NATIONAL BUREAU OF STANDARDS REPORT

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REPORT
OF
EXPERIMENTS TO DETERMINE THE FIRE RESISTANCES
OF
TWO PREFABRICATED WOOD WALLS

by

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NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

[illegible]

1. INTRODUCTION

Two walls assembled from insulated prefabricated wooden panels were subjected to standardized fire exposure in order to determine the fire resistance limits of the walls. One wall was of a design for the outside walls of a building and the other was of a design for fire-break walls. The first wall was made up of the prefabricated panels with bronze screen wire and an extra sheet of 1/4 in. marine grade plywood on the exterior surface and a proprietary vinyl plastic material applied to the interior surface. The second wall assembly consisted of two parallel walls of the prefabricated panels spaced 6 in. apart, which space was filled with insulating material. The vinyl plastic material was applied to both faces of the resulting assembly. All exposed wood surfaces were coated with a paint represented by the manufacturer as being resistant to fire. This work was requested by the Department of the Air Force in a letter of February 6, 1956, signed by Lt. Col. N. S. Stoliaroff of the Air Force Installations Representatives Office, North Atlantic Region.

2. [illegible]

The experimental specimens were assembled from the following material elements: prefabricated panels, 1/2 in. pipe, 1/4 in. marine plywood, bronze screen wire, vermiculite insulating fill, rubber edged wood splines, wood furring strips, paint, vinyl plastic material, nails and screws. The assemblies of the experimental specimens were carried out by craftsmen regularly employed by a commercial contractor.

2.1 Prefabricated Panels

The prefabricated panels, as delivered to the National Bureau of Standards, were 11 ft 4 in. by 4 ft 3 in. by 4 in. Each consisted of a wood frame faced with plywood and filled with glass fiber insulation. The frame consisted of three vertical studs, a top plate, a bottom plate, and horizontal bridging (or fire stops) at third points. The overall height and width of the frame were 10 ft and 3 ft 9 in., respectively. The studs visible along each edge and the top and bottom plates were 1 1/2- by 2 3/4-in. The intermediate stud and the bridging (or fire stops) were 1 5/8 by 3 1/2 in. The "interior" side of the panel was faced with 1/4 in. exterior-grade plywood in a single sheet 4 ft by 10 ft. This sheet lined up with the frame at top and bottom and along one edge but projected 3 in. beyond the other edge. The "exterior" side of the frame was faced with a single sheet of the same plywood 4 ft by 11 ft 4 in. that lined up with the edge of the frame at which the interior face plywood extended but extended 3 in. beyond the other edge and 8 in. beyond the top and bottom of the frame. Each extension of the 1/4 in. face plywood was backed with 3/4 in. plywood in pieces 1 1/2 in. wider than the extension. These pieces bore against the 1 1/2 in. faces of the edge studs and top and bottom plates. The plywood was attached to the frame by 4d galvanized annularly grooved (Potter ringed) box nails about 4 in. on centers into the studs, plates, and fire stops. In each panel, a 7/8 in. inside diameter fiber tube or sleeve was put through the studs parallel to and centered 2 1/2 in. from the top of the frame and another similarly located with respect to the bottom. All visible surfaces were covered with a coat of a gray paint represented to be fire resistant. Observations made after the fire tests indicated that all surfaces inside the panels were painted also, except those glued together. Four holes, each 5/16-in. diameter, were drilled in each vertical extension; one each about 4 in. from the top and bottom of the frame and the other two about 3 ft from top and bottom.

