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Burnthrough Test Procedures for Cargo Liner Design Features

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16. Abstract

Tests were conducted on the cargo liner burnthrough apparatus simulating the design features of actual cargo liners. The design features include joints, seams, fastening systems, corners, and a light fixture. Due to geometric constraints, many of these design features cannot be readily tested in the prescribed cargo liner test rig, and therefore a standardized method of testing has been developed.

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EXECUTIVE SUMMARY

Fire burnthrough testing of cargo liner design features in the 2-gallon-per-hour burner, as prescribed in Federal Aviation Regulation (FAR) 25.857, effective June 16, 1986, presents several difficulties. Presently, the rule only describes the test procedure for a flat 16- by 24-inch panel, as there is no provision for testing seams, joints, fastening systems, lighting fixtures and corners which in most cases will not fit the 16- by 24-inch test rig. Moreover, the location of the design feature (once it is mounted in the test rig) relative to the burner flame will dictate the severity of exposure and affect the likelihood of failure. It is recommended that testing such design features should fall under any one of three basic test configurations.

When testing joints and seams, they should be positioned longitudinally in the ceiling sample holder centered over the burner cone. If the seam or joint is located in the sidewall of the actual cargo liner (in either a horizontal or vertical orientation), it should be tested in the longitudinal position of the sidewall sample holder 2 inches below the sidewall top. The intensity of the burner flame along the sidewall holder is most intense here (reference 1). All fastening systems should be tested similarly.

When testing corners, the test rig can be altered slightly to accommodate this design feature. The corner should be positioned in the test rig as it normally is in service. This will require the removal of the angle iron on the back corner of the rig.

When testing lighting fixtures or pressure relief valves, any material forming the fire barrier should be tested as a flat sheet in the ceiling or sidewall position (depending on actual location of fixture in service) and treated as a liner.

INTRODUCTION

PURPOSE.

The purpose of this report is to present the results of various burnthrough tests performed on several cargo liner design features such as joints, seams, fasteners, corners, and fixtures and to prepare a standardized test procedure for these particular systems as they pertain to Federal Aviation Regulation (FAR) 25.857.

BACKGROUND.

Cargo liner fire testing, as per FAR 25.857, effective June 16, 1986, prescribes the use of a 2-gallon-per-hour kerosene burner in which test specimens are subject to flame impingement for 5 minutes (reference 2). Specimens are required to resist flame penetration and the peak temperature measured at 4 inches above the horizontal sample may not exceed 400 degrees Fahrenheit (°F). As stated in the FAR, "Each specimen tested must simulate the cargo compartment sidewall or ceiling liner panel, including design features such as joints, lamp assemblies, etc., the failure of which would affect the capability of the liner to safely contain a fire." Problems occur with the testing of certain design features as they cannot fit in the test apparatus due to its size. For this reason, several tests have been performed on various design features in order to establish a standardized testing method in which the existing test rig can be used with little or no modification.

DISCUSSION

TEST APPARATUS.

Several tests were run simulating actual cargo liner systems. These included a series of joints, seams, and fastening systems in both the ceiling and sidewall positions, and a corner test. When dealing with design features such as recessed lighting fixtures or pressure relief valves, it is recommended that the material comprising the fire barrier be tested as a flat sheet in either the ceiling or sidewall position (depending on the position of the actual fixture as it is in service). This will represent the most severe condition that the design feature will encounter. To further illustrate this point, a lighting fixture was constructed using both aluminum and a previously tested burnthrough resistant honeycomb cargo liner material and positioned over the burner cone in the sample holder (figure 1). The maximum temperatures recorded directly above the aluminum section of the fixture were 231 °F, 271 °F, and 226 °F on thermocouples 1, 2, and 3, respectively. Although the fixture collapsed partially during the test, neither the aluminum or honeycomb liner burned through. Next, a flat aluminum sheet of the same thickness as that comprising the fire barrier of the lighting fixture was tested (0.125 inch). As expected, the aluminum burned through in 4 minutes 20 seconds. This proved that burnthrough is dependent on the distance to the burner cone. It is therefore recommended that fixtures be tested as flat sheets in order to evaluate the worst case condition and simplify the test procedure.

