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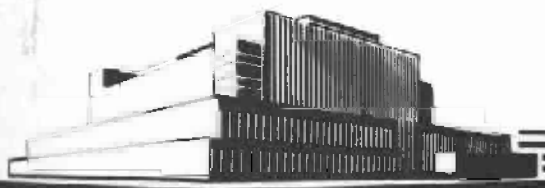

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

EVALUATION OF FLAME-SPREAD RESISTANCE OF FIBER INSULATION BOARDS

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Knowledge of the behavior of fiber insulation boards used as interior finish when they are exposed to fires of varied intensities and severities, is of interest to many users of such materials. Also of concern is information on the effectiveness of fire-retarding coatings in reducing flame spread on such boards.

During the past several years the Forest Products Laboratory, in cooperation with the Technical Committee of the Insulation Board Institute, has conducted studies with the objective of obtaining information in this field. The purpose of this publication is to record the results of flame-spread-resistance tests that have been made and in which laboratory-scale test methods have been used.

Methods of Test

The three principal methods of test used and the reasons for their selections were:

1. The horizontal-panel fire test prescribed in Federal Specification SS-A-118a for "slow-burning classification."

This method, although developed for testing acoustical materials, has in recent years been used for testing other sheet building materials such as insulation board and plywood. (For example, Federal Specification JAN-P-66, Plywood, Flat Panel, prescribed this method for testing fire-retardant-treated plywood.) It is under consideration for adoption by some building-code authorities as a test method for evaluating the resistance of interior finish to flame spread.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

2. The vertical-panel fire test designated as the "mild" Schlyter test.

The modification of the original test developed by Schlyter[2] and designated by this Laboratory as the "mild" Schlyter test has been used extensively for evaluating the effectiveness of fire-retarding coatings applied to plywood. A considerable amount of test data has been accumulated with this method, which has proved satisfactory for application to coated plywood. It offered promise as a test method for insulation boards.

3. The inclined-panel fire test, which is a modification of the fire test in British Standard Specification No. 476 (Test of Non-Inflammability of Materials).

When various known methods of measuring flame spread were reviewed, the flame-spread procedure prescribed in British Standard Specification 476 appeared to have good possibilities as a rapid, simple method for determining differences in flame-spread characteristics of coated insulation boards. A large number of preliminary tests made in accordance with the procedure specified and with various modifications of this procedure confirmed the possibilities of the method, since the area of char developed by the igniting flame seemed to offer a satisfactory quantitative means for measuring flame-spread resistance. It was found desirable, however, to modify the original method in the following three respects: (a) The size of the specimen was increased from 6 inches square to 1 foot to make it possible to obtain greater variations in area of char in boards of different properties; (b) the amount of fuel was increased from 0.3 to 1.0 cubic centimeter to increase the severity of exposure; and (c) the preliminary conditioning of the specimen was changed from an oven-dry treatment to a conditioning at 50 percent relative humidity and at a temperature of 75° F. to enable the test specimen to have a moisture content similar to what it would have under normal use conditions.

Details of Test Procedures

The details of the test procedures used were as follows:

1. Horizontal-Panel Fire Test Conducted by the Method Prescribed in Federal Specification SS-A-118a for "Slow Burning" Classification

Apparatus.--The apparatus used in making the horizontal-panel fire test consisted of the following:

A square frame was constructed of 2- by 2- by 1/8-inch steel angle irons to form a clear opening of 30 by 30 inches. Four angle-iron legs supported

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[2] Meddelande 66, Statens Provningsanstalt, Stockholm. "Av Statens Provningsanstalt Godkanda Byggnadskonstruktioner I De Olika Brandterniska Klasserna," by Ragnar Schlyter. 1935.

the angle-iron frame in a horizontal position with the flat side uppermost for reception of the test specimen. A chromel-alumel thermocouple made of No. 8 (B and S gage) wire and in the form of a 3-inch-diameter horizontal coil was placed 1 inch below the center of the specimen. The wires were bared for a distance of 2 inches from the junction. Other items of equipment included:

A 36- x 36-inch square of 1/2-inch-thick soft asbestos board.

A 36- x 36- x 2-1/2-inch concrete slab provided with a lifting ring.

A hoist for raising and lowering the concrete slab.

A 3/4-inch gas-air burner. In most of the tests the burner used was the Imperial Brass Manufacturing Company's (Chicago) gas-air blow torch with a gas nozzle of 29/32-inch inside diameter and an air nozzle of 9/32-inch inside diameter. In some tests a hand-made burner of an aspirated type was used.

A portable air compressor for supplying air to the blow torch.

A potentiometer calibrated for use with a chromel-alumel thermocouple and capable of recording temperatures to 1,800° F.

A suitable timing apparatus.

The assembled apparatus is shown in figure 1.

Specimen.--The board specimens were 36 by 36 inches, cut at random from sample sheets supplied by the cooperator.

Most specimens were conditioned at a relative humidity of 50 percent and at a temperature of 75° F. before testing, although a few were conditioned at a relative humidity of 30 percent at 80° F.

Test Procedure.--The specimen was placed on top of the frame with the surface to be exposed to the fire facing downward, the asbestos square was laid on top of the specimen, and the concrete slab was lowered upon the sheet asbestos. The burner was located so that its flame was directed at the center of the lower surface of the specimen, and the height of the burner was adjusted so that its top was 28-3/4 inches below the lower surface of the specimen. After the burner was lighted the flame was regulated to produce temperatures that followed the American Society for Testing Materials standard time-temperature curve (A.S.T.M. E119-47). The flame was adjusted during the test so that it would touch the specimen during at least the last 13 minutes of the 20-minute test exposure, but would at no time cover a greater area on the specimen than a circle 8 inches in diameter.

A record was made of the temperature at 1-minute intervals, of the time that ignition occurred, of the time that flames reached the frame, of

the duration of flaming subsequent to the removal of the igniting flame after the 20-minute exposure, and of the presence of smoke or glow after flaming on the panel ceased. To insure adequate observations of flame spread two observers were employed, one to measure flame spread in the north-south direction and the other the spread in the east-west direction. For possible use in correlation studies, observations were recorded at half-minute intervals. About 10 minutes after the burner flame was extinguished, the specimen was removed from the apparatus. If any glow was present, as indicated by smoking, it was extinguished and the panel was set aside for subsequent photographing.

2. Vertical-Panel Fire Test, Designated as the "Mild" Schlyter Test

Apparatus.--The apparatus used in making the vertical-panel fire test consisted of the test assembly, a suitable gas burner, facilities for regulating the supply of gas to the burner, and a scale for measuring the height of flaming on the assembly.

Test Assembly.--Two test panels were arranged with their long axes in an upright position in such a manner that the test surfaces were parallel and facing each other 2 inches apart, with the bottom of one offset in the vertical direction, 4 inches above the bottom of the other. The distance of 2 inches was maintained between the test surfaces by asbestos-board separators nailed to the edges of the test panels. A wood prop clamped near the edge of one of the panels made the assembly self-supporting.

A scale for measuring the height of flame during the test was mounted at one side of the assembly so that the graduations were visible between the two panels when viewed from the opposite side.

Igniting Burner.--A low-form Bunsen burner fitted with a wing tip was used.

The apparatus and burner used in this test are shown in figure 2.

Specimen.--Each of the pair of specimen panels used in the assembly for the modified Schlyter test measured 12 inches in width by 31 inches in length. They were cut at random from the sample boards furnished by the cooperator and were conditioned to equilibrium at a relative humidity of 30 percent and at a temperature of 80° F. before testing.

Test Procedure.--The air ports of the Bunsen burner were adjusted to produce a yellow flame when city gas (at 520 B.t.u. per cubic foot) was burned at the rate of 8.5 cubic feet per hour. The burner was placed on a 2-inch-thick block of wood and was quickly inserted between the panels, midway between the edges and the faces and with the gas slot of the wing tip at right angles to the faces.

The height of the flame on the panels was recorded immediately at the start of the test and at 15-second intervals thereafter. After 3 minutes of exposure, the burner was removed.

A record was made of the time after removal of the burner at which (a) the flaming had been reduced to widely scattered small flames of less than 1 inch and (b) all flaming ceased. Recordings of flame height were continued for as long as 3 minutes after removal of the burner, at which time any flames were extinguished. In those cases where strong flaming developed during the flame-exposure period and continued unabated after the burner was removed, the test was stopped at an earlier period. No record was made of the persistence of glow.

Spread of flame was reported as the difference between the maximum and the initial heights of the flame recorded. The principal criterion used in this test method for evaluating the effectiveness of a coating is the average flame spread developed during the 3 minutes of exposure to the igniting flame. This average is obtained by dividing the total of the flame-spread values recorded at 1/4-minute intervals by the number of readings taken (12). A record of the appearance of the burned surfaces was usually preserved in photographs.

3. Inclined-Panel Fire Test, A Modification of the Flame-Spread Test Prescribed in British Standard Specification No. 476, Test of Non-Inflammability of Materials

Apparatus.--The apparatus for the inclined-panel fire test consisted of (a) a metal stand with four upright prongs for supporting the specimen so that its major plane was at an angle of 45° and two of its edges were horizontal; (b) a suitable pedestal for supporting the cup containing the igniting fuel; (c) a suitable pipette for measuring the alcohol; and (d) a flat-bottomed cylindrical steel cup for holding the igniting alcohol, the dimensions of which were 11/16 inch in outside diameter, 9/32 inch in height, and 1/32 inch in wall thickness. The apparatus is shown in figure 3.

Specimen.--The specimens were 1 foot square, cut at random from sample sheets supplied by the cooperator. All were conditioned at a relative humidity of 50 percent and at a temperature of 75° F.

Test Procedure.--The height of the support for the igniting cup was adjusted so that the center of the cup base was 1 inch vertically below the lower face of the specimen. One cubic centimeter of absolute alcohol was then pipetted into the cup. The previously weighed test specimen was placed on the tips of the four rods with its vertical center line over the center of the alcohol cup and its lower edge resting against the supports of the shorter rods. The alcohol was ignited with a match or spark. Recordings were made of the time the flame reached the upper edge of the test specimen, the time the alcohol flame burned

out, and the time flaming continued on the test specimen after the igniting flame disappeared. If the specimen was burning at 1 minute after the alcohol flame had gone out, the flame was extinquished by mechanical means. The specimen was weighed immediately. Any visible glow was extinguished with water. The charred portion was traced on thin paper, and its area was determined either by a planimeter or by transferring the tracing of the outline of the charred area to cross-section paper (100 squares per square inch) and counting the squares. In case of doubt as to whether portions of the specimen were actually charred or merely discolored by smoke, thin sections (approximately 1/64-inch thick) of the questionable portion were removed by a sharp-edged instrument to reveal the line of demarcation between charred and uncharred areas.