2.2 Accessory Materials

Materials used in the assembly of the prefabricated panels into one or both of the experimental specimens were:

a) Splines: 10 ft lengths of 2 by 3 in. wood members. The four long edges were recessed and slotted, and fitted with 3/8-in. diameter foam rubber beading, as shown in figure 1, detail A. There were 1 1/8-in. diameter holes through the splines centered 2 1/2 in. from each end, parallel to the 3 in. dimension. The wood surfaces were coated with the same paint as the panels.

b) Pipe: 16 ft lengths of 1/2-in. pipe, threaded both ends; with nuts and washers.

c) Marine grade plywood: 1/4-in thick plywood of marine grade (phenolic resin paper bonded to each face) in sheets 4 ft by 11 ft 4 in. This plywood came with the gray paint on both faces.

d) Paint: a gray paint manufactured by the S. K. Laboratories, Inc. (2402 Pennsylvania Avenue, Baltimore 17, Maryland) and labeled "'All Purpose' Fire and Weather Resist" -- Color No. 101; type Finish, was used for extra coats or to touch-up the paint already on the components of the assemblies. The paint already on the components was represented to be the same paint.

e) Plastic finishing material: a material consisting of a vinyl plastic coating on one side of a glass fabric came in 37 in. wide rolls. If the two rolls used, one came with a factory-applied adhesive on the glass fabric side, and one edge cut smooth; the other roll came without adhesive or cut edge. The material, known as Dexolium (The Dexolium Corp., South Norwalk, Connecticut), was a light gray color on the vinyl side; was from 0.015 to 0.023 in. thick, and weighed 0.1/4 lb/ft^2 without adhesive. With the Dexolium were used: "Fire Resistive Primer-Activator" 1402-4 (Benj. Foster Co.); L-7-AK-1 activator (The Dexolium Corp.); Clear Joint Sealer (The Dexolium Corp.); and an unlabeled adhesive.

f) Insulating fill: a coarse granulated vermiculite insulating fill (labeled "Zonolite Insulating Fill", net weight 18 lb, approximately 4 ft^3, Vermiculite Products Corp., Washington, D. C.), actual gross weight 26 lb/bag.

g) Hardware: a bronze screen wire of 0.010 in. diameter (No. 34 B&S) wires 14/in. in one direction and 16/in. at right angles, in a 48 in. wide roll. It weighed approximately 0.14 lb/ft^2. Various sizes of nails and wood screws were used.

2.3 Assembly of Specimens

Each specimen was assembled as much as possible in the horizontal position and then tipped up and bolted into a mounting frame.

2.3a) Outside wall. One of the prefabricated panels was laid in a horizontal position such that, when tipped upright and bolted into the mounting frame, the face away from the furnace fire would be the face that extended beyond the panel frame at top and bottom. This was the exterior face, and will be so designated in the remainder of this report. One of the 1/2-in. pipes was passed through the fiber sleeve at each end of the panel. One of the splines was placed on the pipes passed through the holes and was slipped up to the panel, resting on the extension of the exterior face along the panel edge. A second panel was similarly put "on the pipes" in position similar to the first panel and slipped into place, the extension of the interior face passing over the spline. Additional splines and panels were placed in the same manner until four panels and three splines were in place. The assembly was drawn together firmly by tightening nuts on the threaded ends of each pipe tie. Four 2 1/2-in. No. 20 flat head hot galvanized wood screws were driven into both sides of each spline, passing through the holes provided in the edge extensions of the panels. These holes had been countersunk and the screw heads were flush with or slightly below the panel surface. The extension of the exterior face was cut off flush with the panel frames along the bottom of the assembly to provide a flat surface to rest on the support in the mounting frame. The extension of the exterior face along the top was cut down to 1 5/8 in. above the frames of the panels. The extensions along each edge of the assembly were cut to about 1 in. to facilitate the fitting of the assembly into the mounting frame. The exterior face was given another coat of the SF paint by roller application.

), actual gross weight 26 lb\bag.

Bronze screen wire was laid on the exterior face in full height strips with less than 1 in. lap along the edges of the adjoining strips. These strips were stapled down along the top and bottom and along the edges of the assembly. Over the screen wire, 1/4-in. marine grade plywood, with AA paint on both sides, was nailed on with 6d annularly grooved box nails about 4 in. o.c. into the studs, plates, and bridging. This plywood was in 4 ft by 11 ft sheets. It was cut to length and placed vertically so the joints between sheets fell over the centers of the prefabricated panels. The exposed surface of the plywood was given two coats of AA paint after having been nailed down. Wooden batten strips of 1 1/2-in. diameter half rounds were placed over the joints between plywood sheets and attached by 2 in. No. 8 ga flat head wood screws about 12 in. o.c. The batten strips were given one coat of AA paint. The assembly then was tipped erect and placed in the mounting frame in a vertical plane.