In the series of tests involving seams/joints and fasteners, configurations were first tested in the ceiling position, longitudinally centered in the test fixture. This was followed by two sets of tests with the seams longitudinally centered over the burner cone, as well as laterally centered over the burner cone (figure 2). The seams consist of aluminum face strips fastened with rivets spaced 3.5 inches apart, using Conolite® (BMS 8-2A) liner material of 0.013-inch thickness. The liner was overlapped the width of the strip. In an effort to monitor the activities of the seam during the test and to help determine which of these configurations represented the worst case condition (lateral or longitudinal), three thermocouples were positioned 4 inches above the seam at various points (figure 3). The lateral versus longitudinal tests are summarized in table 1.

In a similar fashion, a seam configuration was tested in the sidewall position, 2 inches from the ceiling (figure 4). As stated earlier, previous tests show that the flame impingement on the sidewall is most intense here (see reference 1). Next, a corner mockup was tested which involved the slight modification of the burner apparatus (figure 5). The corner mockup was similar to the type used in the Airbus A320 (figure 6).

TEST RESULTS.

Test 1: Since Conolite (BMS 8-2A) was used extensively during the tests, a baseline temperature was obtained using a sheet of this liner in the ceiling position with Kaowool® blocking on the sidewall. The panel did not burn through and reached a maximum temperature of 298 °F at 4 inches above the center of the sample.

Test 2: A longitudinal seam consisting of an aluminum face strip with aluminum rivets spaced 3.5 inches apart was centered in the sample holder. Conolite was used as the liner with Kaowool blocking in the sidewall position. The face strip melted away within 1 minute 30 seconds, but no flames penetrated the seam as the maximum temperature reached 266 °F at 4 inches above the center of the sample.

Test 3: Next two seams were tested; the first being centered over the burner cone in a longitudinal fashion followed by one mounted in a lateral fashion, each consisting of the identical aluminum face strip and rivets. The face strip melted within 1 minute 30 seconds in both tests, but no flames penetrated the seam. The temperatures reached a maximum of 262.6 °F, 322.3 F, and 246.9 °F on thermocouples 1, 2, and 3, respectively, during the longitudinal test, while the temperatures reached a maximum of 257.7 °F, 263.7 °F and 230.4 °F on thermocouples 1, 2, and 3, respectively, during the lateral test (table 1).

Test 4: In an effort to consistently show that the longitudinal orientation is a more severe case then the lateral, test 3 was repeated. In a similar fashion, the face strip melted within 1 minute 30 seconds in both cases. Although no flames penetrated the seams, the configuration utilizing the longitudinal seam sustained greater damage and sagging since it possessed more unsupported length along the seam in the absence of the face strip. The resulting temperatures also support this observation, as they reached a maximum of 191.1 °F, 211.3 °F and 269.6 °F on thermocouples 1, 2, and 3, respectively, for the longitudinal case, and only 221.4 °F, 227.1 °F, and 197.4 °F on the respective thermocouples for the lateral case (table 1). Inconsistencies in the maximum temperatures obtained during the longitudinal test can be attributed to the behavior of the seam; i.e., warpage may be greater in one area than another, allowing higher temperatures.

Test 5: A longitudinal seam identical in previous tests in construction was run in the sidewall position, 2 inches from the top. The face strip melted away within 1 minute 15 seconds, however, no flames penetrated the seam. Kaowool blocking was used in place of the ceiling panel. The temperature reached 149 °F maximum at 4 inches above the center of the ceiling panel.

Test 6: A honeycomb panel used by Messerschmitt Bolkow Bolm was run in the ceiling position to establish a baseline for tests using this material. The panel did not burn through, reaching a maximum temperature of 212 °F.

Test 7: A corner structure was tested in a slightly modified test rig. The structure was similar to the type used on the Airbus A320, using honeycomb panels in the top and sidewall positions with a 0.050-inch aluminum sheet in the corner. The aluminum sheet warped badly during the test allowing flames to pass on the backface of both the top and sidewall panels (which did not burn through). The temperature reached 212 °F during the test.