Materials

The type of fiber insulating board on which flame-spread tests were made is that known to the trade as interior board, building board, or fiber wallboard. Products such as insulation-board lath and sheathing, which are not used as interior finish, were not included in the flame-spread studies.

In order to determine whether any difference existed in the flame-spread properties of various insulating interior boards now being manufactured, a number of such boards, furnished by the cooperator, were tested by the inclined-panel test. A list of these boards, together with density and factory-finish data, is given in table 1. After the initial tests had been completed, the more detailed tests on treatments that followed were made on two or three types of boards, which represented (1) those comparatively difficult to protect against flame spread with fire-retardant coatings and (2) those comparatively easy to protect.

Discussion of Results of Tests

First Series of Tests

The only method used for determining the flame-spread characteristics of the 20 different boards as submitted and coated with monoammonium phosphate was the inclined-panel test. In this series the ammonium phosphate was applied as a 25 percent aqueous solution containing a wetting agent. The results of these tests are summarized in table 2.

Several performance characteristics were indicated by the data from these tests as follows:

(1) Considerable variation in flame-spread characteristics was present in boards of different manufacturers.

(2) The "factory finish" surface, in practically all cases, presented a greater resistance to flame spread than the "factory rough" surface, as indicated by the area of char. In a few instances, such as board G-8, the factory-finish surface reduced the area of char by a very substantial amount.

(3) In all cases, the application of 5 grams per square foot of ammonium phosphate reduced the area of char appreciably; the area of char was less than 20 square inches on 15 of the 20 types of board tested.

(4) The consistency of "area of char" values obtained on replicate samples was good.

Second Series of Tests

In the second series of tests, additional data on the effectiveness of monoammonium phosphate in checking flame spread were obtained. Three types of boards were selected for these tests on the basis of their performance in the first series of tests. Board A-1 represented a type that, with no fire-retardant coating applied, had a comparatively high area of char in the inclined-panel test and that appeared relatively difficult to protect against flame spread. Boards B-5 and C-6 represented types that could be protected against flame spread more readily. Coating weights of 5, 10, 15, and 20 grams of monoammonium phosphate per square foot were used. As in the first series of tests, an aqueous solution was used for the specimens coated with 5 grams. For the heavier coatings, however, a special monoammonium phosphate preparation was used. This consisted of pulverized monoammonium phosphate dissolved and suspended in an aqueous gel of the thickening agent, sodium alginate. The formula of the preparation (parts by weight) was:

Monoammonium phosphate	45
China clay	5
Sodium alginate	1
Water	49

The composition of the dry coating, therefore, was:

Monoammonium phosphate	88.2
China clay	9.8
Sodium alginate	2.0

In applying this preparation, the quantity used was such as to produce a coating of 10, 15, or 20 grams per square foot of monoammonium phosphate.

The specimens were tested by the three methods described. The results of the tests are recorded in table 3. In this table, under "Paint designation," the number 1 refers to Forest Products Laboratory

monoammonium phosphate preparations and the suffixes a, b, c, and d refer to coating weights of 5, 10, 15, and 20 grams, respectively.

In evaluating the performance of the specimens, the area of char was the criterion used in the inclined-panel test. In the horizontal-panel (SS-A-118a) test, the flame-spread requirement of the specification for meeting the slow-burning classification is "No flame from the specimen shall reach the angle frame at any point during or after the flame application." All specimens in which flame reaches the frame before 20 minutes are classified as combustible whether the time of failure is, for example, as low as 4 minutes or as high as 19 minutes. In order to evaluate quantitatively the improvement in flame-spread properties effected by the coatings, the time of failure when a flame touched the frame was used as the criterion in this test. In the vertical-panel (mild Schlyter) test, the criterion used was the average flame spread developed during the period of exposure to the igniting flame.

Examination of the data in table 3 reveals that, as evaluated by all three methods of tests, substantial improvement in flame-spread behavior was accomplished through the use of monoammonium phosphate coatings. In the inclined-panel test, a 10-gram coating reduced the area of char on boards B-5 and C-6 to approximately 10 square inches, and 15 grams effected an equal reduction on board A-1. In the horizontal-panel flame-spread test a 10-gram coating brought five of the six specimens of boards B-5 and C-6 tested within the slow-burning classification. A 20-gram coating was required for board A-1, however, before any of the specimens met the slow-burning classification requirements. It will be noted that the results of the tests on the B-5 and C-6 boards were very consistent, whereas those on the A-1 specimens were decidedly erratic.

In the mild Schlyter test, 10-gram coating weights, in all cases, effected substantial improvement in flame-spread characteristics.

Third Series of Tests

Since the results of the second series of tests had established definitely the effectiveness of monoammonium phosphate in retarding flame spread and had also shown indications of a general correlation between the results of the three methods of tests when ammonium phosphate was used as a coating, a third series of tests was planned specifically to obtain additional information for use in establishing a correlation between the results of the inclined-panel and horizontal-panel (SS-A-118a) tests. For this series only boards A-1 and C-6 were used. Three proprietary paints were used in the tests, applied as one and two coats. Two of the paints were fire-retardant coatings, whereas the third one was a conventional resin-emulsion paint for which no fire-retardant properties were claimed. The results of these tests are recorded in table 4 under "Inclined-panel test" and "SS-A-118a test." Results of mild Schlyter tests that had previously been made on specimens coated with the same preparations are also included in this table. Under "Paint designation,"

the number refers to the specific paint used and the small letter suffixes a and b refer to one and two coats, respectively.

A review of the results of table 4 shows that paint No. 3 effectively checked flame spread on both boards, as evaluated by all three methods of test; paint No. 2 performed well on board C-6, but it did not protect board A-1 sufficiently for it to meet the slow-burning classification in most cases. Paint No. 4 provided practically no protection to board A-1 in the horizontal- and in the vertical-panel tests and furnished only slight protection in the inclined-panel test. On board C-6 it showed some fire-retarding effectiveness as measured by the inclined-panel and vertical-panel tests, but very slight retardance in the horizontal-panel test. The appearance after test of representative specimens that had been coated with the three paints used in this series is shown in figures 4, 5, and 6.

The correlation of the results of the tests obtained in this series and of results obtained in other series of tests is discussed subsequently.

Fourth Series of Tests

In a fourth series of tests are grouped the tests made by the inclined-panel and vertical-panel methods on specimens coated with preparations other than those used in the first three series. All of the coatings used were proprietary preparations except the whitewash. The data collected and recorded in table 5 show that, although most of the preparations were unable to check flame spread consistently, a few such as paints Nos. 5, 7, 8, and 14, gave good performances, especially when applied to board C-6.

Correlation of Results of Tests Obtained by Various Methods

In general, the three methods of test showed similar, comparative results with the different types of fiber insulation board as received from the manufacturers and after being coated with the same kind and amount of fire-retardant materials. As previously indicated, the three tests have received some consideration and recognition[3] as methods of evaluating flame

[3]The horizontal-panel test is part of Federal Specification SS-A-118a, Acoustical Units; Prefabricated. The vertical-panel test is well known through its description in Forest Products Laboratory Report No. R1443, "Fire Test Methods Used in Research at the Forest Products Laboratory."

The inclined-panel test is a modification of the Test of Non-Inflammability of Materials in British Standard Specification 476 and is the fire test specified in Commercial Standard CS42-49, Structural Fiber Insulating Board, Commodity Standards Division, National Bureau of Standards.

spread of combustible types of panels. Hence, more detailed comparison of the results of the tests are of interest. To determine correlation trends, the data recorded in tables 3, 4, and 5 were plotted graphically in figures 7, 8, 9, and 10. A discussion of the correlation trends revealed by these graphs follows.

Correlation of Results of Tests Obtained in the Inclined-Panel and Horizontal-Panel Test Methods

Flame-spread values recorded in tables 3 and 4 as obtained by the inclined-panel and the horizontal-panel test methods are plotted graphically in figure 7.

The values of char areas obtained in the inclined-panel test are plotted as abscissas, and those of the time for flame to spread in the horizontal-panel test (SS-A-118a) are plotted as ordinates. Average values were used. Obtaining an average for the flame-spread values in the SS-A-118a test posed a problem in those cases in which specimens met the slow-burning requirement, since, because the flame is extinguished at 20 minutes, 20+ minutes is the only value that can be used. As indicated on figure 7, those points appearing above the 20-minute axis represent tests in which the slow-burning classification was met. The relative vertical position of these points has no significance.

In general, a good correlation between the results of the two methods of test is shown. The one value that is seriously out of line from the general trend is that for the A-1 board coated with 5 grams of ammonium phosphate per square foot (1a). No explanation is offered for this inconsistency, but an examination of the SS-A-118a test data in table 3 shows that A-1 boards with both 5- and 10-gram coatings per square foot of ammonium phosphate behaved erratically.

A critical examination of figure 4 shows, further, that sufficient improvement in flame-spread performance in the SS-A-118a test to meet the slow-burning classification was not obtained until the coating was sufficiently effective to reduce the area of char in the inclined-panel test to less than 12 square inches. The data further indicate that no positive assurance can be given that a coated board showing less than 12 square inches of char in the inclined-panel test will, in all cases, meet the slow-burning classification requirement of Specification SS-A-118a. For example, of the 43 specimens listed in tables 3 and 4 on which SS-A-118a tests were made and on which the average area of char in the inclined-panel test was less than 12 square inches, 34 specimens, or 80 percent, met the slow-burning classification requirement. Of the nine specimens that failed to meet the slow-burning classification requirement of SS-A-118a, however, areas of char of less than 10 square inches were found in four cases.

Since area of char is the criterion used for evaluating performance in the inclined-panel test, it was felt that information of interest might be obtained by measuring the area of char of the SS-A-118a specimens and determining the possible correlation between areas of char in the two test methods. Accordingly, the damaged paint was scraped off the specimens coated with paints 2, 3, and 4 to provide a line of demarcation for the charred area, and these areas were then calculated. The values are recorded in table 4. The areas of char produced in the two methods of test are presented graphically in figure 8. As in figure 7, average values are used. The correlation obtained is reasonably consistent.