One Dexolium with preapplied adhesive was cut in strips slightly over 10 ft in length. Starting at the edge of the assembly, the interior face was given a brush coat of the 140 x 42 Primer-Activator about 40 in. wide and full height of the wall. The surface was allowed to dry to a tacky condition and the Dexolium rolled on, starting at the bottom, and carefully smoothed by hand with some pressure. The manufacturer's representative who applied the Dexolium stated that the material was normally applied to the prefabricated walls while still in the horizontal position. Therefore, he was permitted to secure the top of each strip to the wall with large tacks to help support the Dexolium as the adhesive set. Subsequent strips were applied in the same manner with an overlap of about 2 in. on the preceding strip. Each strip was trimmed even with the top of the wall. The entire face was covered and then the joints closed by applying the 1-7-AA-1 activator to the back of the overlapping strip and the front or vinyl surface of the overlapped strip and pressing the former down firmly. The following day, the offset at the edge of the overlapping sheet was treated with two brush coats of clear joint sealer.

2.3b) Fire-break wall. Four of the prefabricated panels and three of the splines were assembled, in the horizontal position, the the same manner as described above for the outside wall. Four more prefabricated

panels were assembled, with splices, in the same manner on top of the first assembly, while both were in the horizontal position. The edge and bottom extensions were cut off as for the outside wall. However, the top extensions were cut off flush with the top of the panel frames. No screen wire nor extra layers of plywood were applied. The painted surfaces were touched up but not given additional full coats. The two assemblies were separated and 1 by 1 in. wooden furring strips were nailed across the bottom and up both edges of one face of each assembly. The two assemblies were placed with the furred faces in and were joined together by placing 6 in. wide by 10 ft long strips of 1/4-in. plywood at right angles to the assembly faces and nailing them to the furring strips. This produced a wall 13 7/8 in. thick with a 6 in. air space in the middle. Five 1-in. wide and 11 1/2-in. long strips of 3/16-in. steel were attached along each edge to provide additional strength for erection. The wall was tipped upright and the 6 in. cavity filled with vermiculite insulating fill. A total of 23 bags, each containing about 4 ft^3, were emptied into the cavity. The wall was tamped vigorously by hand to induce any settling of the fill that might occur, and the cavity was filled to the top. The wall was then fastened into the mounting frame. The surface to be exposed to the fire was covered with Dexolium of the same type and in the same manner as the to-be-exposed surface of the outside wall. The not-to-be-exposed surface of the fire-break wall was covered with Dexolium, also. One strip was of the material with preapplied adhesive but the remainder were of the material without adhesive. For the strips without adhesive, the adhesive was brushed on the wall surface and the Dexolium applied. All the strips on each surface were tacked across the top and bottom. The overlapped joints were closed and sealed in the same manner as those on the outside wall.

3. EXPERIMENTAL FACILITIES AND PROCEDURE

The experimental determinations of the fire resistances of the walls were made in facilities of the National Bureau of Standards designed and regularly used for such purposes. The procedures followed were those usually followed and were in accordance with standard methods generally recognized throughout this country.

3.1 Furnace and Mounting Frame

The experiments were conducted in a gas fired furnace in the form of an open box which was closed by the test

wall and mounting frame. The furnace was equipped with 96 gas burners in the back wall and with observation windows in each side wall to permit observations of the exposed surface.

Each wall was mounted in a movable frame suspended from overhead beams. The frames were rectangular steel and concrete panels with smaller rectangular openings in which the walls were mounted. The opening in each frame was approximately 16 ft wide and 16 ft high. The bottom of the opening consisted of two lengths of heavy steel channel, each of which rested on two hydraulic loading pistons. The channels and pistons were protected by a concrete apron on the fire side.

