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Burnthrough Resistance of Aluminum Ceiling Panels in A Simulated Class D Cargo Compartment

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16. Abstract

This report contains the results of a full-scale fire test in a simulated class D cargo compartment. Suitcases were used for the fire load. Cardboard boxes representing approximately 35 percent of the compartments volume were placed in the test article to displace air but were not involved in the fire. Aluminum panels, 1/8-inch thick, were installed in the ceiling, directly above the point of ignition. The fire melted through the aluminum panels after approximately 11 minutes and consequently, the fire was not contained or suppressed through oxygen starvation.

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EXECUTIVE SUMMARY

This report contains the results of a fire test performed in a simulated class D cargo compartment. This work was performed to verify the results of small-scale testing of aluminum panels used as cargo lining material. The small-scale testing utilized the new test method described in Notice of Proposed Rulemaking (NPRM) 84-11. The new test is more severe than existing flammability requirements and uses a 2-gallon per hour kerosene burner that subjects the cargo liners to temperatures of 1700° Fahrenheit (F) and heat flux levels of 8.0 Btu/ft^2-sec. Using this new test method, it was determined that aluminum panels must be at least 1/4-inch thick to pass the test. The full-scale test used 1/8-inch thick aluminum panels in the ceiling of the test article and a fire load similar to the type used in previous full-scale class D and class C cargo fire tests. The test fire melted through the aluminum ceiling in approximately eleven minutes and consequently the fire was not contained or suppressed through oxygen starvation.

INTRODUCTION

PURPOSE.

The purpose of this report is to present the results of a cargo fire test in a simulated class D cargo compartment test article fitted with an aluminum ceiling liner.

BACKGROUND.

Full-scale fire testing has previously been conducted on simulated class D and class C cargo compartments (references 1 and 2). This work concluded that these cargo compartments can effectively control cargo fires, provided that the lining material remains relatively intact. Another conclusion from this work was that the bunsen burner tests specified in FAR 25.853 and 25.855 for cargo liners do not adequately measure the lining materials ability to resist burnthrough. Based on this, a new, more severe, fire test method has been proposed for cargo lining materials (reference 3). This proposed test method utilizes a kerosene burner and subjects the lining material to temperatures of 1700° Fahrenheit (F) and heat flux levels of 8.0 Btu/ft^2-sec for 5 minutes. A variety of cargo lining materials were subjected to this proposed test method and the results reported in reference 4. Subsequent to this evaluation, aluminum panels were tested using the proposed test method. These tests determined that the aluminum must be at least 0.25 inch-thick to pass the new test. A full-scale test evaluation of an aluminum ceiling liner was conducted to verify the kerosene burner results.

DISCUSSION

TEST ARTICLE.

The test article was a converted school bus with an interior volume of 640 cubic feet. A drop ceiling was installed 1 foot below the top of the bus. This ceiling consisted mainly of sheet metal, except for two aluminum panels, measuring 2 feet by 4 feet each and 1/8-inch thick, which were installed directly over where the fire was to be ignited. A fan was mounted on the front of the bus above the drop ceiling. It was used to draw air from an opening in the rear of the bus, through the area between the drop ceiling and the top of the tests article and out the front. This fan was calibrated at 260 cubic feet per minute (ft^3/min) and simulated the path of cabin air around the cargo compartment on its way to overboard exhaust valves. Another fan was mounted on the forward bulkhead and forced air into the simulated cargo compartment area. This fan was calibrated to deliver approximately 23 ft^3/min into the test article. This was the maximum allowable leakage rate for this size class D cargo compartment. This leakage rate was based on the formula that the sum of the compartment volume in cubic feet and the leakage rate in cubic feet per hour ft^3/h must be less than 2000.

The test article was loaded with cardboard boxes that filled approximately 35 percent of the compartments volume. These boxes were used to displace the air in the test article and were not involved in the fire. The fire load for the test consisted of ten suitcases filled with clothes and piled on top of the boxes.

The fire was ignited in a small gym bag filled with rags, newspaper, matches, and one quart methyl alcohol and placed on top of the suitcases. This bag was approximately 8 inches below the aluminum ceiling panels. The bag was ignited by passing a current through a length of Nichrome wire imbedded in the bag. Figure 1 shows the test article and the position of the fire load.