Correlation of Results of Tests Obtained in the Inclined-Panel and in the Vertical-Panel (Mild Schlyter) Test Methods

Flame-spread values recorded in tables 3, 4, and 5 that were obtained by the inclined-panel and by the vertical-panel test methods are plotted graphically in figure 9. The values of char areas obtained in the inclined-panel test are plotted as abscissas, and those of the average flame spread obtained in the mild Schlyter test are plotted as ordinates. As in the other graphical presentations, average values were used.

The correlation between the results of these two test methods, on the whole, was not so good as that shown for the results of the inclined-panel and SS-A-118a tests. This difference probably is to be expected because of the larger number of different coatings used. It is to be noted that, when using an area of char of 12 square inches as a criterion for performance in the inclined-panel test, the average flame spread in the Schlyter test of most of the specimens tested was less than 5 inches.

Correlation of Results of Tests Using the Mild Schlyter Method and the SS-A-118a Method

The flame-spread data recorded in tables 3 and 4 by the mild Schlyter and by the SS-A-118a methods are plotted graphically in figure 10.

A fairly good correlation between the results of these two test methods is marred by the inconsistency of the SS-A-118a values obtained on board A-1, coated with ammonium phosphate (1a, 1b, 1c).

Summary

Flame-spread characteristics of fiber building boards were determined by three test methods, an inclined-panel test, a vertical-panel test, and a horizontal-panel test. The following information was revealed through the results of these tests:

(1) As evaluated by the inclined-panel test, considerable variation in flame-spread behavior was found in boards of different manufacturers and the factory finish applied by certain manufacturers was found to have some flame-retarding properties.

(2) As evaluated by all methods of test, certain fire-retarding coatings improved greatly the resistance of the boards to flame spread, with the resistance increasing with the amount of coating applied.

(3) Certain boards were easier to protect against flame spread than others.

(4) Reasonably good correlation trends between the results of the three test methods were found. For example, boards showing 12 square inches or less of char in the inclined-panel test usually met the slow-burning classification of the horizontal panel (SS-A-118a) test and usually did not develop more than 5 inches of average flame spread in the vertical-panel (mild Schlyter) test. The data accumulated indicated, however, the difficulty of predicting infallibly, on the basis of performance in one test method, what the performance would be in another test method.

Table 1.--Fiber insulating boards used in first series of flame-spread tests

Board designation[1]	Weight	Factory finish
	Lb. per sq. ft.	
A-1	0.74	Very lightly pigmented
A-2	.75	None
A-3	.72	Pigmented
A-4	.75	None
B-5	.70	Pigmented
C-6	.65	Pigmented
G-7	.63	None
G-8	.65	Pigmented
H-9	.74	None
H-10	.63	Pigmented
J-11	.69	None
J-12	.66	Pigmented
K-13	.67	None
K-14	.67	Pigmented
L-15	.73	None
L-16	.78	Pigmented
M-17	.79	None
M-18	.74	Pigmented
N-19	.65	Lightly pigmented
O-20	.70	Pigmented

[1] The letter indicates the manufacturer; the number, the specific product of the manufacturer.

Table 2.—Summary of results of inclined-panel fire tests made on 20 types of interior fiber boards

Board designation[1]	No. of tests	Area of char			Time flame reached top edge			Duration of flaming after alcohol was consumed			Loss in weight		
		Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
		Square inch			Minutes			Minutes			Percent		
"Factory finish" side exposed to fire													
Laboratory coating: None													
A-1	4	72.5	63.7	67.9	0.84	0.79	0.81	1.00+	1.00+	1.00+	5.6	5.0	5.3
A-2	4	69.1	68.2	68.6	.80	.68	.76	1.00+	1.00+	1.00+	5.0	4.7	4.8
A-3	4	29.3	22.7	27.1	(2)	1.06	—	1.00+	.90	.98+	1.8	1.1	1.6
A-4	4	69.7	66.0	67.1	.77	.76	.76	1.00+	1.00+	1.00+	5.0	4.8	4.9
B-5	10	49.0	34.7	40.2	.87	.75	.80	1.00+	.50	.79+	3.3	2.0	2.6
C-6	4	36.9	34.6	35.6	.83	.80	.82	.32	0	.12	2.0	1.8	1.9
G-7	4	64.4	61.4	62.9	.80	.69	.74	1.00+	1.00+	1.00+	5.5	5.2	5.3
G-8	4	18.2	17.6	17.8	(2)	(2)	(2)	0	0	0	.9	.6	.8
H-9	4	60.0	59.4	59.6	.79	.75	.78	1.00+	1.00+	1.00+	4.4	2.3	3.8
H-10	4	53.6	44.6	50.0	.91	.85	.88	1.00+	1.00+	1.00+	4.4	3.5	4.0
J-11	4	43.4	37.0	38.7	.81	.79	.80	.65	.32	.44	2.4	2.0	2.2
J-12	4	32.7	31.8	32.0	.91	.86	.88	.21	0	.05	1.6	1.4	1.4
K-13	4	57.1	54.8	56.2	.83	.78	.81	1.00+	1.00+	1.00+	4.4	4.0	4.2
K-14	4	40.3	38.3	39.3	.82	.75	.79	.62	.44	.53	2.4	2.2	2.3
L-15	4	56.3	54.4	55.5	.92	.91	.92	1.00+	1.00+	1.00+	4.4	4.1	4.3
L-16	4	34.5	32.5	33.2	1.03	.94	.97	.60	.39	.50	1.8	1.6	1.7
M-17	4	49.1	45.3	46.3	.96	.93	.94	1.00+	.79	.88+	2.8	2.4	2.6
M-18	4	50.1	37.9	43.6	.98	.92	.95	1.00+	.59	.82+	3.5	2.3	2.8
N-19	4	30.0	28.8	29.2	.98	.94	.96	.35	0	.16	1.8	1.4	1.6
O-20	4	34.5	31.1	32.9	.78	.76	.77	.51	.44	.47	2.2	1.9	2.1
Laboratory coating: 5.0 grams monoammonium phosphate per square foot													
A-1	2	28.7	28.3	28.5	1.52	1.48	1.50	1.00+	1.00+	1.00+	1.4	1.2	1.3
A-2	2	24.4	24.0	24.2	(2)	(2)	(2)	0	0	0	.9	.8	.8
A-3	2	10.7	10.5	10.6	(2)	(2)	(2)	0	0	0	.3	.3	.3
A-4	2	26.4	24.8	25.6	(2)	(2)	(2)	0	0	0	1.0	.8	.9
B-5	2	16.8	14.9	15.8	(2)	(2)	(2)	0	0	0	1.0	.7	.8
C-6	2	21.5	17.3	19.4	(2)	(2)	(2)	0	0	0	.8	.6	.7
G-7	2	19.7	19.0	19.4	(2)	(2)	(2)	0	0	0	.8	.7	.8
G-8	2	13.8	13.6	13.7	(2)	(2)	(2)	0	0	0	.6	.5	.6
H-9	2	20.4	19.4	19.9	(2)	(2)	(2)	0	0	0	1.0	.8	.9
H-10	2	22.9	21.6	22.2	(2)	(2)	(2)	0	0	0	.9	.9	.9
J-11	2	18.7	18.5	18.6	(2)	(2)	(2)	0	0	0	.6	.4	.5
J-12	2	16.6	15.9	16.2	(2)	(2)	(2)	0	0	0	.7	.6	.6
K-13	2	21.0	20.2	20.6	(2)	(2)	(2)	0	0	0	.8	.6	.7
K-14	2	12.9	12.7	12.8	(2)	(2)	(2)	0	0	0	.4	.4	.4
L-15	2	19.6	19.2	19.4	(2)	(2)	(2)	0	0	0	.8	.7	.8
L-16	2	11.6	11.5	11.6	(2)	(2)	(2)	0	0	0	.4	.3	.4
M-17	2	17.9	17.4	17.6	(2)	(2)	(2)	0	0	0	.7	.6	.6
M-18	2	16.2	16.1	16.2	(2)	(2)	(2)	0	0	0	.6	.6	.6
N-19	2	14.0	13.3	13.6	(2)	(2)	(2)	0	0	0	.8	.5	.6
O-20	2	14.8	14.7	14.8	(2)	(2)	(2)	0	0	0	.6	.6	.6
"Factory rough" side exposed to fire													
Laboratory coating: None													
A-1	4	75.2	71.6	73.6	0.73	0.69	0.72	1.00+	1.00+	1.00+	5.6	5.2	5.3
A-2	4	68.0	66.2	66.9	.81	.76	.78	1.00+	1.00+	1.00+	4.7	4.4	4.6
A-3	4	67.1	62.0	64.8	.89	.73	.83	1.00+	1.00+	1.00+	4.4	4.2	4.3
A-4	4	70.3	66.7	68.7	.86	.76	.82	1.00+	1.00+	1.00+	4.8	4.5	4.7
B-5	4	66.9	54.7	59.2	.86	.76	.82	1.00+	1.00+	1.00+	4.8	3.6	4.2
C-6	4	64.7	57.7	61.8	.81	.79	.80	1.00+	1.00+	1.00+	5.4	4.6	5.0
G-7	No tests												
G-8	4	52.7	41.2	44.8	1.01	.94	.98	1.00+	.65	.84+	3.8	2.4	2.9
H-9	No tests												
H-10	4	50.5	47.4	48.6	.92	.84	.88	1.00+	1.00+	1.00+	4.4	3.1	3.7
J-11	No tests												
J-12	4	53.9	40.7	49.2	.86	.81	.84	1.00+	.42	.82+	3.8	2.1	3.0
K-13	No tests												
K-14	4	58.9	53.4	56.8	.77	.74	.76	1.00+	1.00+	1.00+	4.1	3.8	4.0
L-15	No tests												
L-16	4	59.6	57.1	58.3	.95	.89	.92	1.00+	1.00+	1.00+	4.9	4.0	4.3
M-17	No tests												
M-18	4	58.0	56.6	57.4	.92	.89	.91	1.00+	1.00+	1.00+	4.4	4.2	4.3
N-19	4	61.0	60.0	60.5	.83	.78	.81	1.00+	1.00+	1.00+	4.4	4.1	4.2
O-20	4	57.8	55.8	56.9	.90	.86	.88	1.00+	1.00+	1.00+	4.0	4.0	4.0
Laboratory coating: 5.0 grams monoammonium phosphate per square foot													
A-1	2	23.2	22.0	22.6	(2)	(2)	(2)	0	0	0	.9	.8	.8
A-2	2	23.3	21.5	22.4	(2)	(2)	(2)	0	0	0	.8	.8	.8
A-3	2	23.0	22.6	22.8	(2)	(2)	(2)	0	0	0	.8	.8	.8
A-4	2	24.4	23.0	23.7	(2)	(2)	(2)	0	0	0	.9	.8	.8
B-5	2	20.2	19.4	19.8	(2)	(2)	(2)	0	0	0	1.0	.8	.9
C-6	2	19.8	16.2	18.0	(2)	(2)	(2)	0	0	0	1.0	.8	.9
G-7	2	22.5	18.6	20.6	(2)	(2)	(2)	0	0	0	.9	.8	.8
G-8	2	17.5	16.4	17.0	(2)	(2)	(2)	0	0	0	.6	.6	.6
H-9	2	20.0	18.0	19.0	(2)	(2)	(2)	0	0	0	.8	.7	.8
H-10	2	18.0	17.1	17.6	(2)	(2)	(2)	0	0	0	.8	.7	.8
J-11	2	19.3	18.8	19.0	(2)	(2)	(2)	0	0	0	.9	.8	.8
J-12	2	18.2	17.3	17.8	(2)	(2)	(2)	0	0	0	.7	.7	.7
K-13	2	22.7	22.5	22.6	(2)	(2)	(2)	0	0	0	1.0	.9	1.0
K-14	2	20.9	20.4	20.6	(2)	(2)	(2)	0	0	0	.7	.7	.7
L-15	2	23.6	23.2	23.4	(2)	(2)	(2)	0	0	0	.8	.8	.8
L-16	2	16.3	16.0	16.2	(2)	(2)	(2)	0	0	0	.6	.6	.6
M-17	2	20.8	19.2	20.0	(2)	(2)	(2)	0	0	0	.7	.7	.7
M-18	2	16.5	15.6	16.0	(2)	(2)	(2)	0	0	0	.7	.6	.6
N-19	2	25.9	24.5	25.2	(2)	(2)	(2)	0	0	0	1.0	1.0	1.0
O-20	2	21.3	21.1	21.2	(2)	(2)	(2)	0	0	0	.9	.8	.8