CONCLUSIONS

To summarize, cargo liner design features, such as recessed lighting fixtures and pressure relief valves, should be tested as flat sheets because tests have shown that this configuration produces the worst case condition that the fixture could likely encounter. Seams, joints and fasteners in the ceiling position should be centered over the burner cone, running longitudinally. The tests have shown this to be a more severe condition, from a burnthrough standpoint, than positioning the seam laterally in the test fixture. The seam tends to have less support in the longitudinal fashion, resulting in more sagging and separation of the sample, possibly allowing flames to pass between the rivet spacings. A longitudinal seam will also receive 11 inches of burner flame as compared to 6 inches of flame for a laterally positioned seam.

Similarly, the sidewall seam or joint positioned 2 inches from the top will represent the worst case condition, as the flame is most severe at this point.

In order for a liner system to safely contain a fire, it is recommended that the design features meet the previously described test methods. By using these guidelines, the design features can be categorized and tested accordingly, using the existing burner apparatus with little or no modification.

REFERENCES

1. Marker, T., A Comparison of Propane and Kerosene Burners for Cargo Compartment Burnthrough Testing, FAA/CT-TN87/45, November 1987.

2. Airworthiness Standards; Fire Protection Requirements for Cargo or Baggage Compartments; Federal Register, Volume 5, No. 95, pp, 18236-18247, May 16, 1986.

TABLE I. LATERAL VERSUS LONGITUDINAL TEST RESULTS

TEST #3

CONDITION	LONGITUDINAL			LATERAL		
	#1	#2	#3	#1	#2	#3
Max Temps F	262.6	322.3	246.9	257.7	263.7	230.4
Max Average F		277.3			250.6	
Average Temps F	197.3	214.2	218.5	217.1	217.2	191.3
Overall Ave F		210.0			208.5	

TEST #4

CONDITION	LONGITUDINAL			LATERAL		
	#1	#2	#3	#1	#2	#3
Max Temps F	191.1	211.3	269.6	221.4	227.1	197.4
Max Average F		224.0			215.3	
Average Temps F	166.3	186.4	230.3	189.5	189.9	176.1
Overall Ave F		194.3			185.2	

