Fire-Detection Requirements for the Martin XP6M-1 Airplane Powerplant

By

Joseph Osman

Aircraft Division

TECHNICAL DEVELOPMENT REPORT NO. 320

CIVIL AERONAUTICS ADMINISTRATION

TECHNICAL DEVELOPMENT CENTER

INDIANAPOLIS, INDIANA

December 1958

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

FIRE-DETECTION REQUIREMENTS
FOR THE MARTIN XP6M-1 AIRPLANE POWERPLANT*

SUMMARY

Studies of the flame paths occurring within the XP6M-1 powerplant from fuel fires were made and effective locations for detector sensing elements were determined The requirements for both continuous- and surveillance-type systems were established. The final proposed system configurations were tested under simulated full-scale conditions of flight and surface operation and found to provide effective coverage of the engine nacelle space and to detect the existence of fire rapidly

INTRODUCTION

A determination of effective fire-detection system configurations was requested by the Airborne Equipment Division, Bureau of Aeronautics, Department of the Navy, following evaluation at the Technical Development Center of the system originally proposed by the airframe manufacturer This evaluation was limited to one type of system and indicated a need for improvements in detecting fires.[1] Additional studies were desired to provide information on other detector systems as well as to establish requirements for effective detection of fire. The test work covered by this report was conducted during the period August 1, 1955, to March 20, 1956

EQUIPMENT

The test article was a steel mockup of the No 1 nacelle of the XP6M-1 airplane with the outer casing of a J71 engine installed. Operational conditions of the XP6M-1 airplane were simulated within the nacelle by providing ducted ram air from two 1,750-hp blowers into the front of the nacelle and providing aspiration at the rear of the nacelle with two 100-hp blowers arranged in tandem The test article was mounted in a test chamber adjacent to which was an observation room containing the control panel, time recorder, temperature gauges, manometers, and other equipment used in the conduct of the tests

DESCRIPTION OF DETECTOR SYSTEMS USED

Three types of detector systems were used (1) a heat-sensitive, continuous- or wire-type, manufactured by the Thomas Edison Company, (2) a flame-sensitive, continuous-type presently under development by the Thomas Edison Company, and (3) a surveillance-type, manufactured by the Fireye Division, Electronics Corporation of America

The sensing elements of the two continuous-type systems were routed within the nacelle structure adjacent to one another and located as shown in Figs 1, 2, and 3 Sensing elements of the Fireye Surveillance system were located as shown in Figs. 4, 5, and 6

The three systems used are further described as follows

---

*Reprinted for general distribution from a limited distribution report dated September 1957

[1] Joseph Osman, "Evaluation of the Fire-Detection and -Extinguishing Systems of the Navy XP6M-1 Airplane," CAA Technical Development Report No 294, November 1958