[1] The letter indicates the manufacturer; the number, the specific product of the manufacturer.

[2] Flame did not spread to top edge.

2 M 66817 F

Table 3.—Results of flame-spread tests on insulating-board specimens coated with monoammonium phosphate preparations

Type of paint	Paint designation number	Board designation	Results of flame-spread tests by method indicated											
			Inclined-panel test				Specification SS-A-118a test			Mild Schlyter test			Average flame spread
			Test No.	Coating weight (dry)[1]	Area of char			Test No.	Coating weight (dry)[1]	Time flame reached frame	Test No.	Coating weight (dry)[1]	
					Max.	Min.	Av.						
				Gm. per sq. ft.	Sq. in.	Sq. in.	Sq. in.		Gm. per sq. ft.	Min.		Gm. per sq. ft.	In.
None	0	A-1	371-374	0	72.5	63.7	67.9	98	0	3.6	541	0	41.9
None	0	B-5	263,264; 313-320	0	49.0	34.7	40.2	99	0	4.1	448	0	38.7
None	0	C-6	375-378	0	36.9	34.6	35.6	114	0	4.0	547	0	36.2
25 percent solution of monoammonium phosphate	1a	A-1	345-346	5	28.7	28.3	28.5	86	5	18.3	366	5.4	23.1
								87	5	11.4	367	5.0	24.6
								95	5	6.8			
							Av.		5	12.2	Av.	5.2	23.8
F.P.L. monoammonium phosphate preparation	1b	A-1	616-617	10	13.8	12.8	13.3	80	10	11.9	372	10.2	4.2
								81	10	3.9	375	10.2	5.2
								92	10	11.8	378	10.0	12.1
											379	10.0	7.2
							Av.		10	9.2	Av.	10.1	7.2
F.P.L. monoammonium phosphate preparation	1c	A-1	618-619	15	9.6	9.2	9.4	74	15	19.8	327	13.2	1.0
								75	15	14.1	347	16.4	2.9
								89	15	11.4			
							Av.		15	15.1	Av.	14.8	2.0
F.P.L. monoammonium phosphate preparation	1d	A-1	620-621	20	8.8	8.6	8.7	68	20	20+			
								69	20	20+			
								88	20	12.6			
							Av.		20	17.5+			
25 percent solution of monoammonium phosphate	1a	B-5	265-266	5	16.8	14.9	15.8	84	5	19.9	368	5.0	6.5
								85	5	12.5	369	5.2	6.5
								96	5	17.2			
							Av.		5	16.5	Av.	5.1	6.5
F.P.L. monoammonium phosphate preparation	1b	B-5	622-623	10	10.5	10.2	10.4	76	10	20+	373	10.3	2.1
								77	10	19.2	376	10.0	2.0
								93	10	20+			
							Av.		10	19.7+	Av.	10.2	2.0
F.P.L. monoammonium phosphate preparation	1c	B-5	624-625	15	10.4	10.0	10.2	72	15	20+	328	14.6	1.0
								73	15	20+	348	16.4	2.2
								90	15	20+			
							Av.		15	20+	Av.	15.5	1.6
F.P.L. monoammonium phosphate preparation	1d	B-5	626-627	20	9.4	9.4	9.4	66	20	20+			
								67	20	20+			
							Av.		20	20+			
25 percent solution of monoammonium phosphate	1a	C-6	347-348	5	21.5	17.3	19.4	82	5	3.9	370	5.1	23.6
								83	5	5.8	371	5.2	21.8
								97	5	5.4			
							Av.		5	5.0	Av.	5.2	22.7
F.P.L. monoammonium phosphate preparation	1b	C-6	628-629	10	10.5	10.4	10.4	78	10	20+	374	10.2	4.0
								79	10	20+	377	10.2	3.6
								94	10	20+			
							Av.		10	20+	Av.	10.2	3.8
F.P.L. monoammonium phosphate preparation	1c	C-6	630-631	15	9.4	9.3	9.4	70	15	20+	329	16.4	2.8
								71	15	20+	349	17.0	2.7
								91	15	20+			
							Av.		15	20+	Av.	16.7	2.8
F.P.L. monoammonium phosphate preparation	1d	C-6	632-633	20	9.1	9.1	9.1	64	20	20+			
								65	20	20+			
							Av.		20	20+			

[1] This coating weight represents the amount of monoammonium phosphate present.

Table 4.--Results of flame-spread tests on insulating-board specimens coated with paints designated

Type of paint	Paint designation[1]	Board designation	Results of flame-spread tests by method indicated											
			Inclined-panel test					Specification SS-A-118a test				Mild Schlyter test		
			Test No.	Coating weight (dry)	Area of char			Test No.	Coating weight (dry)	Time flame reached frame	Area of char	Test No.	Coating weight (dry)	Average flame spread
					Max.	Min.	Av.							
				Gm. per sq. ft.	Sq. in.	Sq. in.	Sq. in.		Gm. per sq. ft.	Min.	Sq. in.		Gm. per sq. ft.	In.
Chlorinated hydrocarbon (I)	2a	A-1	1009-1012	13.6	12.7	11.9	12.3	139	13.3	14.8	327	541	12.1	17.2
								140	13.4	4.2	446	542	12.1	16.8
								141	13.1	9.4	392			
								Av.	13.3	9.5	388	Av.	12.1	17.0
Chlorinated hydrocarbon (I)	2b	A-1	1017-1020	24.2	11.7	11.4	11.6	145	23.7	20+	386			
								146	23.8	7.6	678			
								147	24.1	5.7	649			
								Av.	23.9	11.1+	571			
Chlorinated hydrocarbon (I)	2a	C-6	1005-1008	13.8	12.4	11.3	11.8	136	13.7	20+	362	536	12.3	10.8
								137	12.6	20+	362	540	12.3	12.5
								138	12.7	15.2	418			
								Av.	13.0	18.4+	381	Av	12.3	11.6
Chlorinated hydrocarbon (I)	2b	C-6	1013-1016	24.2	12.0	10.9	11.3	142	23.7	20+	320			
								143	24.1	20+	396			
								144	23.8	20+	392			
								Av.	23.9	20+	369			
Water-soluble fire-retardant with synthetic resin	3a	A-1	1033-1036	15.6	8.1	7.5	7.8	127	15.5	20+	330	339	14.2	3.5
								128	15.0	20+	314			
								129	15.2	20+	362			
								Av.	15.2	20+	335			
Water-soluble fire-retardant with synthetic resin	3b	A-1	1041-1044	30.3	8.4	6.6	7.5	133	29.7	20+	267			
								134	30.3	20+	254			
								135	30.3	20+	267			
								Av.	30.1	20+	263			
Water-soluble fire-retardant with synthetic resin	3a	C-6	1029-1032	15.8	8.5	7.3	8.0	124	15.0	20+	201	341	15.8	3.2
								125	14.8	20+	201			
								126	16.2	20+	189			
								Av.	15.3	20+	197			
Water-soluble fire-retardant with synthetic resin	3b	C-6	1037-1040	29.9	8.2	7.0	7.4	130	29.9	20+	201			
								131	29.9	20+	201			
								132	30.2	20+	201			
								Av.	30.0	20+	201			
Emulsified resin	4a	A-1	993-996	5.9	48.3	34.9	39.4	151	6.0	3.7	900			
								152	5.8	2.6	900			
								153	5.8	3.7	900			
								Av.	5.9	3.3	900			
Emulsified resin	4b	A-1	1001-1004	15.1	32.3	25.4	28.7	157	12.1	3.8	813	530	12.3	34.8
								158	12.3	3.3	895	531	12.2	35.4
								159	12.1	4.3	875			
								Av.	12.2	3.8	864	Av.	12.2	35.1
Emulsified resin	4a	C-6	989-992	5.7	19.3	17.0	18.3	148	6.5	4.2	883			
								149	6.0	5.8	870			
								150	6.0	3.8	885			
								Av.	6.2	4.6	879			
Emulsified resin	4b	C-6	997-1000	14.8	14.5	13.6	14.3	154	12.8	5.5	751	528	12.0	18.0
								155	12.5	5.2	729	529	12.1	16.2
								156	12.4	6.2	564			
								Av.	12.6	5.6	681	Av.	12.0	17.1

[1] Numbers indicate type of paint, and letter suffixes a and b indicate one and two coats, respectively.