Each wall was mounted in a separate frame, the bottom of the wall resting on the steel channels. The spaces between the frame and the ends of the walls were packed with mineral wool. The outside wall was held in place at the top by nails driven through the 1 1/2-in. extension of the exterior face into a 4 by 4 securely attached to the mounting frame. The interior fire-break wall was held in place at the top by a 2 by 6 in. timber securely attached to the mounting frame. The wall was put in the frame so that this timber fitted into the 6 in. space between the two elements of the double wall. The top, bottom, and side edges of each wall were protected on the fire side by brick or metal lath and plaster.

3.2 Instrumentation

Temperatures in the furnace chamber were measured by means of chromel-alumel thermocouples connected to self balancing potentiometers calibrated to read in degrees centigrade. The wires were put through porcelain insulators and encased in iron pipes. Temperatures on the unexposed surface of each wall were measured by similar thermocouples encased in asbestos sleeving except for the junction and wires immediately adjacent. The junction and a short length of the wires of each surface thermocouple were cooled under a 4 by 6 by 0.4 in. felted asbestos pad secured to the wall. The horizontal deflections of each wall from its initial position were determined by measurements between the unexposed surface and vertical wires suspended from the mounting frame. Twelve thermocouples were distributed symmetrically in the furnace chamber and twelve other thermocouples were located symmetrically on the unexposed surface of each wall. Deflections were measured at nine points on the unexposed surface.

3.3 Experimental Method and End Point Criteria

Each mounting frame and specimen were placed to close the furnace and clamped in place. The outside wall, experimental test 352, was restrained against vertical expansion but not loaded since the design load was so small that accurate application would have been difficult. The interior fire break wall, experimental test 353, was loaded to 1100 lb per linear foot of width. In each experimental test, flames from the burners were directed against the specimen and regulated so that the furnace temperatures approximated those of the standard time-temperature curve defined in Standard Methods of Fire Tests of Building Construction and Materials, ASTM designation E119-51, which include: 1000°F(538°C) at 5 min, 1300°F(704°C) at 10 min, 1550°F(843°C) at 30 min, 1700°F(927°C) at 1 hr, and 1850°F(1010°C) at 2 hr. Observations of the furnace temperatures, unexposed surface temperatures, deflections, and physical conditions of the specimen were made and recorded throughout each experimental test so that the end point that determined the fire endurance of each wall might be known.

The fire endurance of a wall or partition is determined as the time when any of the following first occurs: 1) the average temperature of the unexposed surface becomes 250°F higher than its initial temperature, 2) the temperature at any one point on the unexposed surface becomes 325°F higher than its initial temperature, 3) flames or gases hot enough to ignite cotton waste issue from the unexposed surface, 4) the specimen shall fail to sustain the applied load (applicable to loaded walls only).

3.4 Supplementary Tests

In addition to the determinations of the fire resistances of the two walls, certain other determinations were made of various characteristics of the materials that made up the walls. Experiments were initiated to determine the vapor permeabilities of the Dexolium, marine grade plywood, and exterior grade plywood with and without Dexolium. Samples of the same Dexolium used on the experimental walls and of that supplied under an Air Force contract were included. These experiments were carried out under the provisions of ASTM specification C21-48T with the following modifications: 1) the wet cup method was not employed, 2) the experimental conditions were 100°F ± 1°F and 82 percent relative humidity, ±2

percent, 3) the area of the exposure surface was 11.4 sq in., 4) silica gel was used as the desiccant.

Experiments were carried out to determine the ignition temperatures of the Dexolite. Specimens about 1/2 by 3/4 by 3/4 in., made up of several layers of the Dexolite with prepasted adhesive, were suspended in the space inside an electrically heated furnace. The temperature of the specimen was measured by a thermocouple junction between the two lowest layers of material. Air was introduced into the furnace inside the cylinder on which the heater wire was wound, passed down the wall and under the bottom end of and up through an inner concentric refractory cylinder. The furnace was heated to a desired temperature, as measured by a thermocouple in the air within the inner cylinder, and the specimen introduced into the space just above this thermocouple. The self ignition temperature of the material was determined as the lowest initial furnace-air temperature at which a fresh specimen when introduced eventually glowed or flamed without an outside source of ignition. The flash temperature was determined as the lowest initial furnace-air temperature at which a fresh specimen when introduced eventually released gases which were ignited by a small pilot burner at the top of the furnace. A more detailed description of the experimental method is given in "A Method and Apparatus for Determining the Ignition Characteristics of Plastics", T. J. Ontenko, RP 2034, Journal of Research of the National Bureau of Standards, vol 43, December 1949.