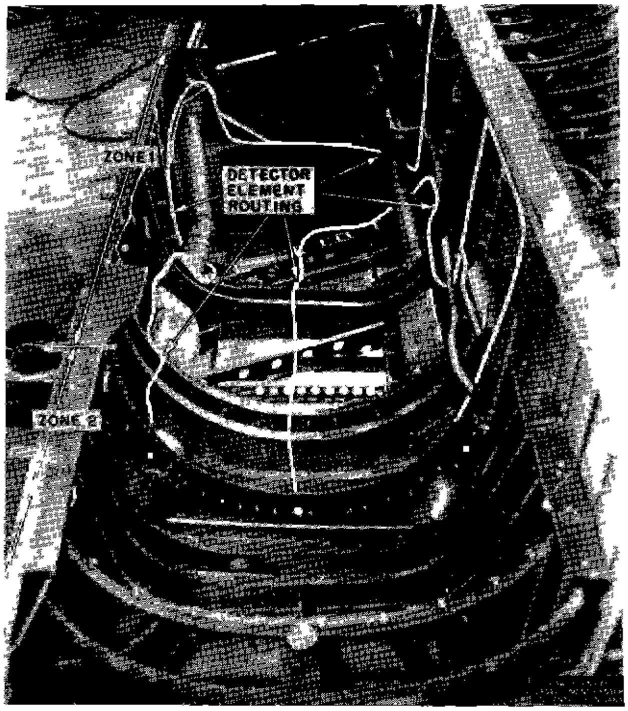

Fig 1 Location of Continuous-Type Sensing Elements - Zone 1

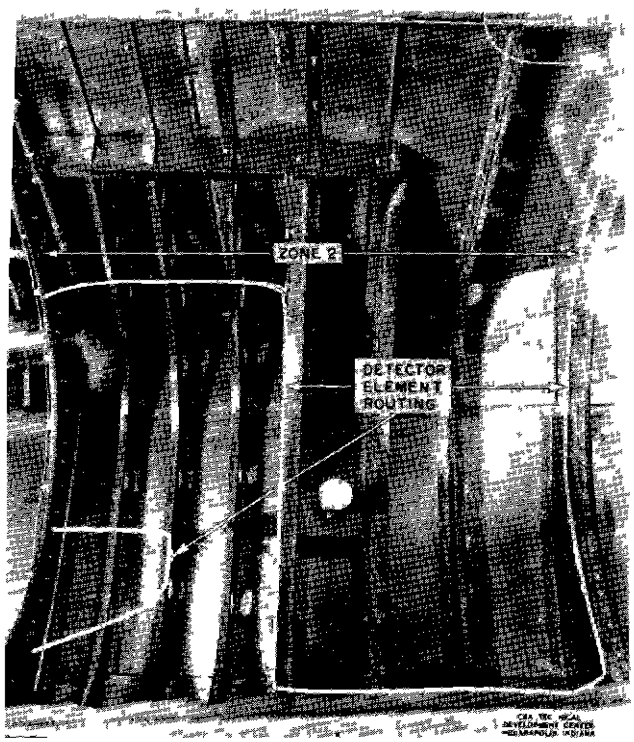

Fig 2 Location of Continuous-Type Sensing Elements - Zone 2

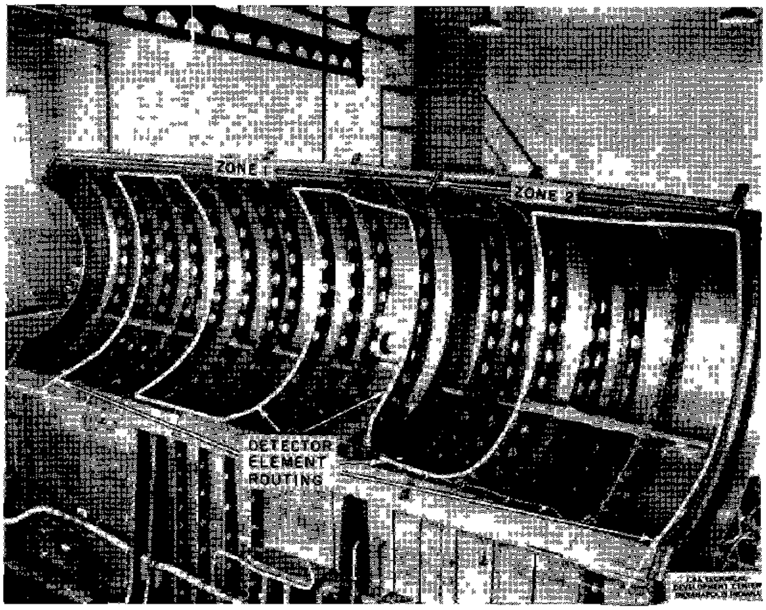

Fig 3 Location of Continuous-Type Sensing Elements - Top Doors

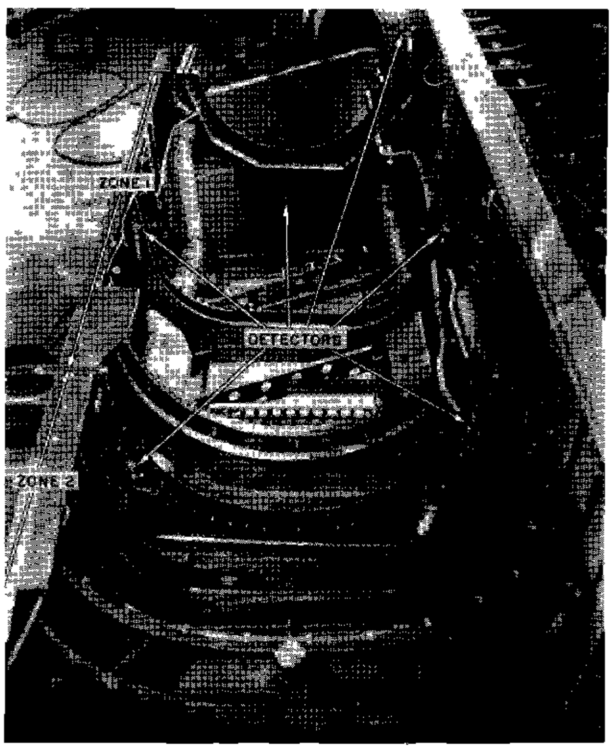

Fig 4 Fireye Detector Locations - Forward View

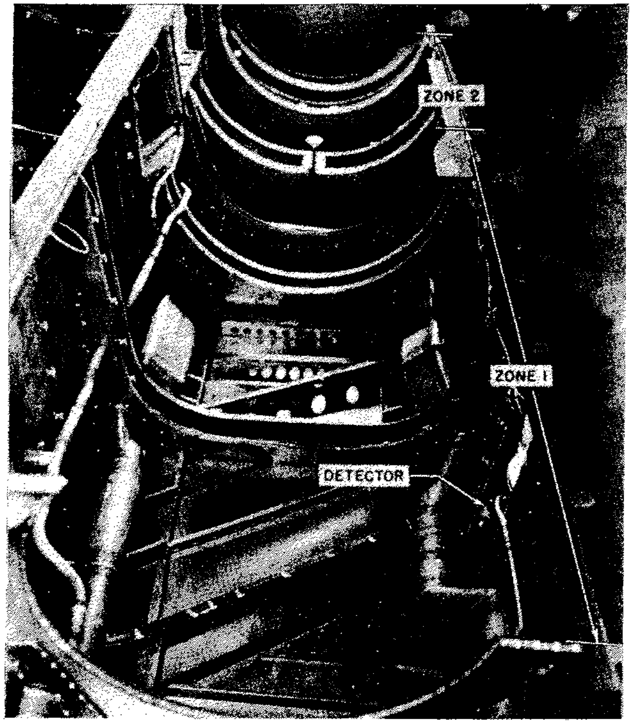

Fig. 5 Fireye Detector Locations - Rearward View

Edison Heat-Sensitive Continuous System.

This sytem consisted of a Model 227 control-box assembly and 96 feet of sensing element, Model 234. The control circuit was adjusted by use of a 100-ohm resistor to cause the system to alarm when the entire length of sensing element was exposed to a temperature of 500° F.

Edison Flame-Sensitive Continuous System.

This system originally was invented by the Petcar Company, and the one tested was produced by the American Machine and Foundry Company under Navy contract. Patent rights since have been purchased by the Thomas Edison Company. The system tested consisted of a control unit, Type 1017-A, containing a transmitter and receiver and 96 feet of sensing element. The element was 1/16-inch stranded steel aircraft control cable installed in the nacelle with ceramic electrical insulators. During operation, a 3-volt a-c signal of low harmonic content was generated by the transmitter and impressed upon the sensing element. When a flame bridged the element and ground (engine or nacelle), a second harmonic of the impressed signal was produced. This was detected by a receiver and amplified to produce sufficient power for a fire warning light.