Table 5.--Results of flame-spread tests on insulating-board specimens coated with paints designated

Type of paint[1]	Paint designation	Board designation	Results of flame-spread tests by method indicated							
			Inclined-panel test					Mild Schlyter test		
			Test No.	Coating weight (dry)	Area of char			Test No.	Coating weight (dry)	Average flame spread
					Max.	Min.	Av.			
				Gm. per sq. ft.	Sq. in.	Sq. in.	Sq. in.		Gm. per sq. ft.	In.
Borax-linseed oil	5	B-5	694-695	12.0	7.7	7.5	7.6	456	11.6	4.1
								457	11.8	3.3
								Av.	11.7	3.7
Borax-linseed oil	5	C-6	696-697	12.0	8.5	8.3	8.4	459	11.4	15.7
								460	11.0	23.4
								Av.	11.2	19.6
Casein	6	A-1	901-904	12.0	29.4	22.9	26.2	526	11.9	35.8
								527	11.8	36.4
								Av.	11.8	36.1
Casein	6	C-6	897-900	12.2	17.6	14.8	16.2	524	12.2	17.2
								525	11.8	18.2
								Av.	12.0	17.7
Chlorinated hydrocarbon (II)	7	A-1	873-876	12.1	16.4	9.9	11.6	545	12.1	28.0
								546	12.4	26.3
								Av.	12.2	27.2
Chlorinated hydrocarbon (II)	7	C-6	869-872	12.1	10.9	10.3	10.7	543	12.2	4.5
								544	12.6	4.5
								Av.	12.4	4.5
Water-soluble fire-retardant with thickening agent	8	A-1	921-922	12.0	10.8	10.6	10.7	324	12.2	1.0
								353	11.7	1.3
								Av.	12.0	1.2
Chlorinated hydrocarbon (III)	9	A-1	929-930	10.5	30.1	29.2	29.6	515	10.7	27.6
Chlorinated hydrocarbon (IV)	10	A-1	925-926	24.7	19.2	19.1	19.2	513	23.6	17.6
Chlorinated hydrocarbon (V)	11	A-1	927-928	12.6	24.2	23.9	24.0	511	13.4	28.3
Whitewash	12	A-1	865-868	12.9	22.5	18.7	21.1	518	12.7	24.3
								519	13.2	22.8
								Av.	13.0	23.6
Whitewash	12	C-6	861-864	12.5	22.3	17.8	20.3	516	12.0	22.2
								517	12.3	19.2
								Av.	12.2	20.7
Chlorinated hydrocarbon (VI)	13	A-1	857-860	12.1	31.9	30.0	30.6	522	11.5	35.4
								523	12.2	37.3
								Av.	11.8	36.4
Chlorinated hydrocarbon (VI)	13	C-6	853-856	12.5	28.0	24.8	26.7	520	12.0	31.2
								521	12.3	29.1
								Av.	12.2	30.2
Aluminum pigment	14	A-1	849-852	12.0	29.0	18.9	24.9	534	12.0	45.7
								535	12.0	42.6
								Av.	12.0	44.2
Aluminum pigment	14	C-6	845-848	11.8	15.9	12.9	14.4	532	12.0	4.2
								533	12.0	5.9
								Av.	12.0	5.0

[1] All paints except whitewash were proprietary preparations. The whitewash formulation used was formula 17 of Forest Products Laboratory Report No. R1280, "Fire-retarding Coatings."

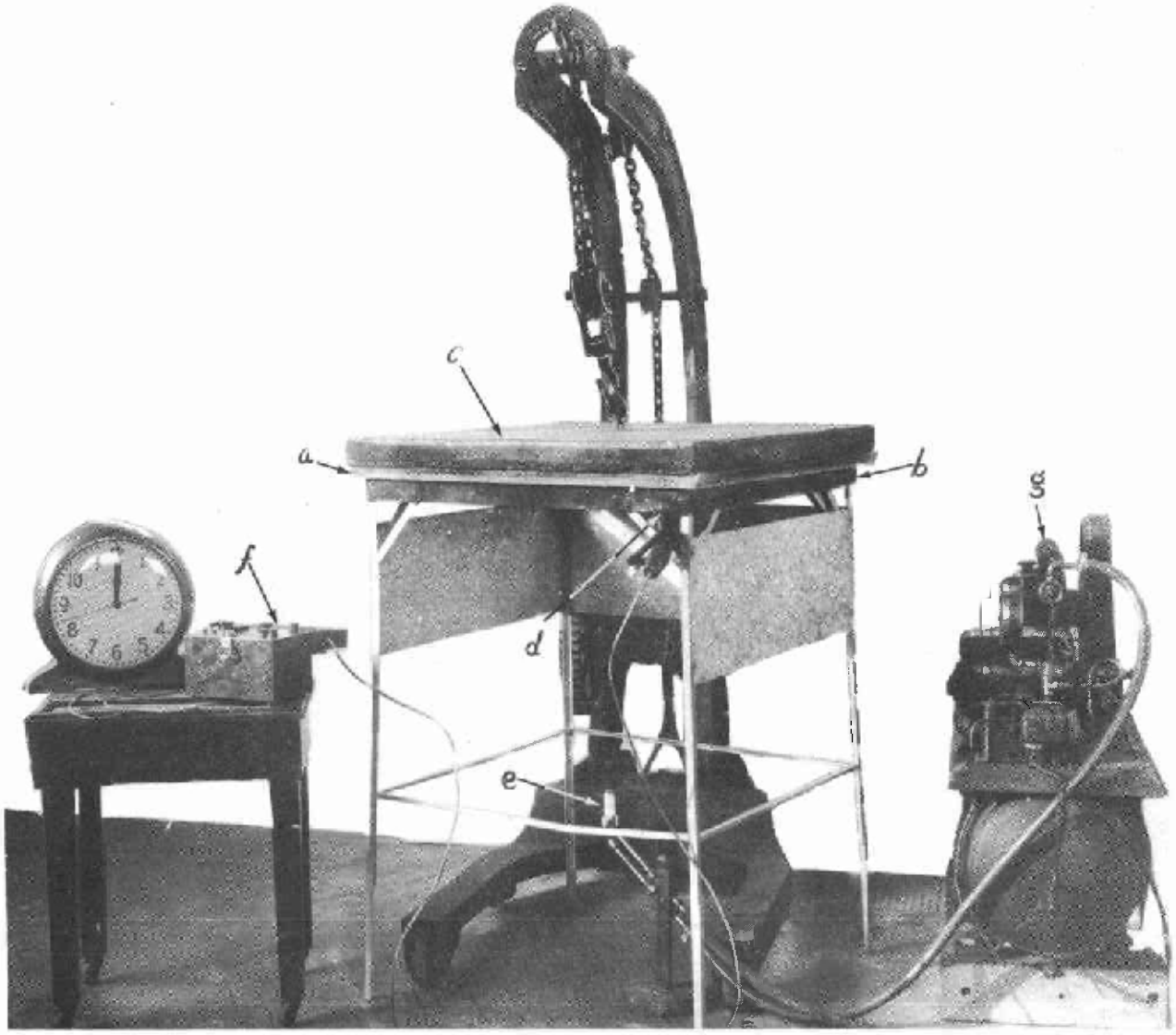


Figure 1. --Apparatus **used for making horizontal-panel tests by the method** prescribed **in Federal Specification SS-A-118a: a, test panel; b, frame for supporting panel; c,** non-combustible **backing** for panel; d, **thermocouple; e, gas burner, f, pyrometer; g, air** compressor.

ZM 65283 F

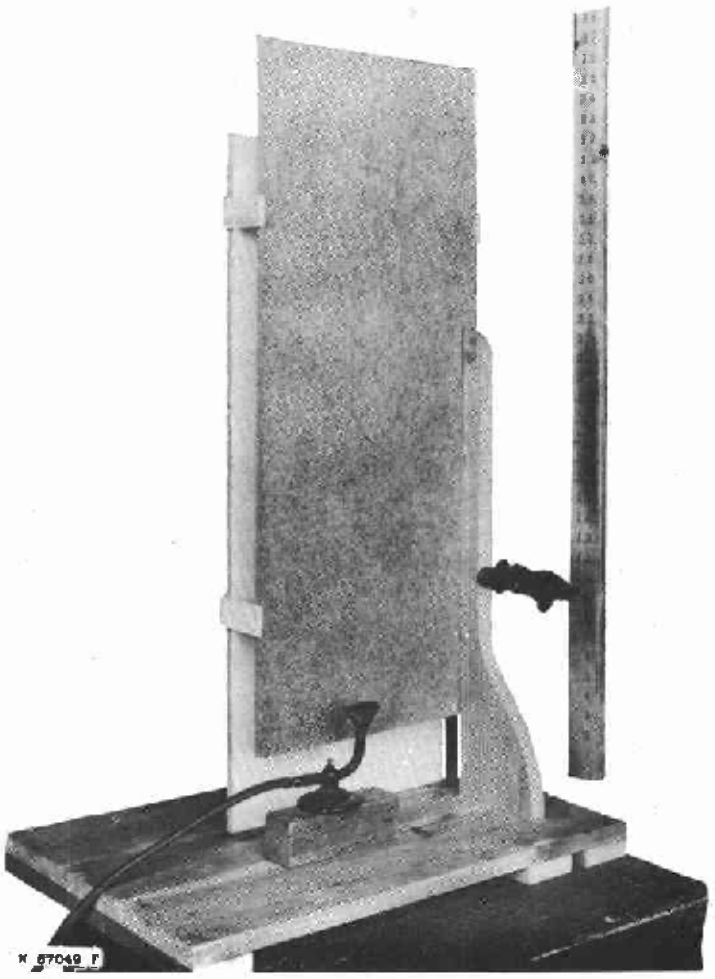


Figure 2. --Apparatus used for making vertical-panel tests by the mild Schlyter method.