4. Results

The results are given as summaries of the observations, plots of the temperatures and representative photographs.

4.1 Outside Wall-Experimental Test 35

This wall consisted of an assembly of prefabricated wooden panels with an extra layer of marine grade plywood on the exterior or unexposed surface and with Dexolite, a glass backed vinyl plastic material, on the interior or exposed surface. The following are the more important observations of the specimen during the fire exposure.

Time hr:min:sec	Description
0:0:30	Flash of flame over Marinite
0:02:00	Visibility in furnace chamber obscured
0:04:00	Heavy flames from joints in exposed surface, cracking sound
0:05:30	Piece of the glass fabric backing of the Marinite fell from North end of exposed surface. Dense white smoke outside furnace
0:13:00	More glass fabric fell
0:17:00	Glass fiber insulation in panel melting and falling where plywood surface burned off
0:19:00	All plywood burned off exposed surface
0:25:00	Uniform flaming on exposed side from all studs and splines. Severe cracking sounds heard during last 10 min.
0:39:00	Blistering and scorching of paint at two locations on unexposed surface
0:42:00	Blackening of unexposed surface at two locations. Flames outside furnace through joint between mounting frame and top of wall
0:52:00	Blackened spots about 1 ft diameter 2 ft from bottom at 1,3,5,7, and 9 ft from North edge of unexposed surface
0:55:00	Continued burning of studs, most of insulation still in place
1:00:00	Additional blackened areas on unexposed surface
1:03:45	Flames through about center of unexposed face
1:04:30	Furnace fires off
1:06	Flames through at two other locations

The specimen and frame were removed from before the furnace and all flaming extinguished by the water stream from a small hose. All the studs were badly charred. The glass fiber insulation was fused on the back of the unexposed surface plywood.

The temperatures observed during the experimental test are represented in figure 2. The temperature at one thermocouple on the unexposed surface had risen 181 degree F above the initial temperature at 30 min and the average on the unexposed surface had risen 250 degree F above the initial temperature at 42 min. The average furnace temperatures were higher than those of the standard time-temperature curve during most of the test. The fire exposure severity, defined as the ratio of the area under the curve of average furnace temperature to the area under the standard time-temperature curve, was 121 percent. Therefore, a correction of +6 min was applicable to the 30 min limiting time, making the corrected fire endurance of the experimental specimen 44 min.

The deflections measured at nine locations on the unexposed surface were all in the direction away from the furnace fires. Those at the four locations having the largest deflections were as follows:

Time	Deflections, inches			
minutes	Top Center	Top North	South Center	Center
0:00	0	0	0	0
0:10	0	0	0	0
0:20	1/8	1/8	1/8	1/8
0:30	1/8	1/8	3/8	1/8
0:40	1/8	1/4	1/2	1/4
0:50	1/4	1/2	3/4	1/8
0:55	3/4	1 1/8	1/2	3/8
1:00	1 1/4	1 5/8	1 5/8	1

4.2 Fire-break wall-experimental test 353

This wall consisted of two parallel assemblies of prefabricated insulated wood panels with a 6 in. space between. This space was filled with a loose vermiculite insulation and Dexolian was applied to both faces of the double wall.

