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FIRE RESISTANCE CHARACTERISTICS OF ASBESTOS BASE PHENOLIC IMPREGNATED MATERIALS FOR USE IN AIRCRAFT FIREWALLS

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FIRE RESISTANCE CHARACTERISTICS OF ASBESTOS BASE PHENOLIC IMPREGNATED MATERIALS FOR USE IN AIRCRAFT FIREWALLS

SUMMARY

Asbestos base, phenolic impregnated materials, suggested for use as aircraft firewalls, were tested in an airplane engine installation and in the laboratory for fire resistant characteristics. The three materials tested were not penetrated by gasoline flames of 1800° F. to 2000° F. for periods up to 30 minutes. However, in each instance the phenolic impregnation was driven from the asbestos base within ten minutes of the beginning of the fire. This resulted in vapor or smoke which was inflammable. In comparison, aluminum alloy sheet metal, 0.040 inches thick, subjected to a similar gasoline fire, disintegrated within 35 seconds of the fire start. A stainless steel firewall 0.018 inches thick was included in fire test engine installations and repeatedly withstood fires of 30 seconds duration.

INTRODUCTION

In an effort to relieve the metal shortage, the Army Air Forces requested the Civil Aeronautics Administration to investigate the use of asbestos base phenolic impregnated materials supplied by the Panelyte Corporation, to replace metal in aircraft firewalls. Accordingly, three such materials were subjected to conditions existing at an aircraft firewall during a powerplant fire in flight. The fire tests of these materials were conducted in an aircraft powerplant installation at the National Bureau of Standards and in the laboratory.

GENERAL TEST PROCEDURE

Simulated Flight Tests: A panel of material approximately 6 x 12 inches was built into a steel box in order that flame should impinge on one panel face only. The box containing the panel was then installed at the bottom of the firewall of the Waco airplane being tested. With the airplane engine developing cruising power and in the blast from a wind tunnel simulating forward motion of the airplane by furnishing an air speed of 60 miles per hour, each panel was subjected to a 3-1/2-gallon per minute gasoline fire. A view of such a fire is shown on Figure 1.

Chromel-alumel thermocouples were used to measure flame temperatures on the panel faces during the airplane and laboratory tests.

Laboratory Tests: In order that the effect of fire on the materials might be more easily and accurately observed, duplicate panels were bolted to a sheet steel mask. Use of the mask made certain that the test flame would impinge on only one face of the material, and made possible observation of the rear faces of the panels during tests. The flame used in the laboratory tests was produced by a gasoline blow-torch and varied between 1800° F. and 2000° F. As a comparative test a piece of 0.040 aluminum alloy sheet was subjected to a gasoline fire of 1800° F. in the laboratory.

Inasmuch as these tests were conducted only to determine the fire resistance of the materials provided, no attempts were made to determine the loss of strength due to temperature or the exact nature of the gases resulting from the breakdown of the phenolic impregnating materials.

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The three asbestos base, phenolic impregnated materials tested were:

1. Panelyte Regular 980 - 0.110 inches thick - consisting of three sheets of phenolic impregnated asbestos. (See Fig. 2A)

2. Panelyte Special 980 - 0.140 inches thick - consisting of five sheets of phenolic impregnated asbestos. (See Fig. 3A)

3. Panelyte 982 - 0.125 inches thick - consisting of four sheets of phenolic impregnated asbestos. (See Fig. 4A)

DETAILED TESTS AND RESULTS

Tests on Panelyte Regular 980

1. Panel tested in gasoline fire in airplane for one minute.

   The material blistered over the entire area of both faces, the blisters varying from 1/4-inch diameter to two inches diameter. Apparently the phenolic material vaporized and expanded and, being unable to escape, caused the blisters which tended to warp the panel. (See Fig. 2B)

2. Panel tested in gasoline fire in laboratory for five minutes:

   A large blister, including both faces, formed in the first 30 seconds which remained for the duration of the test. At the end of five minutes the panel was still in fairly good condition except for warpage due to the blister and some deterioration of the phenolic material on the face exposed to flame. As the phenolic material was driven from the exposed panel face, the flame impinging on the face became somewhat brighter and more agitated. Apparently the vapor from this face burned at the high flame temperature. At the same time, a vapor was driven from the non-exposed face. This vapor did not burn but appeared as a black, oily smoke. Fig. 2C shows the blistering of the exposed face.