ZM 67049 F

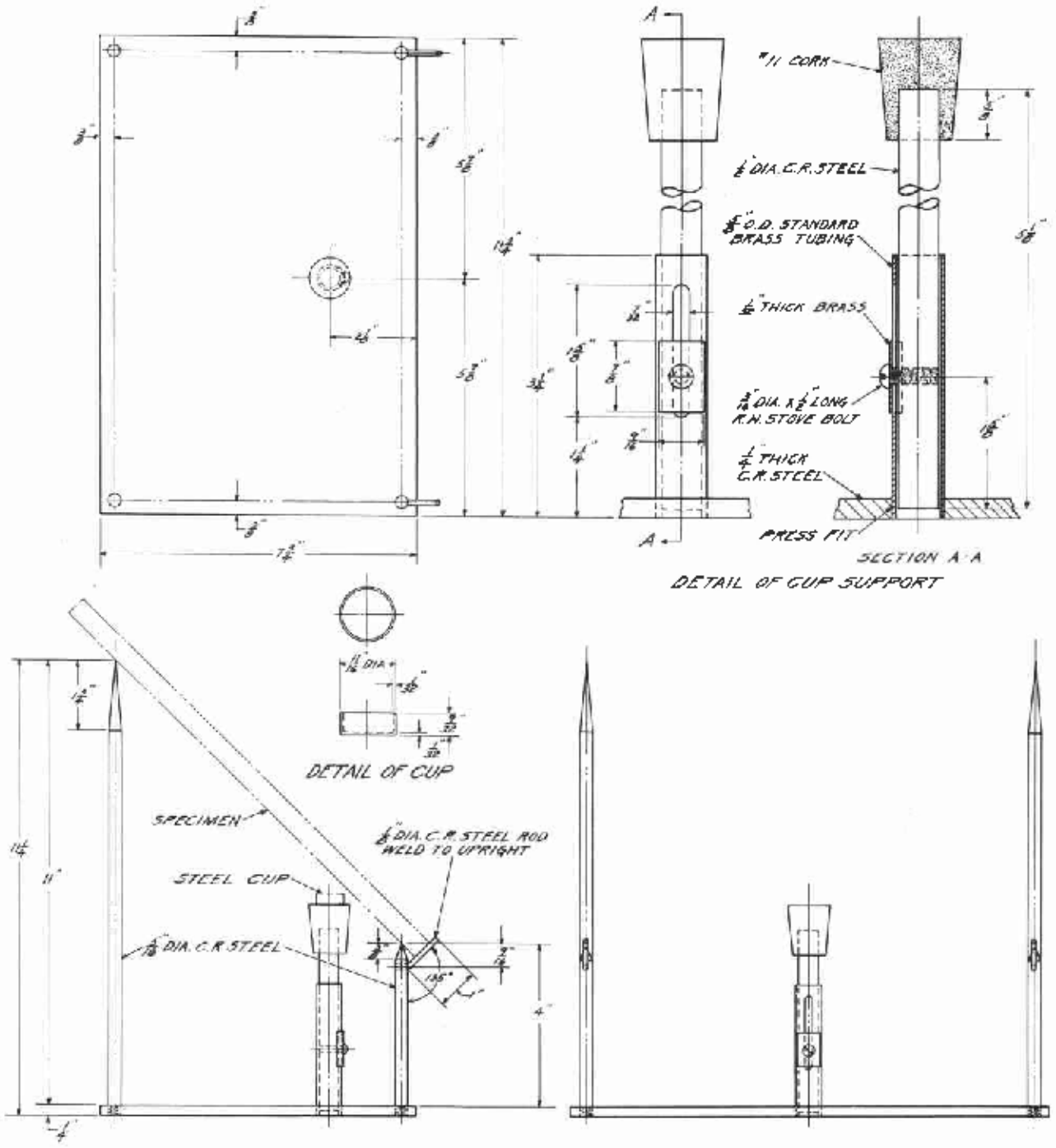


Figure 3. --Apparatus used for making inclined-panel tests by modification of the method prescribed in British Standard Specification 476, Test of Non-Inflammability of Materials.

ZM 67236 F

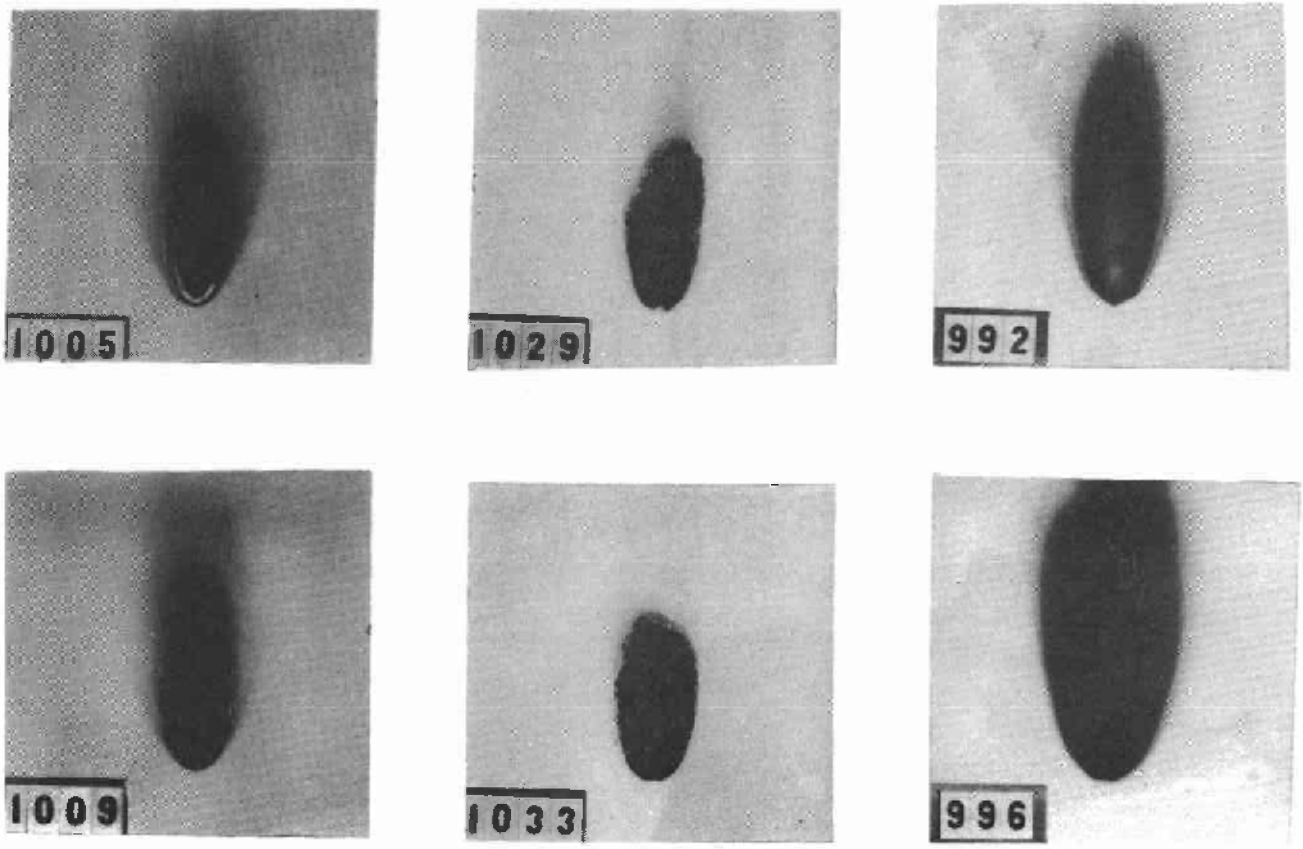


Figure 4. --Insulating-board specimens after exposure in the inclined-panel test. Samples 1005 (board C-6) and 1009 (board A-1) coated with 15 grams per square foot of paint 2. Samples 1029 (board C-6) and 1033 (board A-1) coated with 15 grams per square foot of paint 3. Samples 992 (board C-6) and 995 (board A-1) coated with 6 grams per square foot of paint 4.

ZM 84293 F

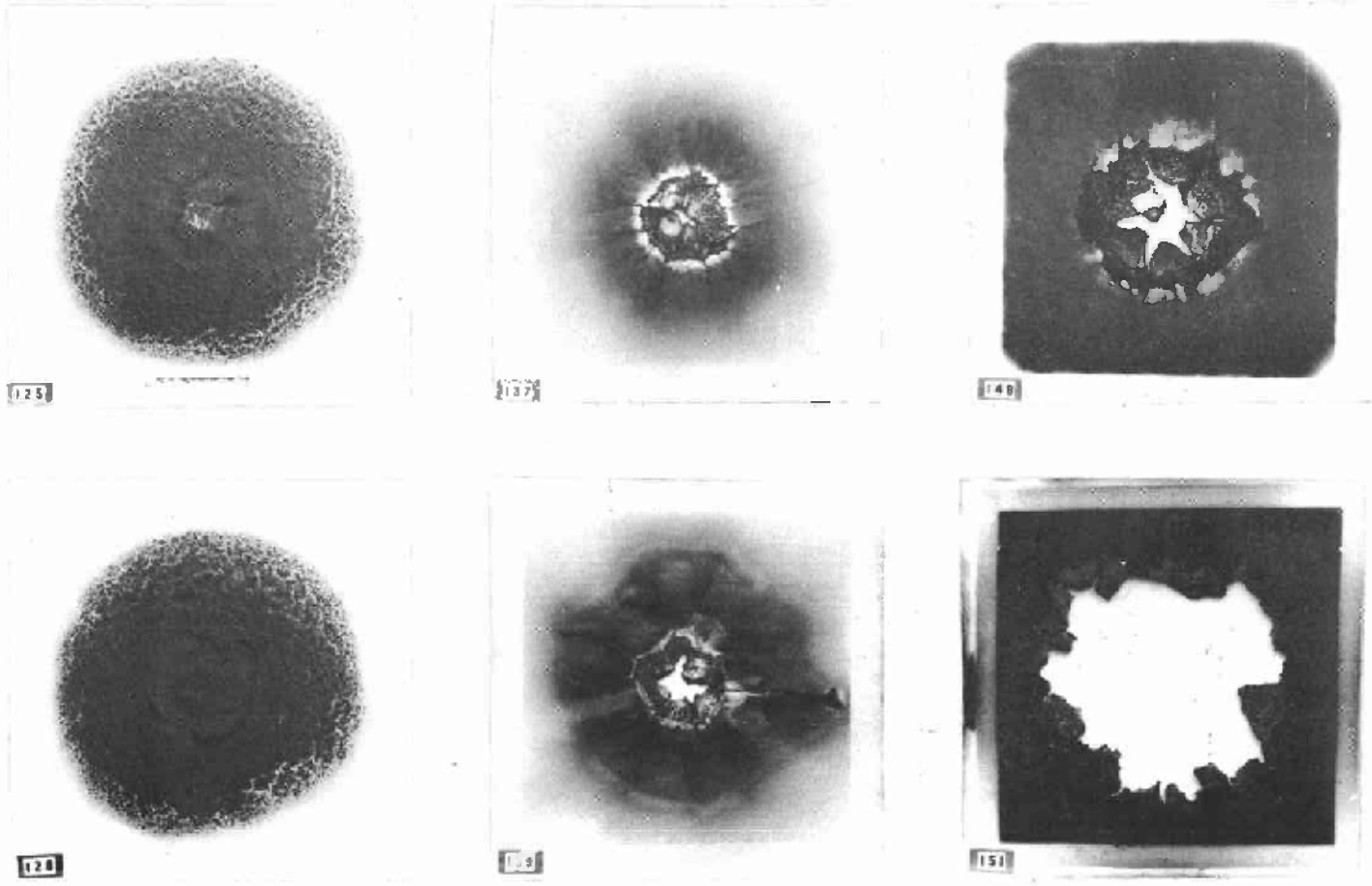


Figure 5. --Insulating-board specimens after exposure in the horizontal-panel (SS-A-118a) **test.**
Samples 125 (board C-6) and 128 (board A-1) coated with 15 grams per square foot of paint 3.
Samples 137 (board C-6) and 139 (board A-1) coated with 13 grams per square foot of paint 2.
Samples 148 (board C-6) and 151 (board A-1) coated with 6 grams per square foot of paint 4.