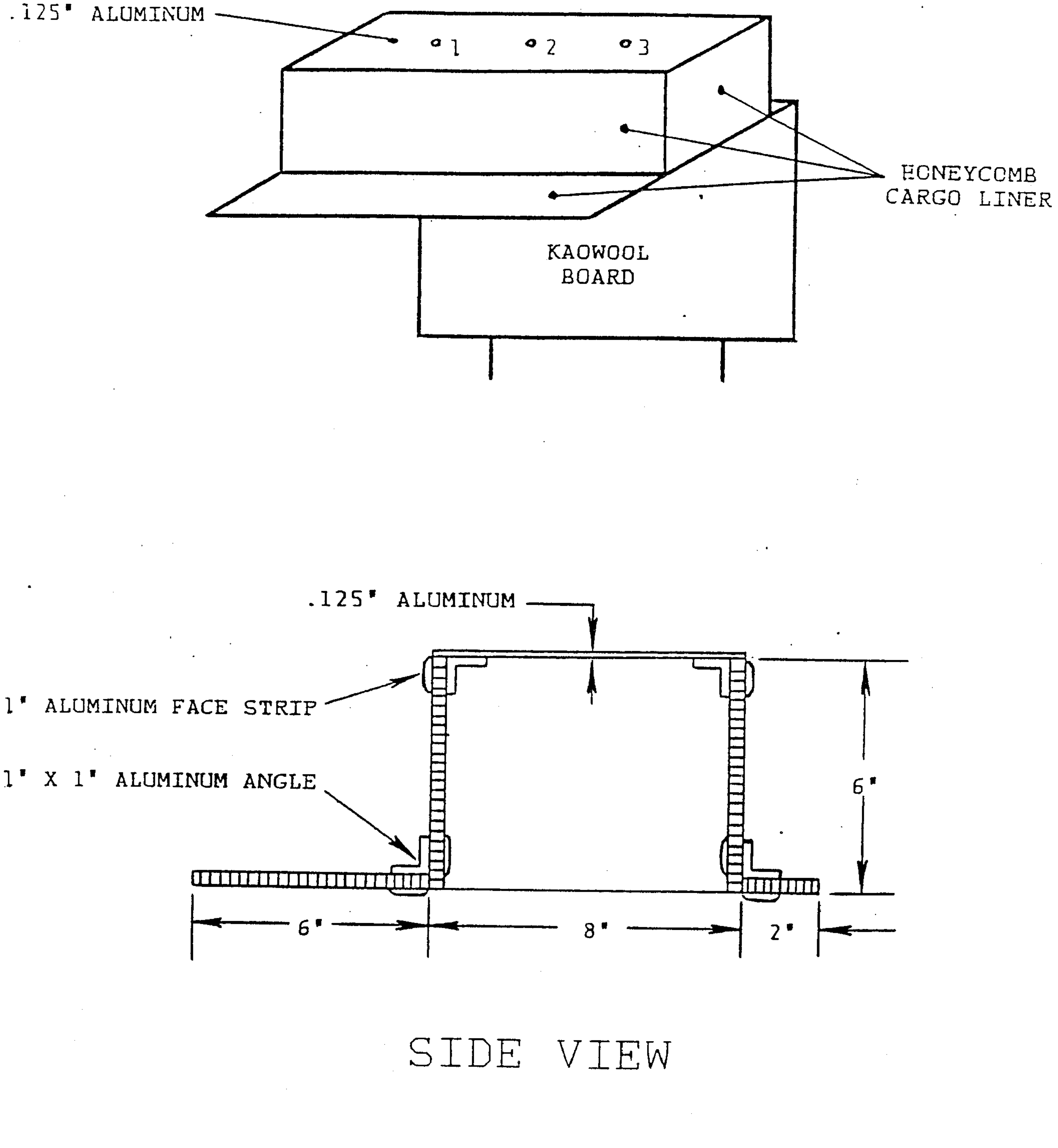


FIGURE 1. SIMULATED LIGHT