3. Panel tested in gasoline fire in laboratory for ten minutes. In this test, the material was surrounded by flame

   The vapor was driven from both surfaces but burned, which made the flame brighter and more agitated. At the end of ten minutes little of the phenolic material remained. The panel was warped, blistered and the three thicknesses of asbestos were extremely brittle and could easily be separated. (See Fig. 2D)

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Tests on Panelyte Special 980

1. Panel tested in airplane in gasoline fire for one minute:

   No effect was apparent except the sooting of the panel surface exposed to the flame. (See Fig. 3B)

2. Panel tested in gasoline fire in laboratory for five minutes:

   At the end of the first minute the phenolic material began to vaporize from the unexposed face of the panel in the form of black oily smoke which did not ignite. At the end of five minutes the phenolic material from the exposed face had deteriorated slightly. There was no blistering or warping and the panel was in good condition. (See Fig. 3C)

3. Panel tested in gasoline fire in laboratory for 30 minutes. In this test the material was surrounded by flame:

   At the end of the first minute the phenolic material began to vaporize and apparently burned. At the end of 30 minutes, very little phenolic material remained but the five thicknesses of asbestos were intact. There was no evidence of warpage or blistering but the asbestos was brittle and the sheets easily separated. (See Fig. 3D)

Tests on Panelyte 982

1. Panel tested in airplane in gasoline fire for two minutes:

   The panel lost some of the phenolic material from the forward face and appeared slightly pockmarked. The panel was in good condition but had warped somewhat due to poor support at the edges. (See Fig. 4B)

2. Panel tested in gasoline fire in laboratory for one minute:

   Panel was in very good condition having lost very little of the phenolic impregnation. In the last few seconds of test a white vapor was driven from the unexposed face of the panel which proved inflammable. (See Fig. 4C)

3. Panel tested in gasoline fire in laboratory for two minutes to check the test in the airplane:

   Essentially the same result as in Test #1, except that there was no warping. This was due to the fact that the panel was correctly supported. During the second minute of the test a considerable volume of the inflammable white vapor was driven from the unexposed face of the panel. (See Fig. 4D)

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4. Panel tested in gasoline fire in laboratory for five minutes:

   At the end of one minute the vaporization of the phenolic material began. This inflammable white vapor continued until the end of 2-1/2 minutes. At the end of five minutes a little warpage was evident and a considerable amount of phenolic material had been removed from the center of the panel. (See Fig. 4E)

5. Panel tested in gasoline fire in laboratory for 30 minutes:

   Vapor was driven off as in the previous test, and it was impossible to keep the vapor from igniting under the test conditions. At the end of 7-1/2 minutes, all the phenolic material had been driven from the panel. There was no apparent change in the remaining 22-1/2 minutes. After 30 minutes the four layers of asbestos were somewhat warped and brittle. (See Fig. 4F)

DISCUSSION

The flame temperatures used in these tests were based on surveys* of accessory section temperatures attained during gasoline fires. The tests showed that all three materials tested would withstand fires up to 2000° F. for periods of 30 minutes and possibly longer. The tests also showed that the phenolic materials were driven from the asbestos base in each instance within ten minutes of the start of the test fires.

*A. W. Dallas and H. L. Hansberry, "Determination of Means to Safeguard Aircraft From Powerplant Fires in Flight," Civil Aeronautics Administration, Technical Development Report No. 34, January 1942.

Section B-B, Figure 97 of the above report indicates that flame temperatures at the firewall may vary between 1600° F. and 2100° F. However, these figures represent the maximum temperatures attained during a series of accessory section gasoline fires at the particular locations shown. In any single fire the temperatures immediately forward of the firewall may vary from 300° F. to 2100° F. due to stratification of accessory section fires. (See Figures 97 to 105.) Thus, it is possible that a considerable expanse of firewall would not be subjected to temperatures as high as those used in the tests but such temperatures will exist over some areas.

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The white vapor driven from Panelyte 982 apparently was more susceptible to ignition than the black oily smoke driven from Panelyte Regular 980 and Special 980. Firewalls made of Panelyte 982 would have to be much tighter than firewalls of the other two materials due to ease of ignition of gas resulting from the breakdown of this particular phenolic.

It is believed that a firewall of sufficient fire resistance could be developed using one or two sheets of asbestos impregnated material, but including the phenolic used in Panelyte Special 980 material.

