A STUDY OF FLAME PROPAGATION THROUGH HOLES IN FIREWALLS

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FOREWORD

The investigation covered by this report was conducted at the Civil Aeronautics Administration's Technical Development Center, Indianapolis, Indiana, under WADC Contract No AF33(616)54-15, Amendment No A2(56-1935), and RDO No R-523-369SR1Z

A STUDY OF FLAME PROPAGATION THROUGH HOLES IN FIREWALLS*

SUMMARY

Aircraft power plant firewalls must allow passage of fuel and oil lines, wiring, ducts, and other components Present practice in routing such items through firewalls often results in small gaps or holes which may allow fire to pass through the firewall and ignite combustibles in the adjacent zone Holes large enough to allow passage of flame of sufficient size to cause damage in adjacent zones or to allow for passage of quantities of flammable fluids or vapors into zones where they might be ignited are hazardous and should be avoided This report describes tests to determine the allowable hole sizes in firewalls which prevent passage of flames

The results indicated that flames will pass through small holes in firewalls and ignite combustibles on the reverse side. Where a higher pressure existed on the flame side of the firewall, the flames passed through very small holes With 4 inches of water lower pressure on the fire side of the firewall no flame passage occurred even with holes as large as 1/4-inch diameter. Tests were not conducted with holes larger than 1/4-inch diameter Increasing the thickness of the stainless steel firewall material from 0 015-inch to 0 025-inch permitted an increase in maximum safe hole size, there was no advantage gained, however, when the thickness was increased from 0.025-inch to 0 040-inch The firewall specimens were heated quite rapidly by the flames, and ignition of the combustible on the opposite side of the specimen occurred in a short time from the heated metal alone

INTRODUCTION

A series of tests was conducted to study the sealing requirements of firewalls to prevent passage of flames The particular conditions chosen for the tests were probably the most severe which could exist, namely, those with a fire burning against one side of the firewall and an explosive mixture of gasoline and air on the opposite side Under those conditions the maximum hole size which would not allow flame passage was determined

TEST EQUIPMENT AND PROCEDURE

An 8.5 cubic-foot cylindrical chamber having an arrangement for attaching 18-inch diameter firewall specimens at one end and a paper blowout panel at the other end was utilized for the tests This test apparatus is shown in Fig 1. Firewall specimens of various thicknesses and with various size holes in the center were attached to the chamber A quantity of gasoline was vaporized by contact with a heated block inside the chamber The quantity of gasoline introduced into the chamber, when fully vaporized, formed an explosive mixture with the air in the chamber The walls of the chamber were kept at a temperature of approximately 180° F. to prevent condensation of the gasoline vapor A 2000° F flame from a hose testing torch was directed onto the firewall specimen This torch consumed two gallons of kerosene per hour and the area of flame contact was elliptical in shape with a major axis of 12 inches and a minor axis of 6 inches. Flame passage through the hole in the firewall was evidenced by an explosion in the chamber In order to assure that ignition of the explosive mixture was a result of flame passage through the hole in the firewall panel, and not a result of hot surface ignition from the heat conducted through the metal, panels of various thicknesses, but without holes were attached to the chamber and were subjected to the test The time required for the inner surface of these panels to become sufficiently heated to ignite the fuel-air mixture in the

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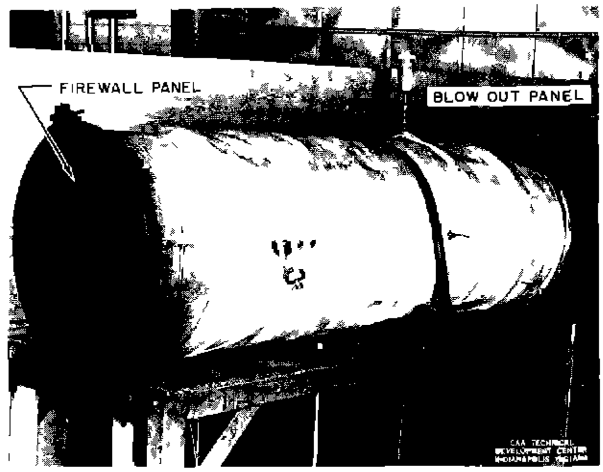

Fig 1 Apparatus for Tests of Flame Penetration Through Holes in Firewalls

chamber was recorded Subsequently, when the panels with the drilled holes were tested it was assumed that if ignition of the fuel-air mixture in the chamber did not occur in less time than was required for hot surface ignition to occur, then passage of the flame through the hole had not occurred Tests were conducted under the following conditions (1) with equal pressure on both sides of the firewall, (2) with a higher pressure on the flame side of the firewall, and (3) with a higher pressure on the side of the firewall opposite the flame