FIXTURE

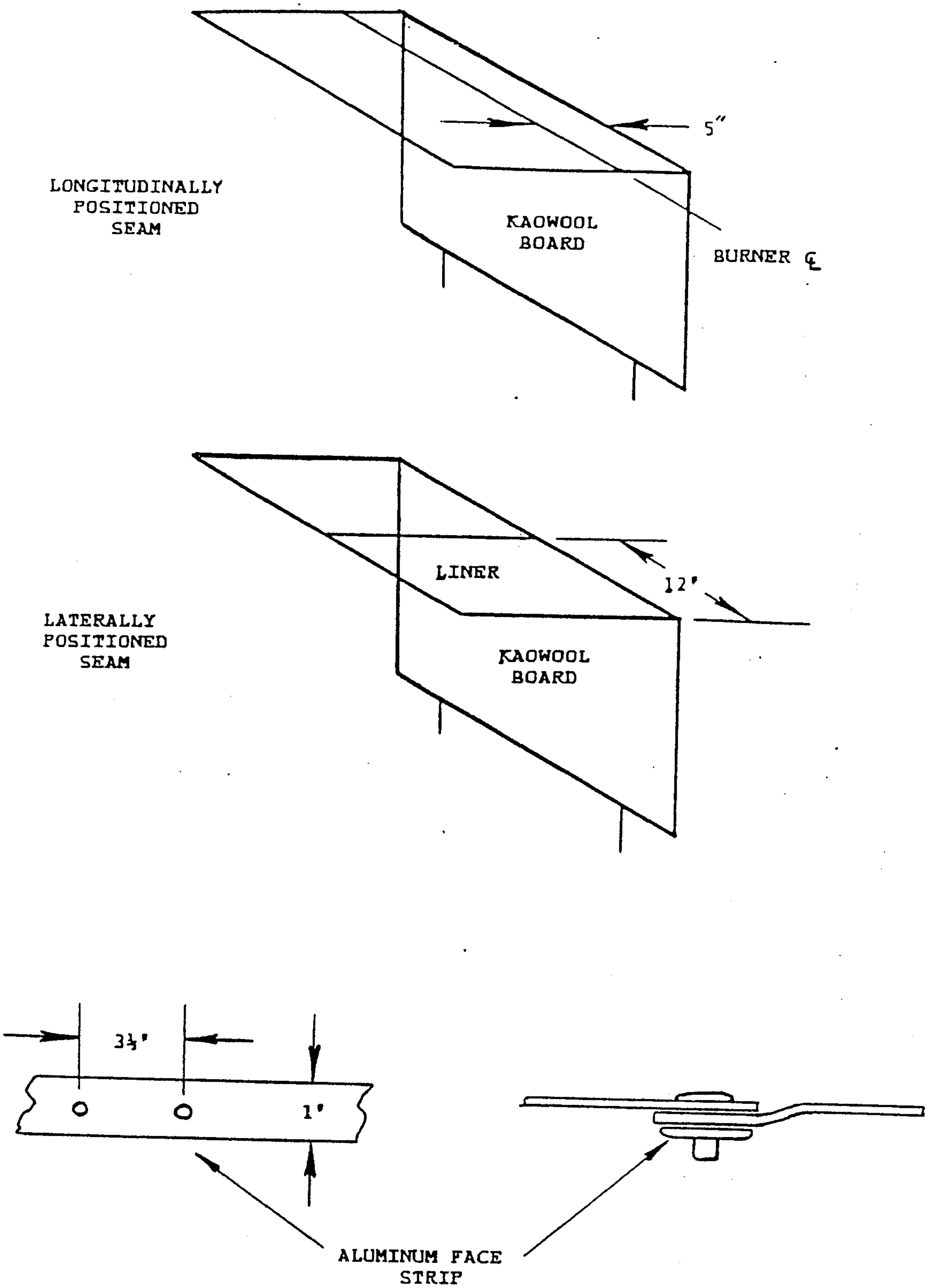