Panelyte Regular 980 material warped within 30 seconds of the start of the test fires because of the fact that the phenolic material between the layers of asbestos broke down due to heat, but the resulting gas was prevented from escaping by the thick phenolic on both surfaces. Expansion of the gas thus produced, separated the asbestos sheets and considerably warped the panel. This action of the phenolic material was not observed in either the Panelyte Special 980 or the Panelyte 982.

In order to demonstrate the severity of the test fires a small piece of 0.040 inches thick aluminum alloy, used in some firewalls, was subjected to a gasoline test fire of 1800° F. The aluminum alloy sheet disintegrated within 35 seconds of the start of the fire.

CONCLUSIONS

1. Panelyte Regular 980, Panelyte Special 980 and Panelyte 982 can withstand gasoline fires (1800° F. to 2000° F.) for periods in excess of 30 minutes.

2. The phenolic impregnation used in the three materials is driven off by flame temperatures of 1800° F. to 2000° F. within ten minutes.

3. Panelyte Special 980 and Panelyte 982 were in fair condition after five minutes of exposure to the test fire. Panelyte Regular 980 warped appreciably after 30 seconds exposure to the test fire.

4. Inflammable vapor was driven from all three materials, during the test fires. The vapor from Panelyte 982 material was more susceptible to ignition than the vapor from Panelyte Regular 980 and Panelyte Special 980.

5. In comparison, aluminum alloy sheet metal, 0.040 inches thick, subjected to a gasoline fire of 1800° F., disintegrated within 35 seconds of the start of the fire, whereas a stainless steel firewall 0.018 inches thick, included in the engine installation used in this investigation, repeatedly withstood fires of 30 seconds duration.

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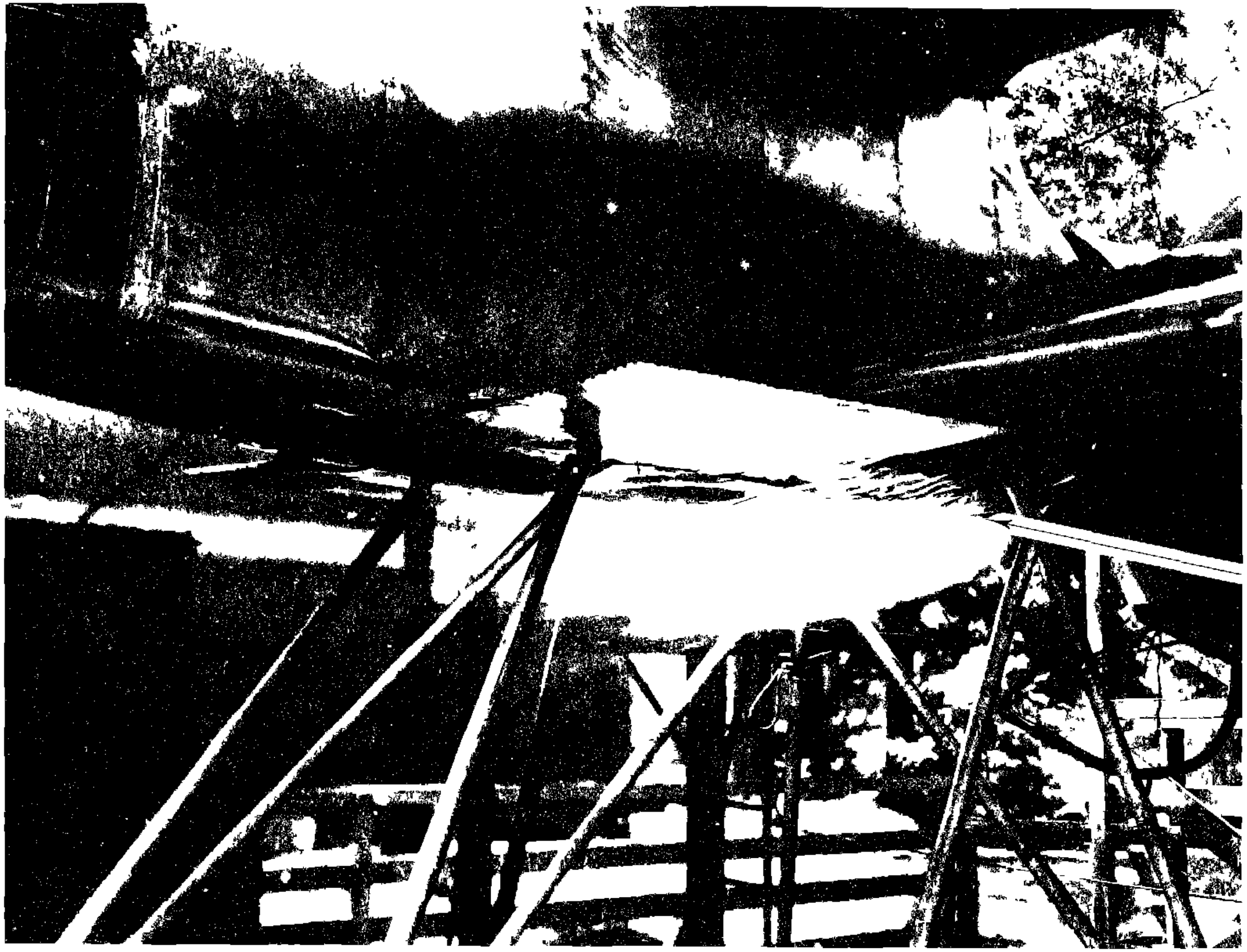