Time hr:min:sec	Observation
0:01:00	Celotex on exposed surface flashed into flames, much black smoke
0:06:30	Glass fabric backing of Celotex down from about one-fourth of exposed surface, plywood ablaze
0:09:00	Plywood burned off above area, area of glass fiber insulation fell
0:21:00	Plywood burned off entire exposed surface, glass fiber insulation appears white, compressed and flaky
0:28:00	Light yellow smoke from around edges of unexposed surface; glass fiber insulation peeling from one panel on exposed side
0:30:00	Vermiculite insulation granules pouring into furnace chamber, studs of exposed side panels thoroughly charred
0:38:00	The appearance of the unexposed surface unchanged
0:44:00	The inner surface of the unexposed side panels ablaze
0:48:00	Celotex blistering on unexposed surface
0:50:00	Studs of exposed side panels thoroughly charred but in place
0:54:00	Brown-orange discoloration of unexposed surface Celotex on three blisters
0:55:00	Discolored spots turning black
1:00:00	Eight discolored spots on unexposed surface each 6 to 12 in. diameter
1:01:00	All the studs that had been at the centers of the exposed side panels burned away
1:05:00	Deflections increasing; load off

Time hr:min:sec	Observation
1:05:30	Flames through wall 3 ft from bottom and 7 ft from north edge
1:06:00	Flames through 5 ft from north
1:07:00	Furnace fires off
1:10:00	Gasoline burned to top of unexposed surface from hole 3 ft from north edge and 3 ft from bottom, no lateral spread; burned about half way to top 7 ft from north and died out

The specimen and frame were removed from before the furnace and a water stream played on from exposed side. The panels that had made up the exposed side of the wall were almost completely gone. The plywood was burned from the inner faces of the panels that made up the unexposed side of the wall and the glass fiber insulation was white and matted. Over some areas, it had a granular texture in place of the original fibrous texture.

The temperatures observed during the experimental test are represented in figure 2. The temperature at the thermocouple on the unexposed surface had risen 327 degree F above the initial temperature at 57 min and the average at all the thermocouples on the unexposed surface had risen 250 degree F above the initial average at 1 hr. The average furnace temperatures were somewhat higher than those of the standard time-temperature curve during part of the test. The fire exposure severity was 107 percent. A correction of +2 min was applicable to the 57 min 11 sec, making the corrected fire endurance of the experimental specimen 59 min.

The greatest deflections were observed at the three locations nearest the bottom of the wall. They were as follows:

Time min	Deflection in inches		
	Lower Left	Lower Center	Lower Right
No load	0	0	0
0:00	3/16	0	0
0:06	3/16	0	1/8
0:11	3/16	0	1/8
0:16	1/4	1/16	0

Line	Deflection in inches		
Mark	Lower Wall	Lower Ceiling	Lower Wall
0.00	1/4	1/16	1/8
0.25	1/4	0	1/8
0.50	7/16	1/4	1/4
0.51	7/16	1/4	3/8
1.03	13/16	7/8	1 3/8

All deflections were in the direction away from the furnace fires.

4.3 Results from Supplementary Tests

The experiments to determine the vapor permeabilities of various components of the walls require a considerable period of time and have not been completed. Therefore, no results are available but will be reported separately when ready.

The experiments to determine the ignition temperature of the hexolite gave the following results:

Self ignition temperature (no outside ignition source)
..... 760°F (376°C)

Flash temperature (small pilot flame)
..... 671°F (355°C)

Several strips of hexolite, each about 4 by 4 inches, were held in the open flame of a gas burner and removed. The hexolite, with and without admixture, burned freely while in the flame but went out quickly when removed, unless over half consumed before being removed. A residue of the blackened glass fabric remained from the burned over areas.