Fireye Surveillance System.

This system consisted of a control unit, Type No. 60-357, Exhibit No. WCEEM-3-41, a test switch assembly, and 9 detector units, Exhibit No. WCEEM-3-40.

GENERAL PROCEDURE

A preliminary investigation of airflow and flame patterns was conducted in order to assist in locating the detector elements of the continuous- and flame-type systems. This was accomplished by burning aviation gasoline at the rate of 1/3-gallon per minute (gpm) at several nozzle locations as shown in Fig. 7 and observing, through Plexiglas windows, the direction of flame travel, type, and size of flame.

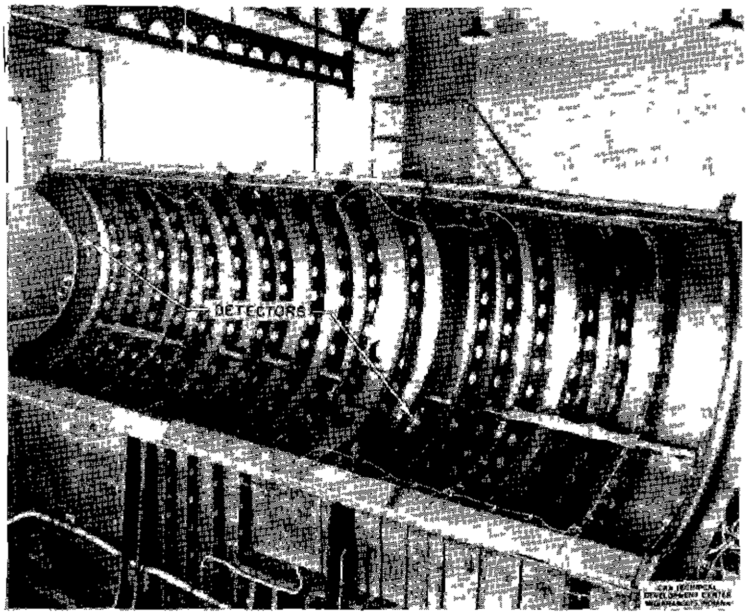

Fig. 6 Fireye Detector Locations - Top Doors

Utilizing the information obtained during the preliminary investigation of airflow and flame patterns, the sensing element of the continuous-type flame detector was mounted on the nacelle structure normal to the direction of airflow and fire A portion of the sensing element was located to provide coverage of the lower forward area and of the air outlets A series of tests then was conducted to determine the effectiveness of the initial configuration to alarm fires burning aviation gasoline at the rate of 0 23-gpm The system then was modified to provide coverage for those areas where the test fires were not readily detected. The final test configuration for the flame-sensitive and heat-sensitive continuous-type systems was that shown in Figs 1, 2, and 3.

The locations of the sensing units of the surveillance system were determined by placing a total of 12 units in positions such that the entire nacelle area would be monitored Tests were conducted to determine the sensing units which individually caused alarm at each fire location It was found that nine sensing units were sufficient to detect nearly all fires The final test locations of the nine sensing units are shown in Figs 4, 5, and 6

A final series of tests was made with all three detection systems installed by providing test fires at numerous locations throughout the nacelle under airflow conditions simulating those occurring during operation of the airplane The alarm reaction of each system was recorded The test fires for these tests were produced by spark ignition of gasoline released at a rate of 1/3-gpm for 10 seconds at the locations shown in Fig 7

The airflows used in each series of tests are shown in Tables I and II They were intended to simulate estimated conditions of airplane operation. This was not possible in the burner compartment (Zone 2) under flight conditions with the facilities available The estimated airflows in the engine compressor compartment (Zone 1) and the engine burner compartment (Zone 2) during airplane operation were provided by the Glenn L Martin Company and were as follows

Zone 1 - Flight operation = 3 5 lb /sec	Surface operation = 3.3 lb /sec
Zone 2 - Flight operation = 16 lb /sec	Surface operation = 10 7 lb /sec