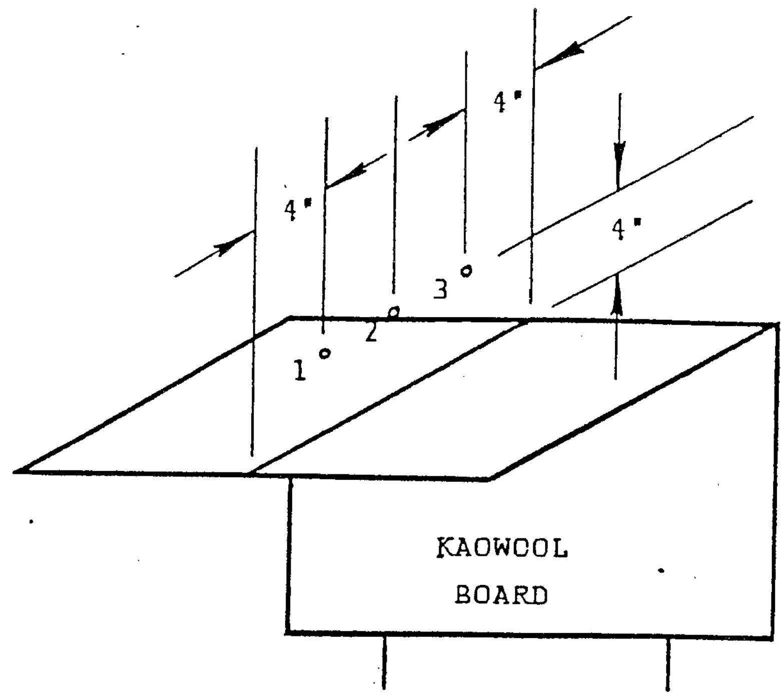
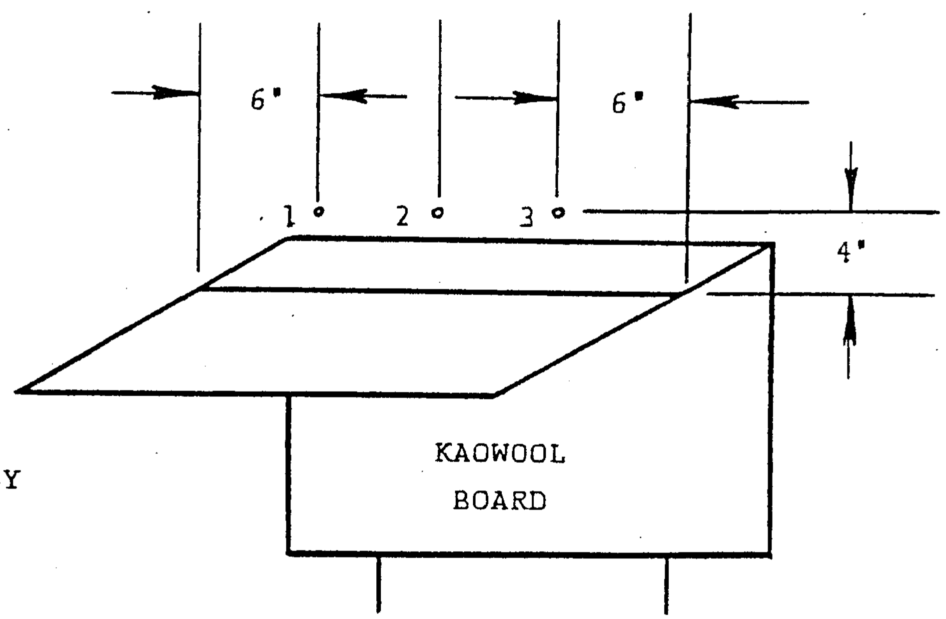