FIGURE 1. ACCESSORY SECTION GASOLINE FIRE
(Arrow indicates location of test panel used in these tests)

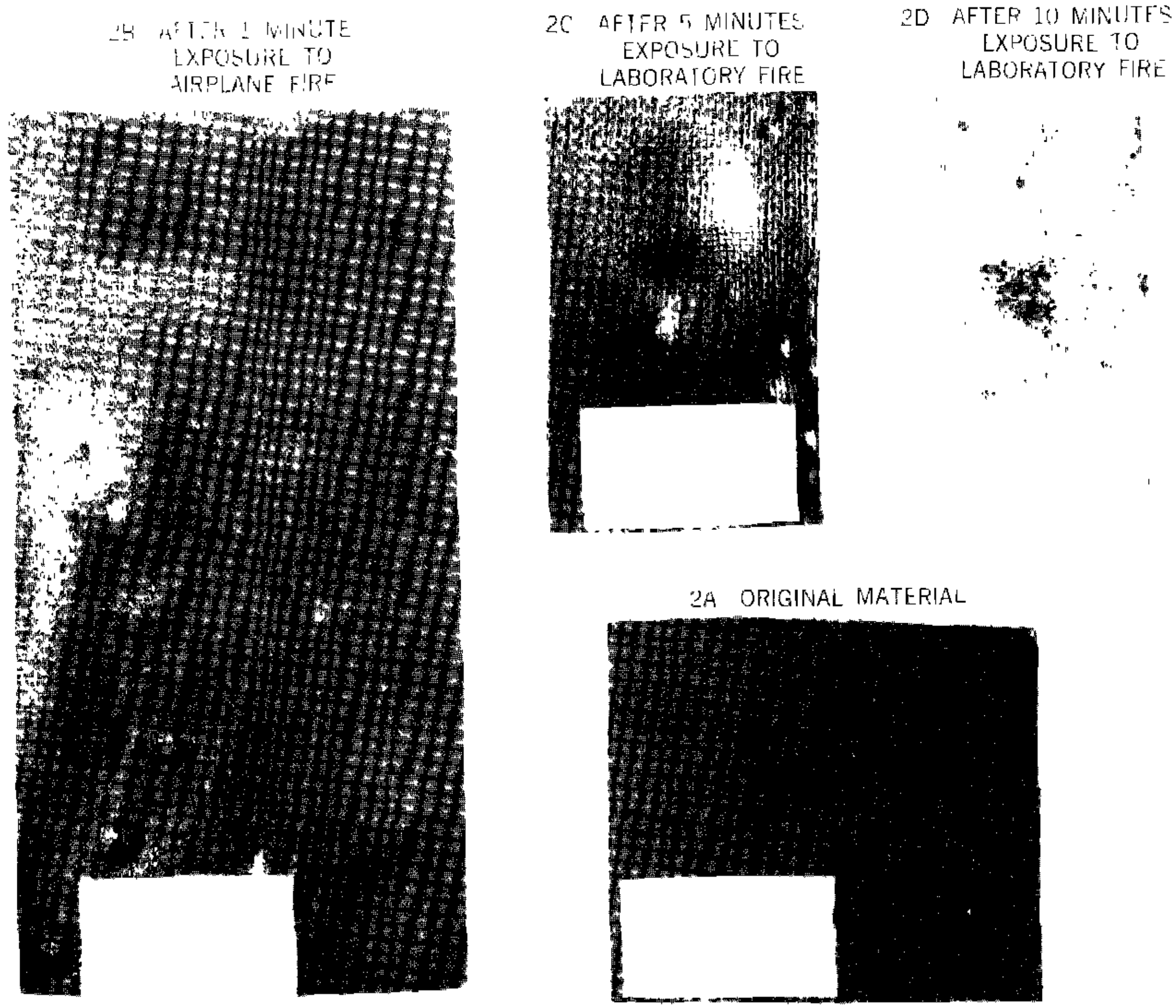