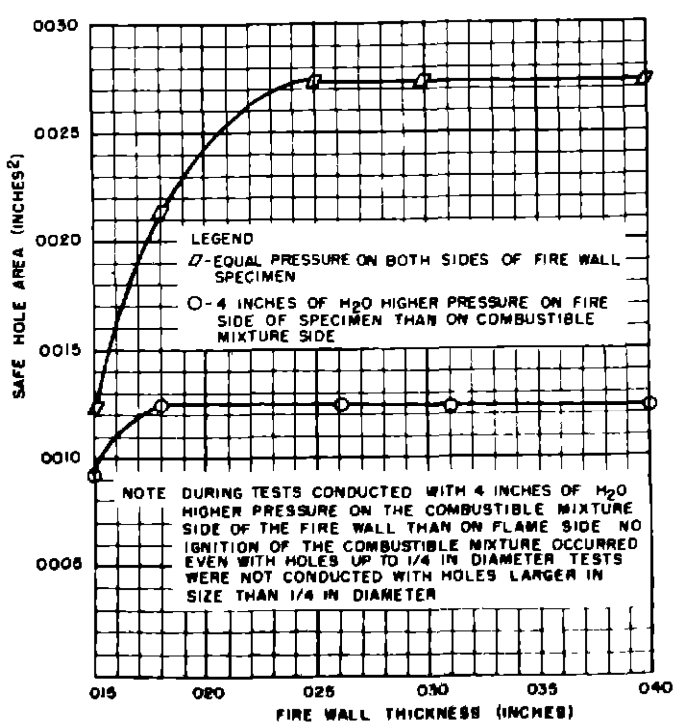

Fig 2 Effect of Material Thickness and Compartment Pressure Differential on Allowable Size of Holes in Firewalls

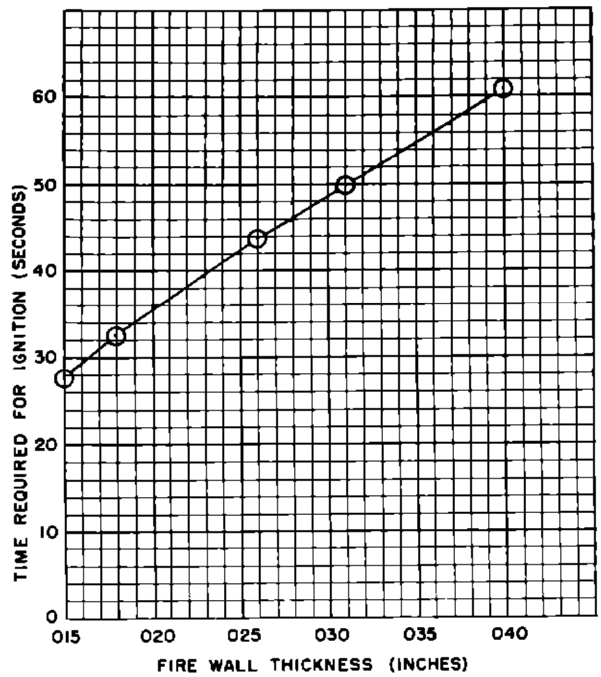

Fig. 3 Time Required for Hot Surface Ignition by Heat Conducted Through Firewall Versus Thickness of ST/ST Metal in Firewall

RESULTS

The results of the tests conducted with equal pressure on both sides of the firewall and with a higher pressure on the flame side of the firewall are shown in Fig. 2. Tests conducted with a pressure of 4 inches of water on the side of the firewall opposite the flame, that is, with the chamber pressurized, produced no ignition of the combustible mixture within the chamber with holes as large as 1/4-inch diameter (0 049-square inch) in the firewall The time required for hot surface ignition of the combustible in the chamber to occur after the torch was placed against the panels without holes, is shown plotted against panel thickness in Fig. 3. During the tests on the panels with holes too small to facilitate flame passage, hot surface ignition occurred after approximately the same period of flame exposure as experienced with the panels without holes

CONCLUSIONS

1. The test results indicate that only very small openings through a firewall can be tolerated if flame ignition through firewalls is to be avoided.

2. Increasing the thickness of firewall material from 0 025-inch to 0 040-inch did not increase the allowable hole size

3. A pressure differential across the firewalls had an appreciable influence on flame passage through holes in firewalls. Higher pressure on the flame side of the firewall assisted flame propagation and lower pressure hindered flame propagation.

4. Restriction of the size of holes in firewalls to a size that will prevent flame passage has only a limited advantage. At best, ignition is delayed until it occurs from the heated firewall surface. Under the conditions of the tests, this delay was less than one minute and was a function of the firewall thickness. Prevention of ignition for an extended period would require the use of firewall materials of low thermal conductivity