FIGURE 2. CEILING POSITIONED SEAMS



LATERALLY
POSITIONED
SEAM



LONGITUDINALLY
POSITIONED
SEAM

FIGURE 3. THERMOCOUPLE POSITIONING FOR SEAMS

SIDEWALL SEAM

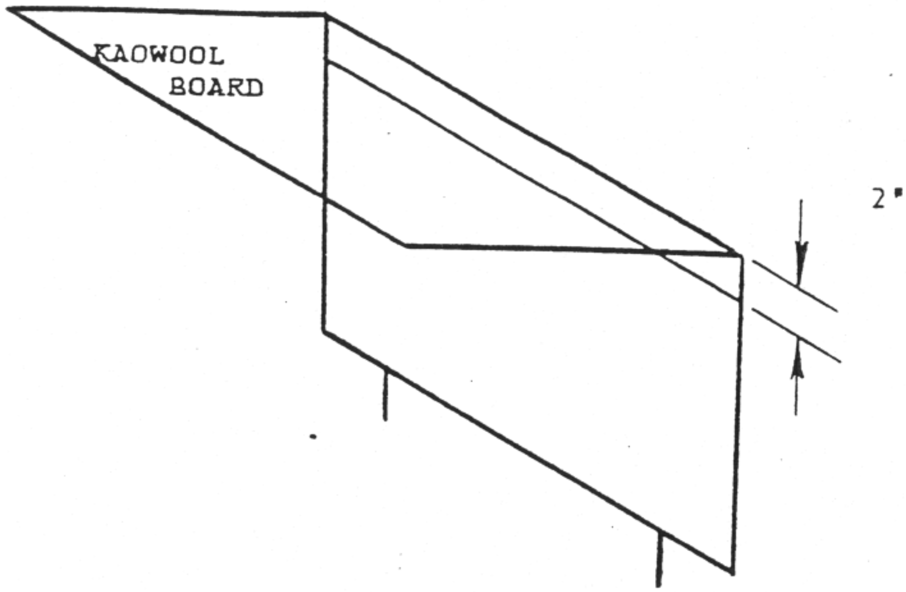


FIGURE 4. SIDEWALL SEAM

CORNER TEST APPARATUS

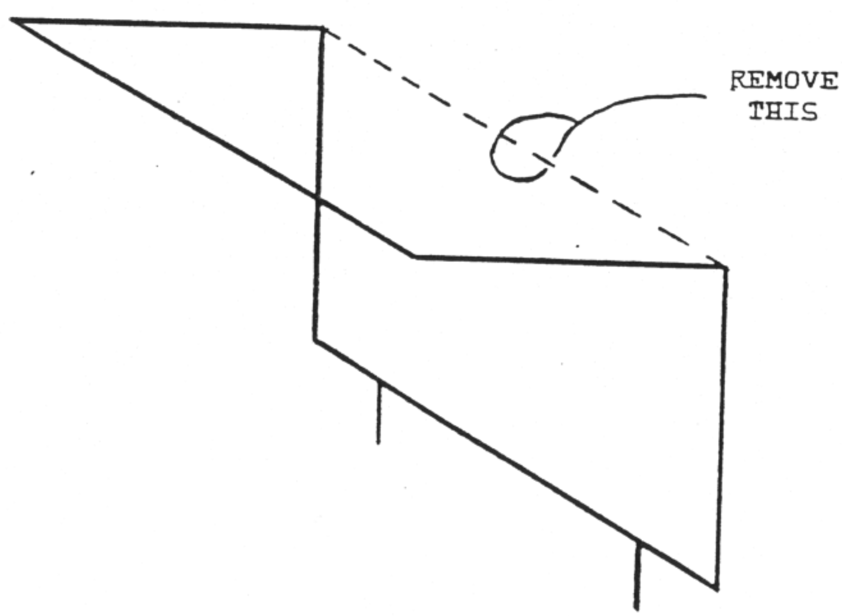


FIGURE 5. CORNER TEST APPARATUS

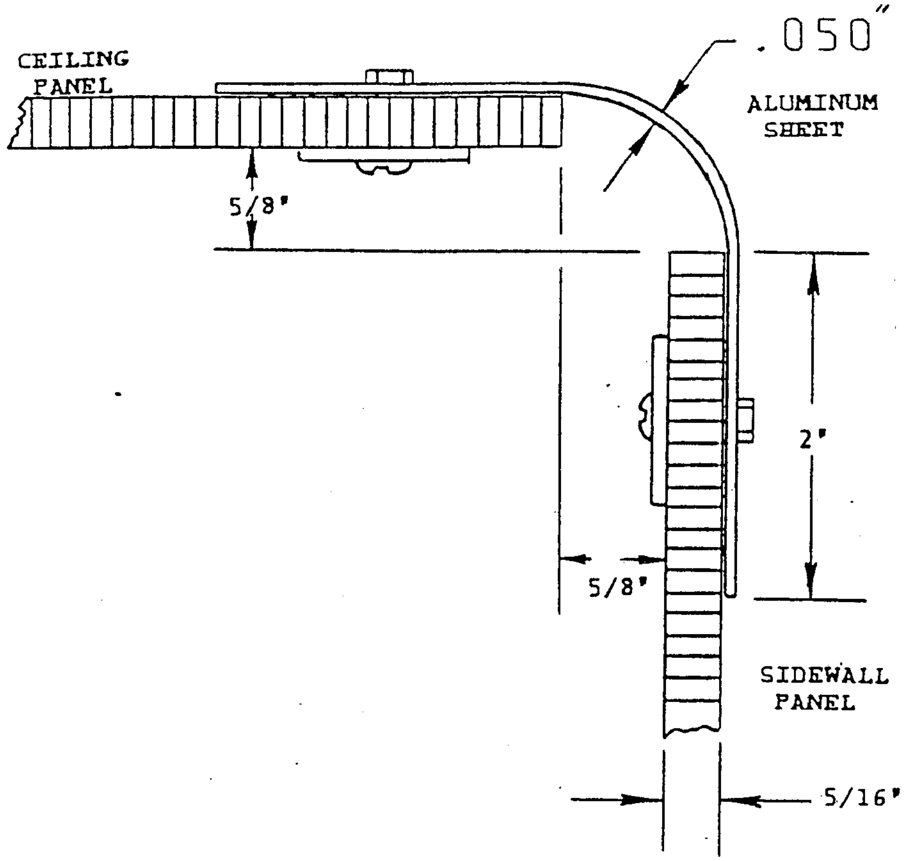


FIGURE 6. TYPICAL AIRBUS CORNER FIXTURE