ZM 84294 F

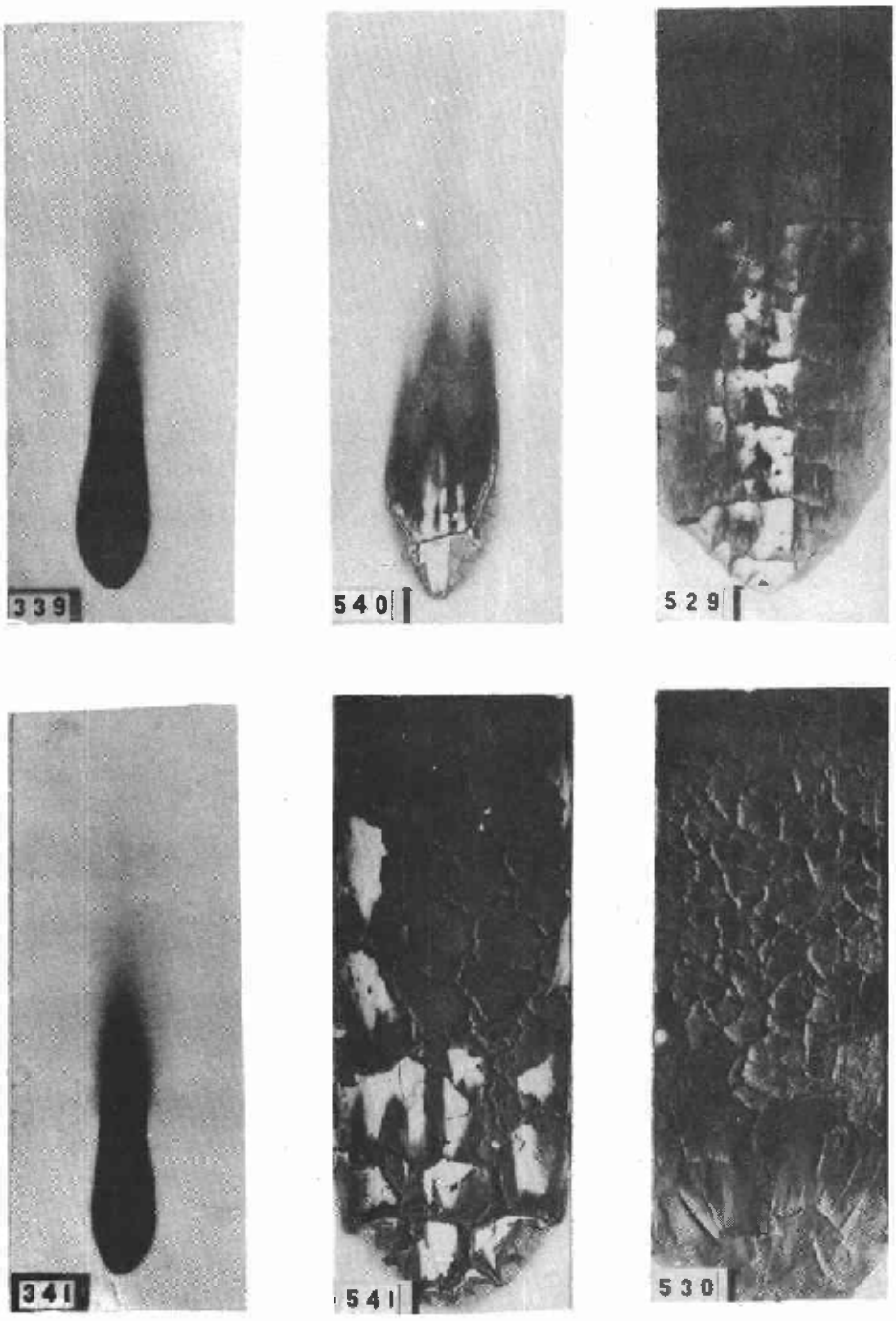
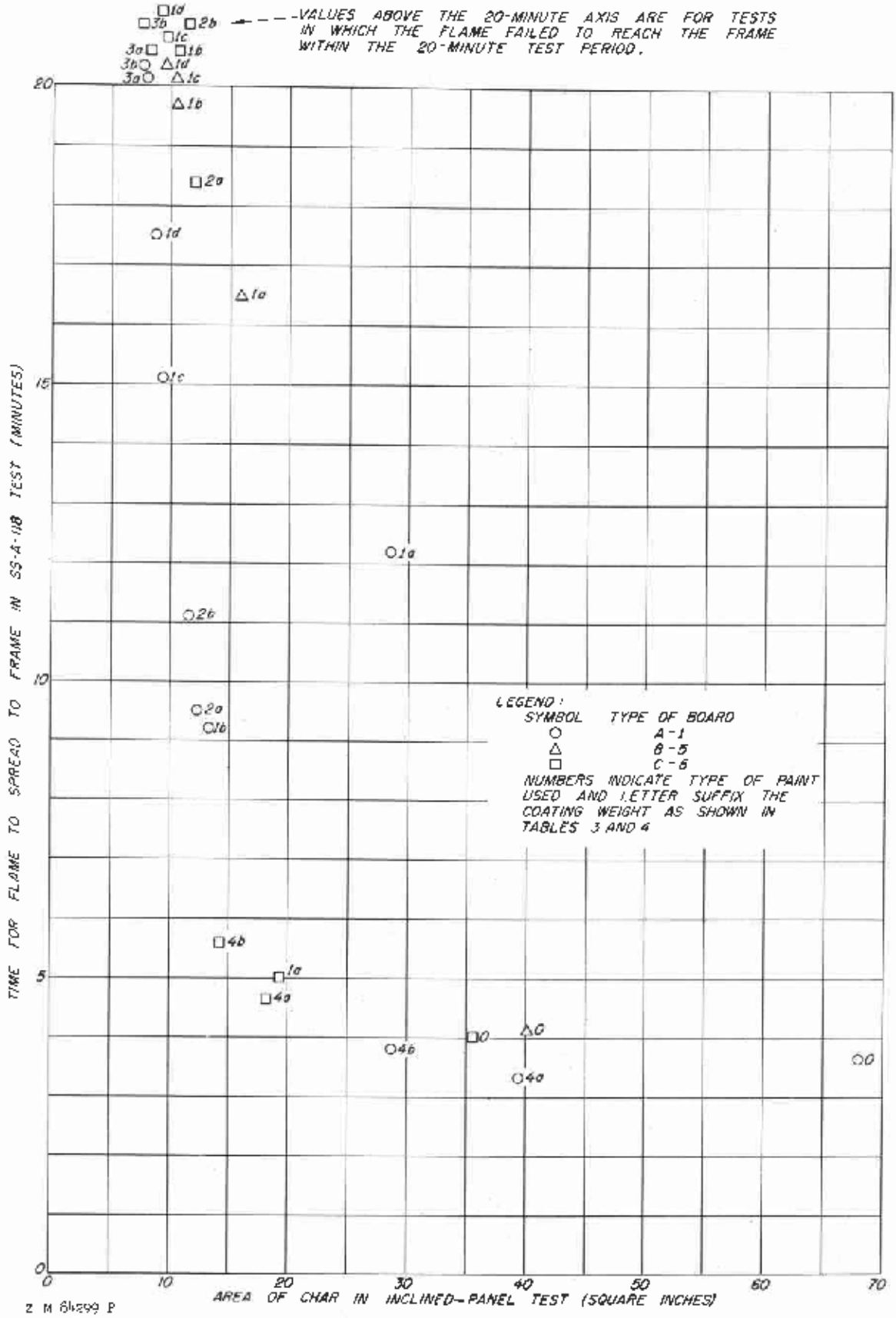


Figure 6. --Insulating-board specimens after exposure in the vertical-panel (mild Schlyter) test. Sample 339 (board C-6) coated with 14 grams per square foot of paint 3. Sample 341 (board A-1) coated with 16 grams per square foot of paint 3. Samples 540 (board C-6) and 541 (board A-1) coated with 12 grams per square foot of paint 2. Samples 529 (board C-6) and 530 (board A-1) coated with 12 grams per square foot of paint 4.

ZM 84295 F



Z M 64299 P

Figure 7. --Correlation between area of char in inclined-panel test and time for flame to spread to frame in horizontal panel (SS-A-118a) test.