In tests conducted under simulated surface operation, Table II, Zone 1 airflow was in a reverse direction to that produced by simulated flight operation Alarm reaction of the detection systems was measured from the instant of fuel release Spark ignition was provided prior to fuel release

TABLE I

RESULTS OF TESTS CONDUCTED ON FIRE-DETECTION SYSTEMS IN XP6M TEST NACELLE UNDER SIMULATED FLIGHT CONDITIONS

Test Fire Fuel Rate 1/3-GPM Aviation Gasoline

Airflow Zone 1 = 3.3 lb /sec
Zone 2 = 7.6 lb /sec

Test Fire Position	Zone 1 Detection Time (seconds) Flame(1)	Fireye(2)	Edison(3)
A	1.0	1.5	3.2
B	1.0	1.8	4.2
C	2.0	1.2	7.4
D	2.0	1.6	6.3
E	1.0	1.2	2.8
F	1.2	1.6	7.5
G	2.1	2.7	5.5
H	2.6	1.3	6.1
I	0.8	2.6	3.7
J	1.6	1.7	6.0
K	1.1	1.7	4.2
L	1.4	3.0	5.2
M	1.8	1.9	5.9
N	0.8	2.0	4.0
O	2.2	1.2	6.2
P	1.6	2.0	5.2
Q	0.8	1.2	3.7
R	1.0	1.3	4.8
S	1.3	2.0	4.5
ZZZ	1.2	2.9	4.8

Test Fire Position	Zone 2 Detection Time (seconds) Flame(1)	Fireye(2)	Edison(3)
T	0.7	1.8	4.0
U	1.2	2.0	5.0
V	0.8	1.4	1.9
W	0.9	1.3	4.3
X	5.6	1.1	9.3
Y	1.3	1.4	3.5
Z	0.8	1.3	3.6
AA	0.5	1.2	1.6
AAA	1.6	1.9	X
ZZ	3.7	2.1	X

(1) Edison flame-sensitive, continuous-type system

(2) Fireye surveillance-type system.

(3) Edison heat-sensitive, continuous-type system

X Indicates no alarm occurred in 10 seconds

TABLE II

RESULTS OF TESTS CONDUCTED ON FIRE-DETECTION SYSTEMS IN XP6M TEST NACELLE UNDER SIMULATED SURFACE CONDITIONS

Test Fire Fuel Rate 1/3-GPM Aviation Gasoline

Airflow. Zone 1 = 3.9 lb /sec (reverse flow)
Zone 2 = 9 65 lb /sec

Test Fire Position	Zone 1 Detection Time (seconds) Flame(1)	Fireye(2)	Edison(3)
A	0 8	1 2	3 0
B	2 0	2 1	5 2
C	0 5	1 6	4 9
D	1 1	1 2	5 2
E	1 4	2 3	8 6
F	0.8	1 3	5.3
G	1.3	1.3	3.4
H	1.0	1.1	4.8
I	3.3	1.9	5.8
J	3 1	1.2	5 5
K	4.5	2.2	7 8
L	4.5	1.4	5 5
M	2.3	2 0	5 2
N	0.8	1.6	3.5
O	0 6	1 7	2 7
P	0 7	1 2	2.4
Q	0 9	3.6	3 3
R	0 6	2 0	3 5
S	1 0	1 3	3.5
ZZZ	0 9	1 1	5.4

Test Fire Position	Zone 2 Detection Time (seconds) Flame(1)	Fireye(2)	Edison(3)
T	0.7	1 7	4 3
U	0 8	1 8	3 8
V	0 6	1 5	4.0
W	0.9	2 8	8.2
X	1.5	1.4	3.9
Y	1 0	1.5	3 3
Z	0 8	1.2	7.1
AA	0 6	1.4	3.0
AAA	0 8	1 2	X
ZZ	4 1	1.5	X

(1) Edison flame-sensitive, continuous-type system

(2) Fireye surveillance-type system

(3) Edison heat-sensitive, continuous-type system.