FIGURE 2. PANELYTE REGULAR 980 MATERIAL

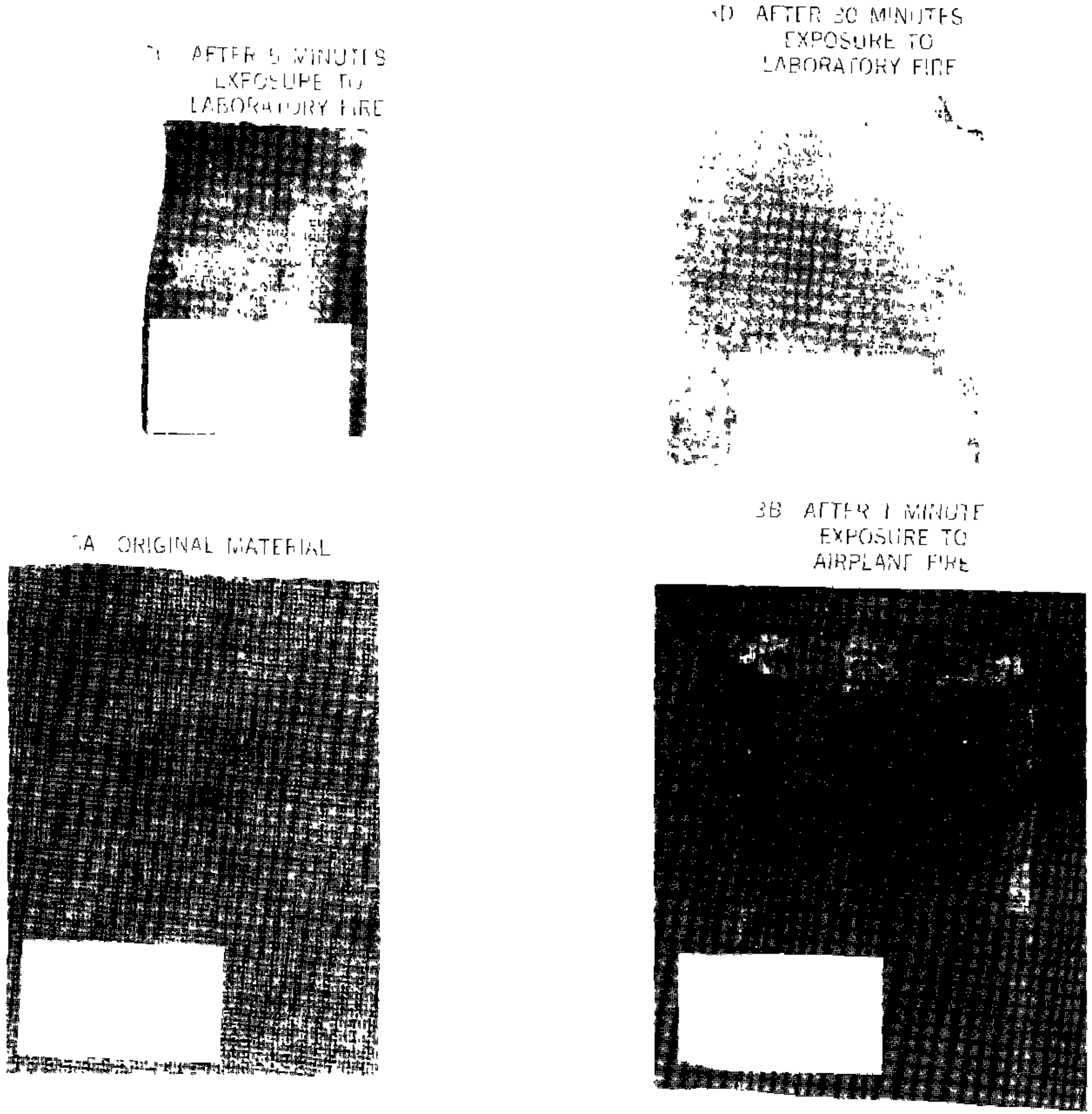
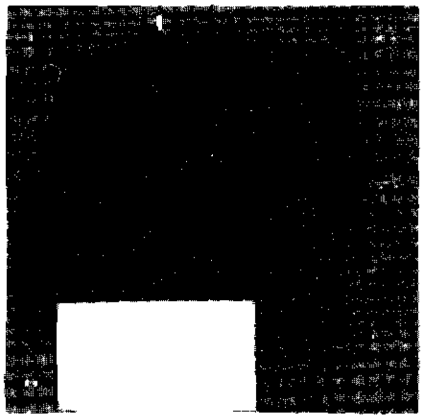
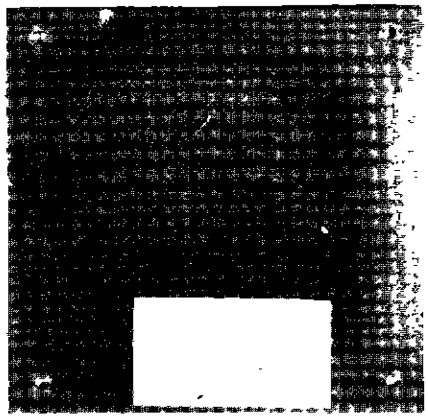