INSTRUMENTATION.

Twenty-four chromel-alumel thermocouples were used in the test article. A thermocouple tree consisting of six thermocouples at varying heights was positioned near the center of the test article. Six thermocouples were installed in the middle third of the test article in the area between the drop ceiling and the top of the bus. These thermocouples were used to determine the time of burnthrough, if it occurred. Nine thermocouples were installed in a uniform pattern on the aluminum ceiling panels. The remaining three thermocouples were installed on the sidewall adjacent to the aluminum panels, approximately 6 inches below the drop ceiling.

A smoke meter was installed just below ceiling level in the forward section of the test article. It consisted of a collimated light beam incident on a photocell placed one meter away.

The oxygen concentration inside the test article was monitored using a Beckman OM-11 oxygen analyzer. The sampling point was on the sidewall 1 foot below ceiling level near the center of the test article. Ambient air was assumed to contain 21 percent oxygen.

The test was visually recorded using a low-light level, black and white video camera. The camera viewed the fire through a window in the bulkhead installed in the front of the test article. Thirty-five millimeter photographs were also taken after the test.

All data channels were fed through an analog-to-digital converter and stored on the fixed disk of a Data General mini-computer. The millivolt data were later converted to engineering units and automatically plotted. Figure 2 shows the instrumentation used for the test.

TEST RESULTS.

The fire was ignited by passing a current through resistance wire placed inside the gym bag. Both the above ceiling fan and the cargo compartment fan were operated for the entire test. Approximately 11 minutes after ignition, thick smoke was observed in the flow of air coming from the above ceiling fan. This indicated that the aluminum ceiling panels had melted through at about that time and smoke from the cargo compartment was drawn through the resulting hole. The test was terminated after 25 minutes when a window in the test article shattered due to the heat. Figure 3 shows the oxygen concentration in the test article. The concentration varied between approximately 7 and 15 percent as the fire cycled between smoldering and flaming combustion. The fire was not reduced to a smoldering state because fresh air was entrained through the hole in the aluminum ceiling panel. Figure 4 gives an indication of how the temperature in the test article varies with height. The thermocouple near the ceiling reached a peak of approximately 1000° F while the thermocouple near the floor only measured a high of 170° F. Figure 5 shows the temperature measured just below the aluminum ceiling panels. The temperature remained fairly constant between 1400° and 1500° F for the first 20 minutes of the test before dropping off. Figure 6 is a plot of the temperature measured by a thermocouple attached to the upper sidewall, adjacent to the fire source. This thermocouple measured a peak temperature of approximately 1300° F. Figure 7 shows the thermocouple trace that produced the highest temperature measured above the aluminum ceiling panels. This thermocouple showed a sharp rise in temperature at approximately 11 minutes into the test. This indicates that burnthrough occured at about that time. The highest temperature measured above the ceiling was 775° F. Figure 8 shows the resulting hole in the aluminum panel after the test.

REFERENCES

1. Blake, D. R. and Hill, R. G., Fire Containment Characteristics of Aircraft Class D Cargo Compartment, FAA/CT-82/156, 1983.

2. Blake, D. R., Suppression and Control of Class C Cargo Compartment Fires, FAA/CT-84/21, 1985.

3. Brown, L. J. and Cole, C. R., A Laboratory Test for Evaluating the Fire Containment Characteristics of Aircraft Class D Cargo Compartment Lining Material, FAA/CT-83/44, 1983.

