0
S	1.0	2.5	2.5	S	1.0	2.7	2.7
T	0.9	2.3	2.7	T	1.0	1.9	2.7
U	X	2.0	3.0	U	X	8.3	9.0
V	0.8	7.0	5.3	V	1.2	10.0	9.5
W	0.9	2.6	3.6	W	4.0	8.0	9.5
X	1.0	4.0	7.5	X	1.2	4.5	7.5
Y	0.8	2.4	3.0	Y	2.0	3.5	4.0
Z	10.0	1.5	2.0	Z	8.0	2.5	3.0
AA	X	1.3	1.8	AA	X	X	3.7
ZZ	1.0	1.7	3.2	ZZ	4.0	1.8	2.3
ZZZ	1.0	1.4	1.4	ZZZ	0.9	2.4	2.3

1. Measured airflow, 11.3 pounds per second.
2. Measured airflow, 3.3 pounds per second.
3. Unable to ignite test fire of reasonable size due to high-velocity cooling airflow at this location.

X No alarm occurred in 10 seconds.

XX No alarm occurred. Fire position was in forward nacelle area, unprotected by any sensing element.

RESULTS AND DISCUSSION

The data obtained during the fire-detection tests are shown in Tables I and II. The results of these tests are not intended to show a true comparison of the response times of the 3 detection systems because this is accomplished more accurately under carefully controlled conditions. It was not practical to obtain the ambient temperatures which will exist in the YP6M airplane under operating conditions. For example, the sensing elements of the Kidde system in the aft section require a higher temperature for alarm than do the forward section elements. The sensing elements of the Fenwal system are the same throughout the nacelle.

TABLE II

RESULTS OF TESTS CONDUCTED ON FIRE-DETECTION SYSTEMS IN YP6M TEST NACELLE UNDER SIMULATED STATIC CONDITIONS (Test-Fire Fuel Rate, 0.3-gpm Aviation Gasoline)

Test-Fire Position	Test No. 3[1] Detection Time (seconds) Fireye	Fenwal	Kidde	Test-Fire Position	Test No. 4[2] Detection Time (seconds) Fireye	Fenwal	Kidde
A	1.0	XX	XX	A	0.9	XX	XX
B	0.9	XX	XX	B	0.9	6.0	4.5
C	1.0	XX	XX	C	0.9	11.2	7.5
D	1.0	XX	XX	D	0.9	XX	XX
E	0.8	X	5.5	E	1.0	10.5	7.0
F	1.0	X	9.0	F	1.0	5.8	3.0
G	1.2	5.8	3.4	G	1.0	4.7	3.0
H	0.7	5.0	3.4	H	0.9	4.5	3.8
I	1.0	2.4	2.3	I	1.0	3.0	2.9
J	1.5	3.3	3.0	J	1.2	5.0	4.2
K	1.5	3.8	3.6	K	1.0	3.2	3.0
L	0.7	5.0	5.3	L	1.1	5.0	4.0
M	1.0	6.5	6.2	M	1.0	4.0	2.8
N	1.1	8.1	9.0	N	1.1	7.8	6.1
O	1.0	6.0	6.5	O	1.0	8.8	9.5
P	0.9	6.2	X	P	1.0	6.2	9.0
Q	1.0	5.2	X	Q	1.0	4.0	6.1
R	3.6	7.0	7.5	R	1.9	3.2	3.7
S	1.2	2.0	2.2	S	1.0	3.0	2.8
T	1.2	2.0	2.7	T	1.1	2.2	3.0
U	X	3.8	6.5	U	X	6.0	8.0
V	1.3	4.8	6.7	V	1.5	4.8	6.5
W	1.8	4.4	7.0	W	3.7	7.4	9.0
X	1.2	4.4	6.4	X	1.0	3.6	6.4
Y	1.0	2.5	3.0	Y	1.0	1.9	2.0
Z	8.5	1.3	2.0	Z	2.4	1.9	2.7
AA	X	5.8	6.0	AA	X	2.5	4.5
ZZ	2.5	1.5	1.8	ZZ	4.5	3.2	2.8
ZZZ	0.9	3.5	3.0	ZZZ	1.0	3.2	2.8

1. Measured airflow, 6.83 pounds per second.
2. Measured airflow, 3.03 pounds per second.

X No alarm occurred in 10 seconds.

XX No alarm occurred. Fire position was in forward nacelle area, unprotected by any sensing element.

The alarm time for both would be affected by ambient temperatures in the nacelle. Two of the seven detectors used in the Fireye system were located in the aft section of the nacelle, and their sensitivity would be reduced somewhat by the higher ambient temperatures under actual operating conditions.

The results of these tests indicate that the continuous-system configuration was effective generally in alarming 0.3-gpm gasoline fires in most areas of the nacelle. The continuous system did not detect fires occurring in the forward portion of the nacelle where no element was routed, however. Also, fires at positions O, P, and W, caused by puddled fuel or by fuel released from a nozzle in such a direction as not to strike the engine, were not detected. Such fires were observed to pass beneath the sensing elements.

The Fireye system detected fires in all areas except at positions U and AA located in the rear top door.

CONCLUSIONS

1. The proposed continuous detection-system configuration should provide effective detection of nacelle fires, if: (1) an additional element is routed near the forward firewall area and the lower forward portion of the nacelle which contains numerous fluid-system components, and (2) the element in the area of fire positions O, P, and W is repositioned halfway between the engine and structural rib surfaces.

2. The Fireye system configuration tested would provide effective detection of nacelle fires, if two additional sensing units are placed near nacelle station 268.25 at the 10 o'clock and 1 o'clock positions, and directed aft.

USCOMM-DC-60330