FIGURE 3. PANELYTE SPECIAL 980 MATERIAL

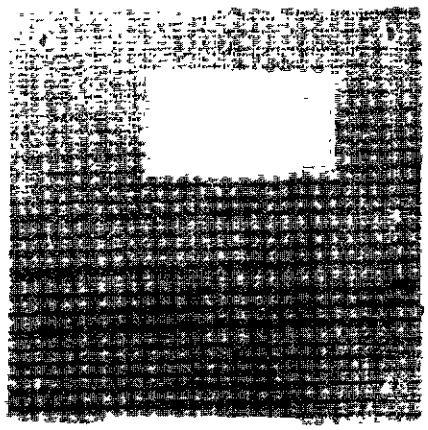
4B AFTER 2 MINUTES EXPOSURE
TO AIRPLANE FIRE



4D AFTER 2 MINUTES
EXPOSURE TO
LABORATORY FIRE



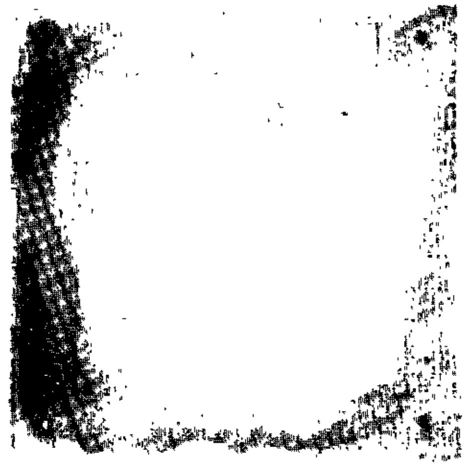
4C AFTER 1 MINUTE
EXPOSURE TO
LABORATORY FIRE



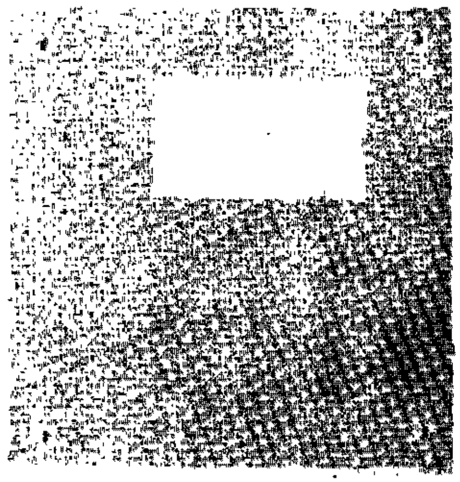
4A ORIGINAL MATERIAL

FIGURE 4. PANELYTE 982 MATERIAL

4E AFTER 5 MINUTES EXPOSURE TO LABORATORY FIRE



4F AFTER 30 MINUTES EXPOSURE TO LABORATORY FIRE



2A ORIGINAL MATERIAL

FIGURE 4 (Continued) PANELYTE 982 MATERIAL