4. Blake, D., An Evaluation of the Burnthrough Resistance of Cargo Lining Materials, FAA/CT-TN85/11, 1985.

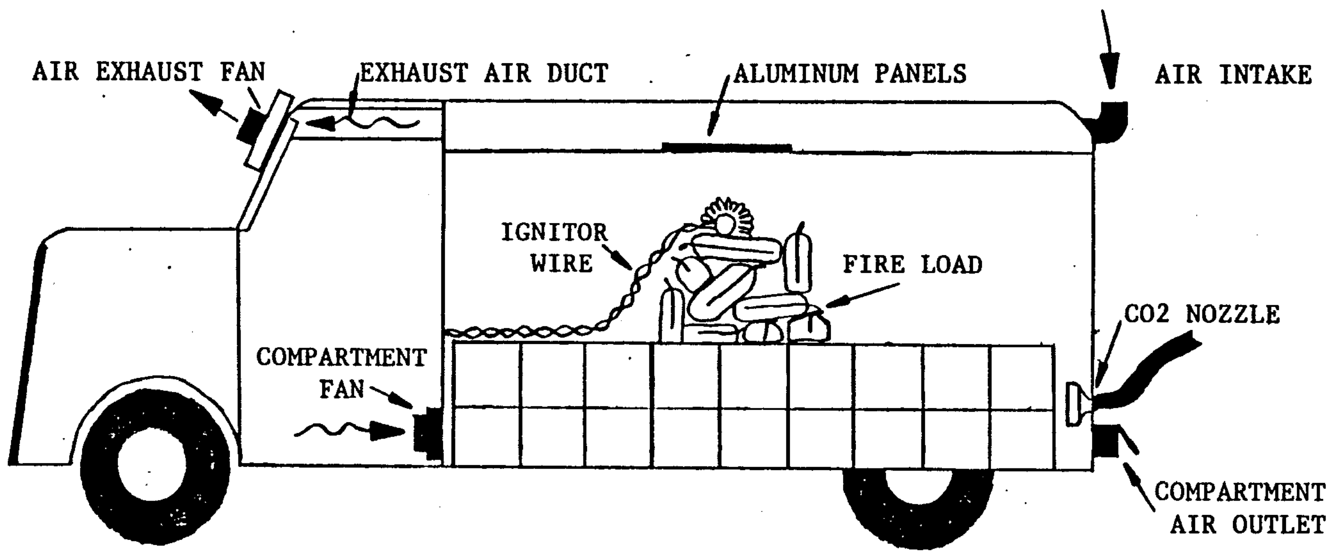
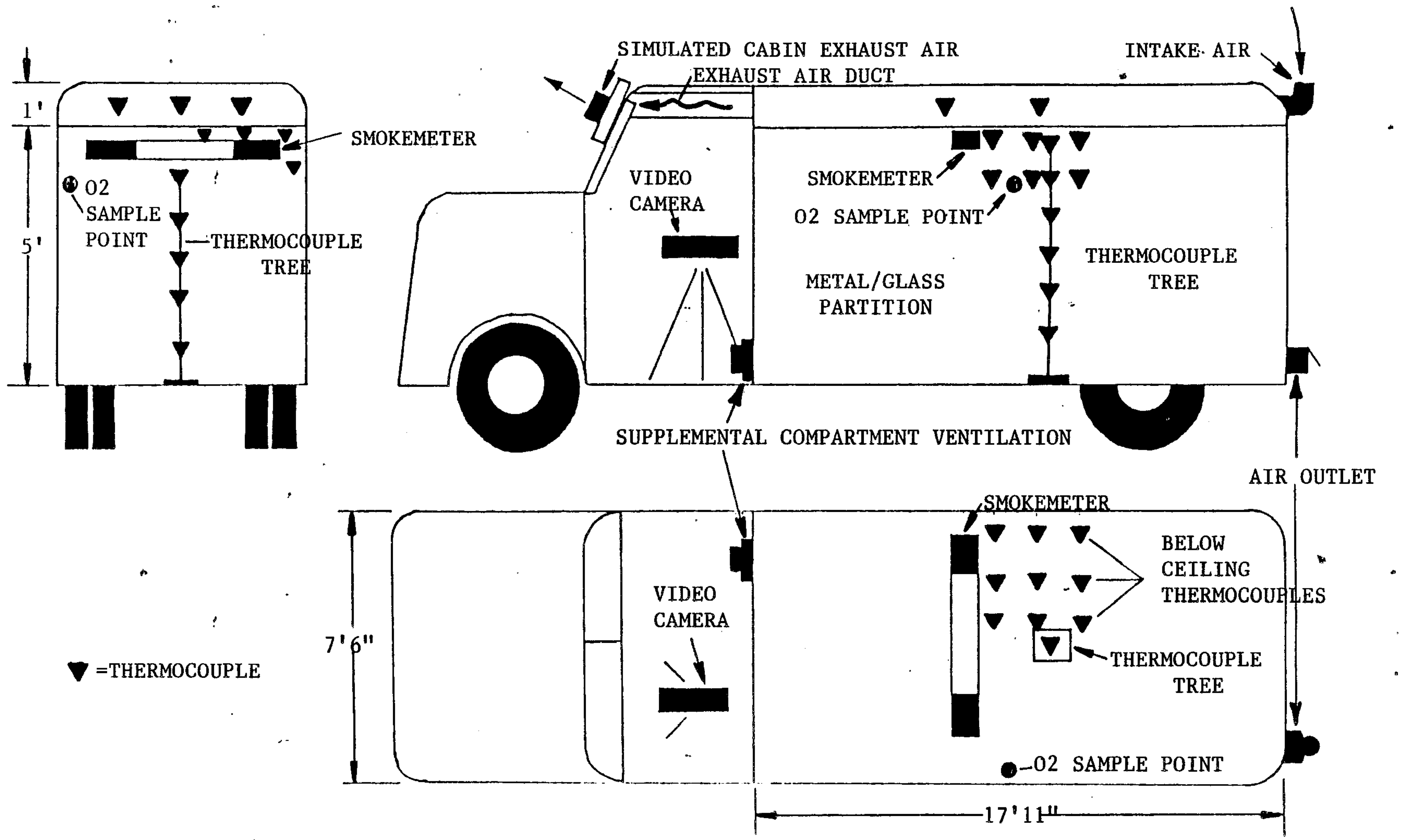