X Indicates no alarm occurred in 10 seconds

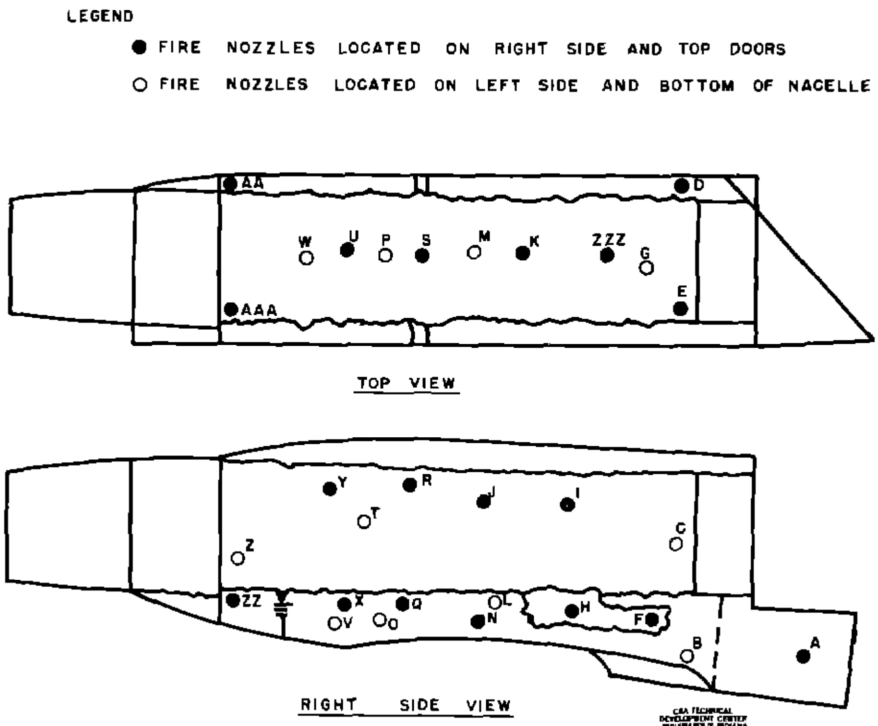

Fig. 7 Test Fire Locations

RESULTS AND DISCUSSION

The data obtained during the final series of tests are shown in Tables I and II. The results of these tests do not show a true comparison of the response times of the three detection systems when installed in the airplane because the alarm time of the heat-sensitive Edison system is a function of ambient temperature It was not practical to obtain the ambient temperatures which would exist in the XP6M-1 airplane under operating conditions For example, the higher ambient temperatures which would exist under actual operating conditions would improve the response time of the Edison system whereas the continuous flame-type system would not be affected The sensitivity of the detectors of the Fireye system may be somewhat reduced by higher ambient temperatures

The results of these tests indicated that the flame- and surveillance-type systems were effective in alarming 1/3-gpm gasoline fires in all areas of the nacelle and the Edison heat-sensitive system alarmed fires in all areas except at positions ZZ and AAA where no alarm occurred in 10 seconds The test fires at these two positions were small as a result of the high velocity of the cooling air in that area

The response time was appreciably greater for the Edison heat-sensitive, continuous-type system than for the flame-sensitive, continuous-type system or the Fireye surveillance-type system as shown in Tables I and II

CONCLUSIONS

Based on the tests conducted, it is concluded that

1 The location and mounting of the sensing elements of the continuous heat-sensitive and flame-sensitive type systems shown in Figs 1, 2, and 3 provide effective detection of fire

2 A Fireye system, having a total of nine detector units located as shown in Figs. 4, 5, and 6, provided effective detection of fire in all areas of the nacelle

3 The flame-sensitive, continuous-type detector system and the Fireye surveillance-type system provided comparable coverage and more rapid detection of fires than the heat-sensitive continuous type