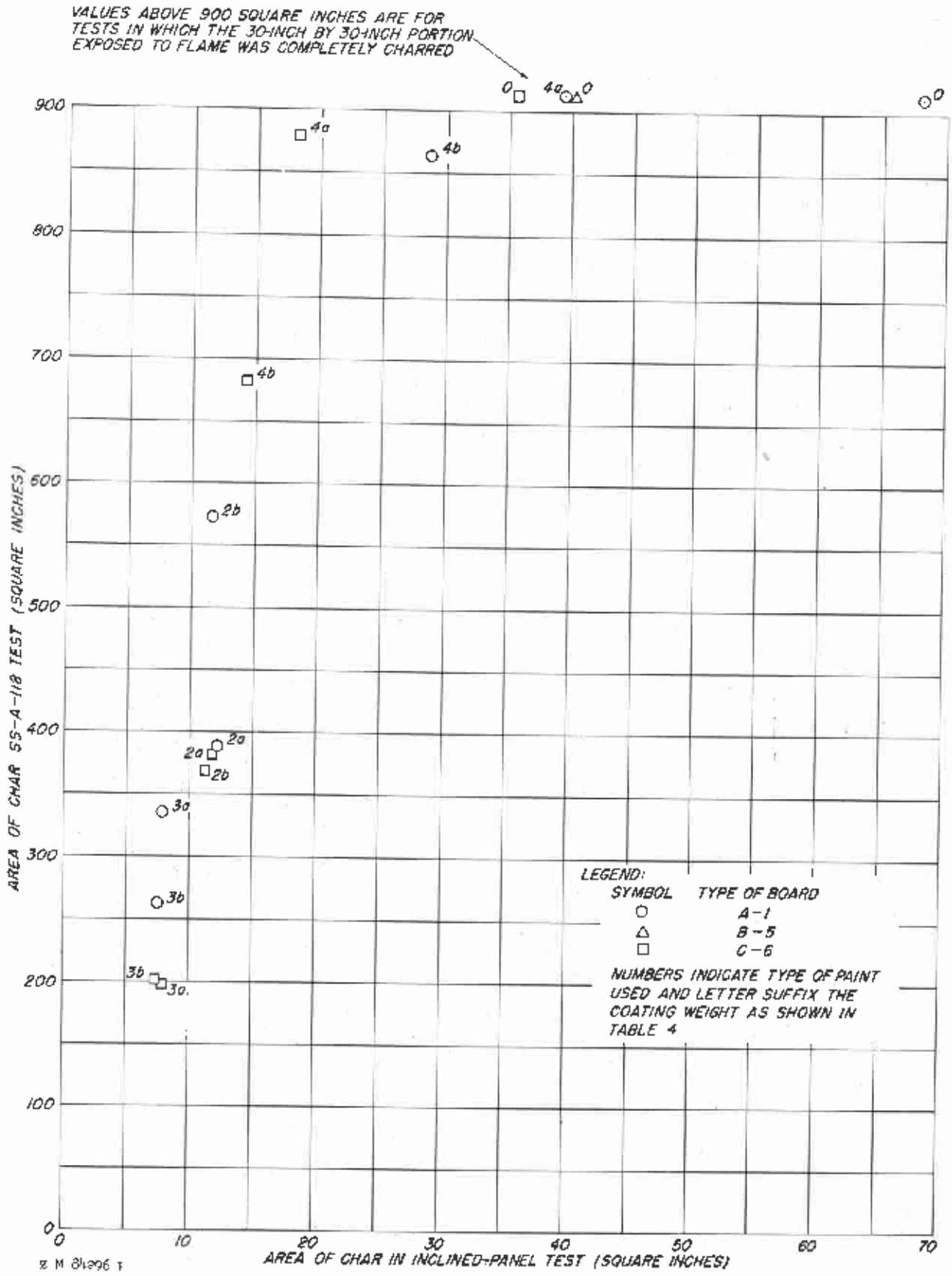


Figure 6. --Correlation between area of char in inclined-panel test and area of char in horizontal panel (SS-A-118a) test.

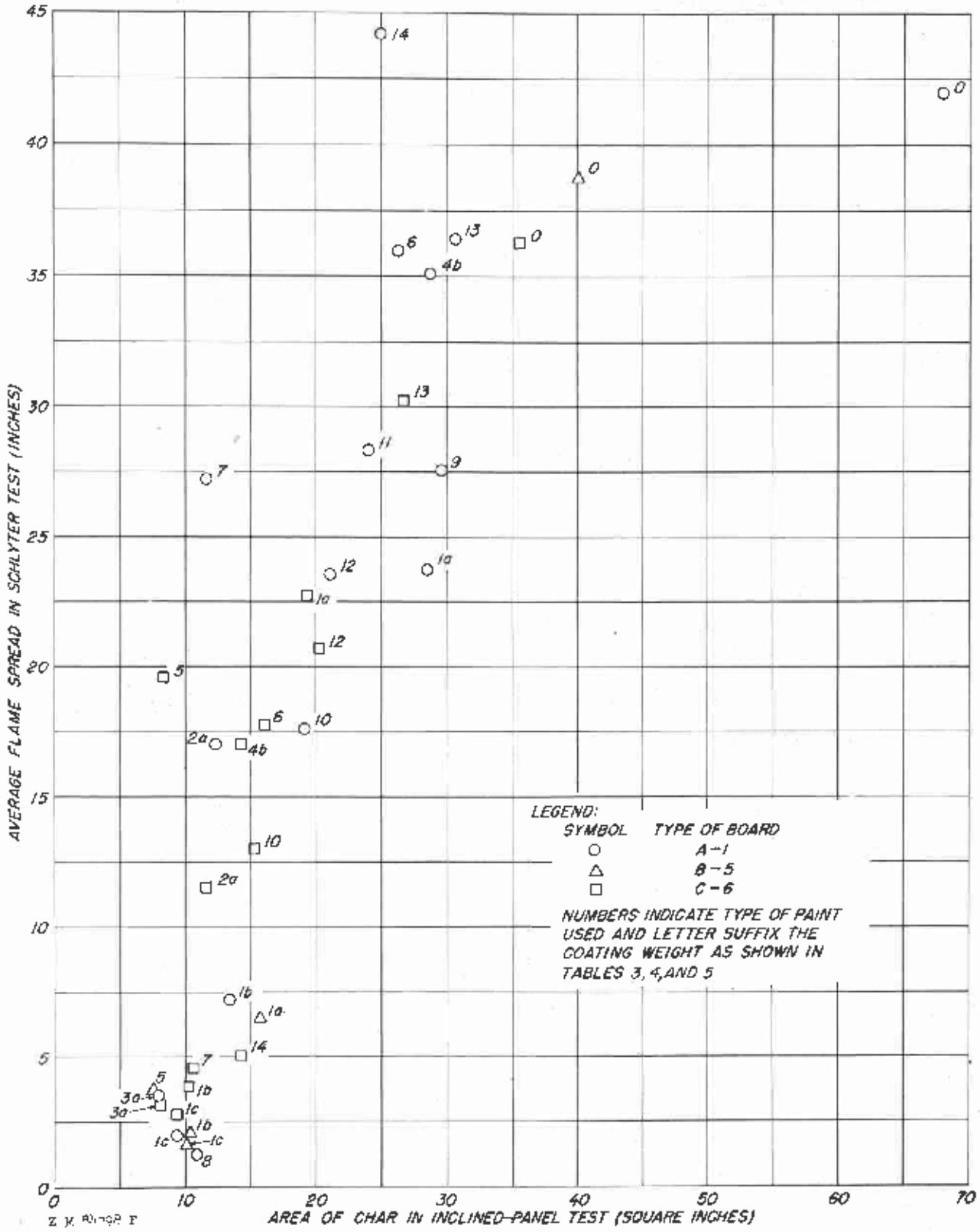


Figure 9.--Correlation between area of char in inclined-panel test and average flame spread in vertical panel (mild Schlyter) test.

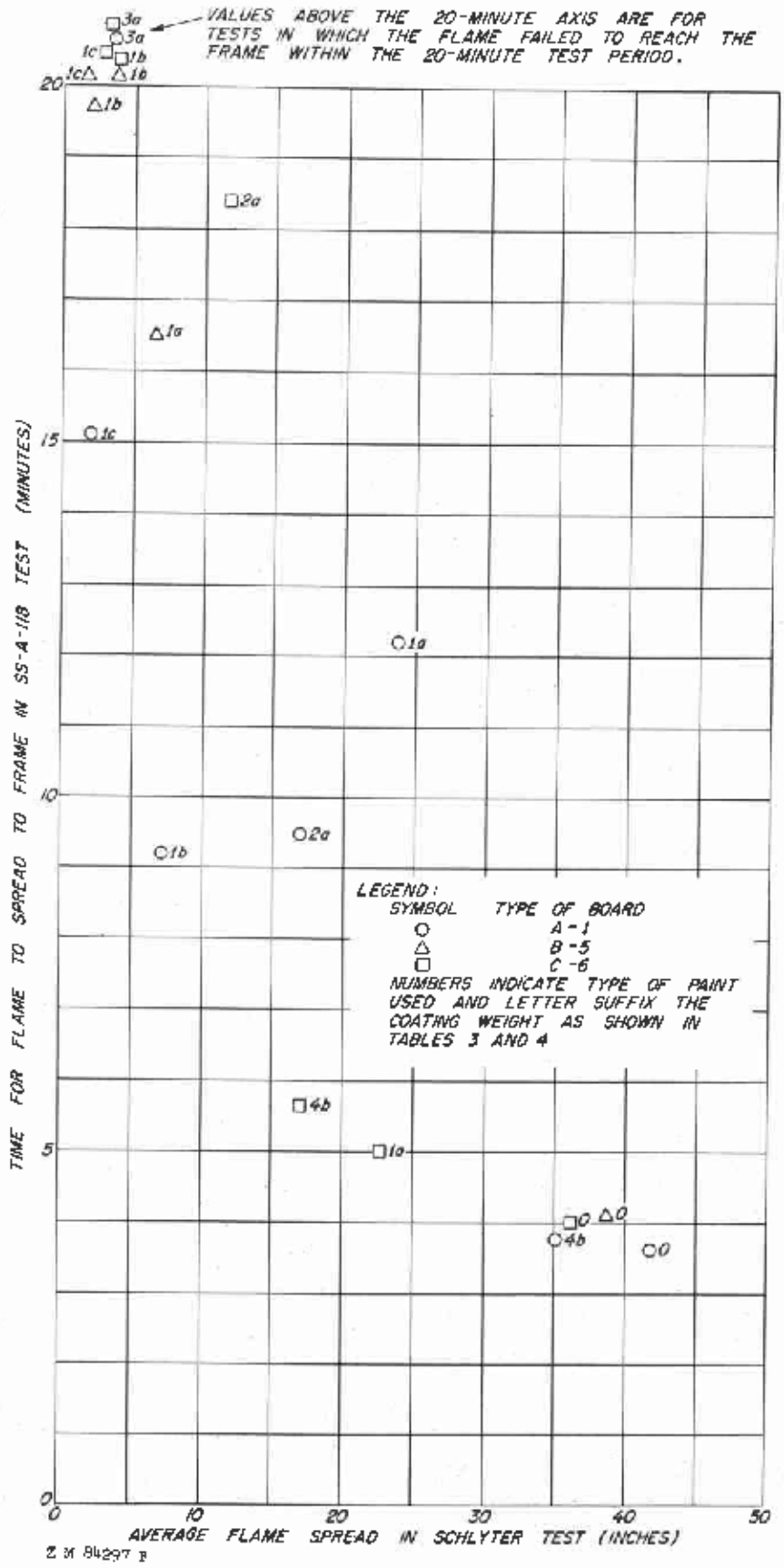


Figure 10.--Correlation between average flame spread in vertical-panel (mild Schlyter) test and time for flame to spread to frame in horizontal-panel (SS-A-118a) test.