FIGURE 1. SIDE VIEW OF TEST ARTICLE



(NOT TO SCALE)

FIGURE 2. TEST ARTICLE INSTRUMENTATION

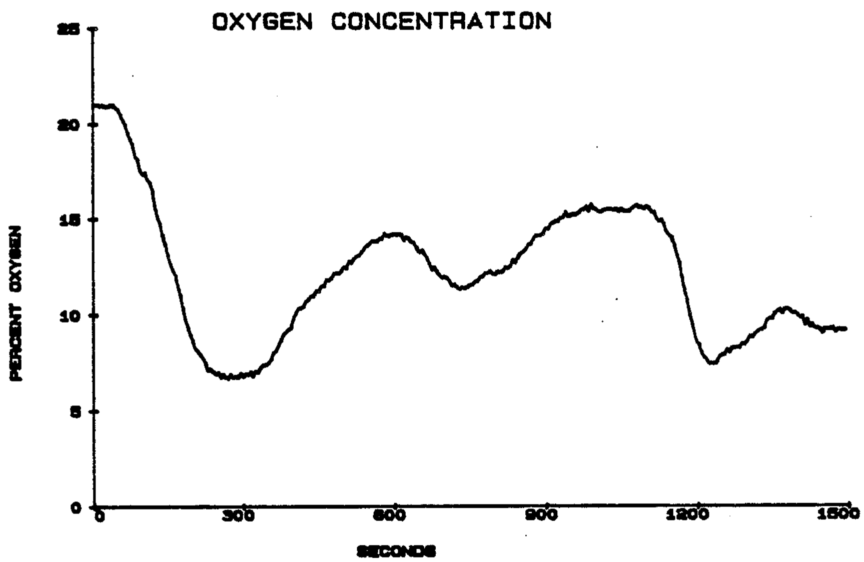


FIGURE 3. OXYGEN CONCENTRATION

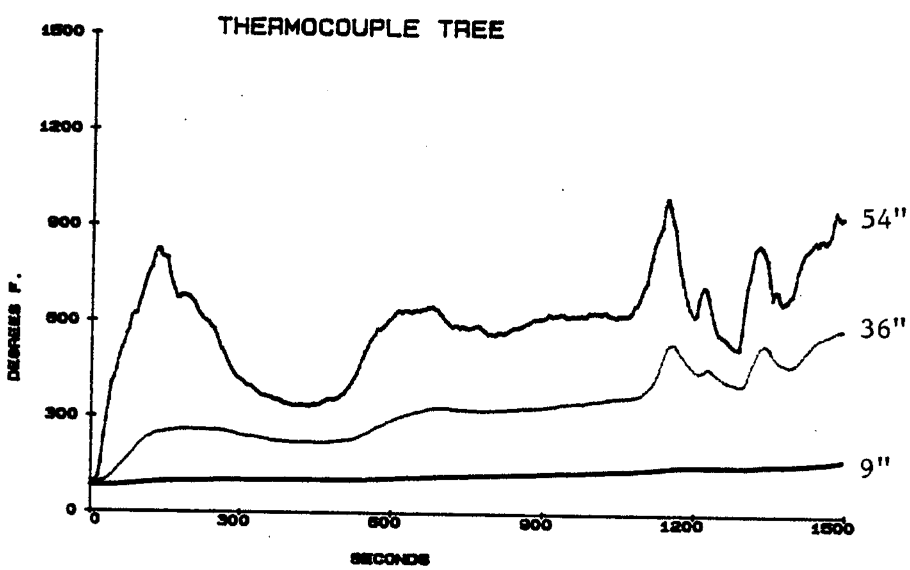


FIGURE 4. THERMOCOUPLE TREE

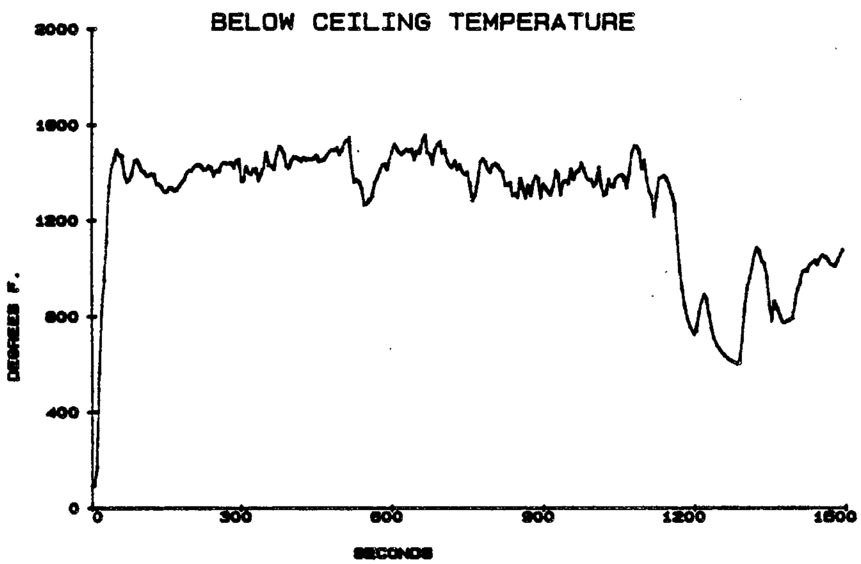


FIGURE 5. BELOW CEILING TEMPERATURE

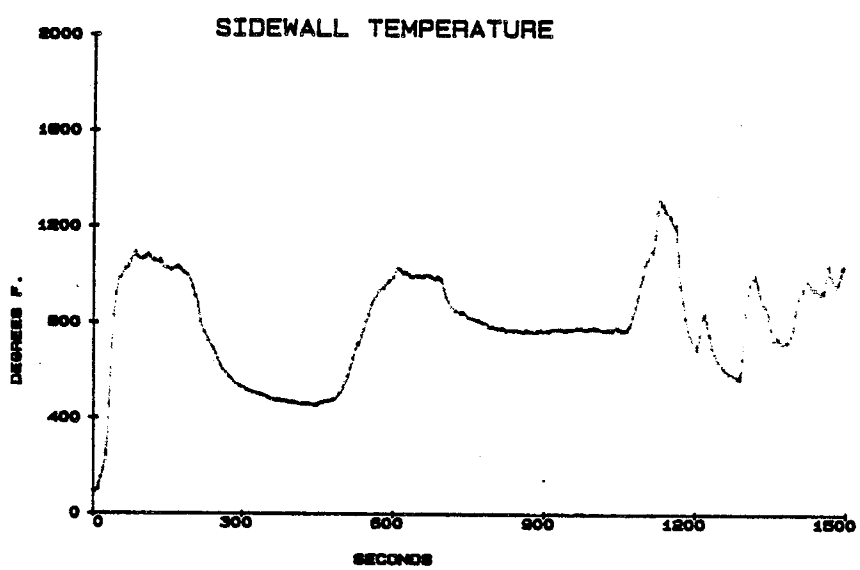


FIGURE 6. SIDEWALL TEMPERATURE

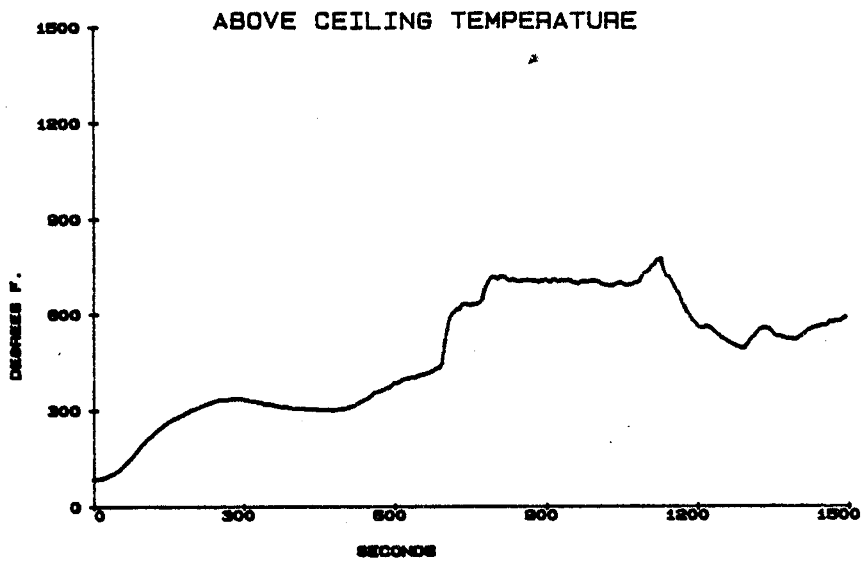


FIGURE 7. ABOVE CEILING TEMPERATURE

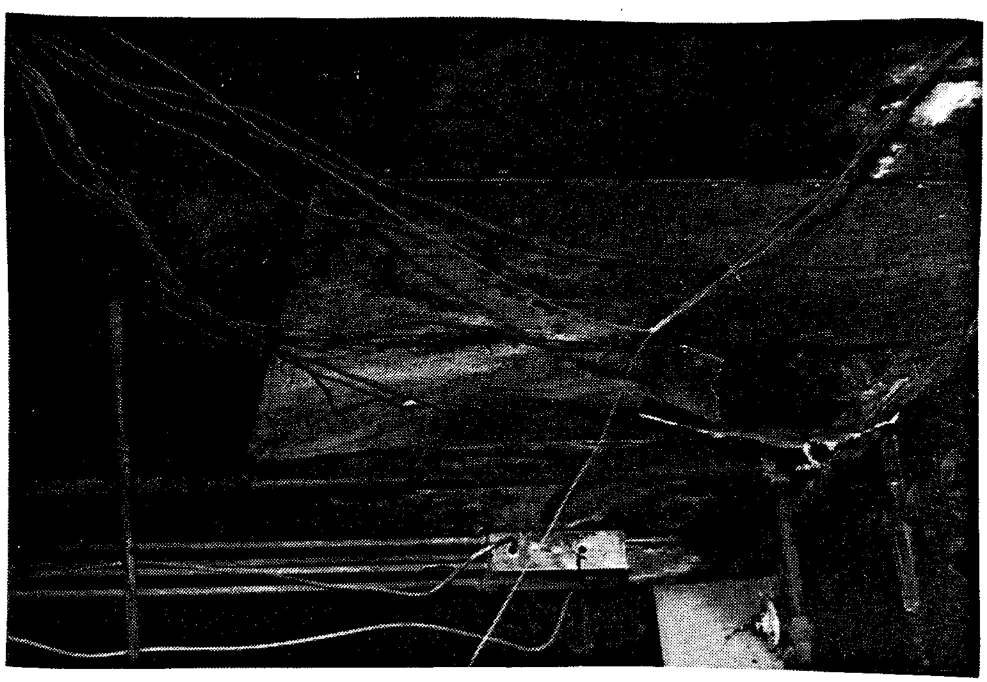


FIGURE 8. ALUMINUM PANELS AFTER TEST