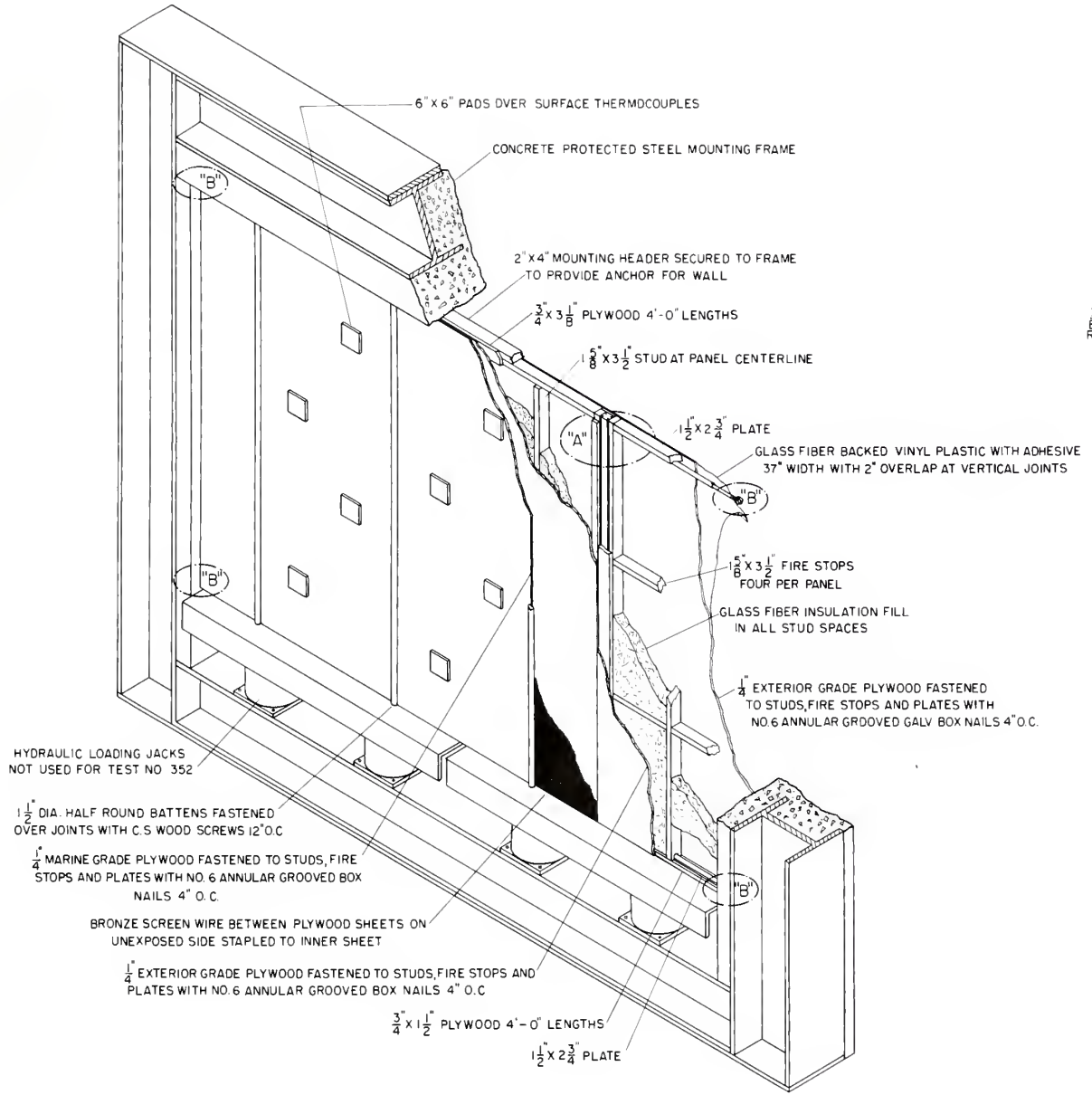
5. [illegible]

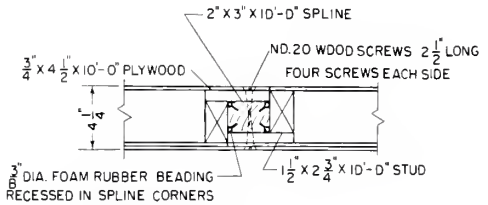
In each experimental test, the hexolite in the exposed surface burst into flame at or over 1 minute. Large quantities of black smoke were produced from the burning hexolite. The glass fabric backing remained in place for several minutes and appeared to prevent flaming of the plywood beneath. When exposed, the plywood burned off quickly. The glass fiber insulation in the panels turned white as the binder burned out of it. As the tests progressed, the glass fiber insulation shrank and more of it lost its fibrous texture. In most cases a hole burned through the exposed side panels of the fire area

wall, the vermiculite loose fill poured out. Ignition of the unexposed surface was ignited where the wall burned through and burned up the wall but ignition did not spread laterally.

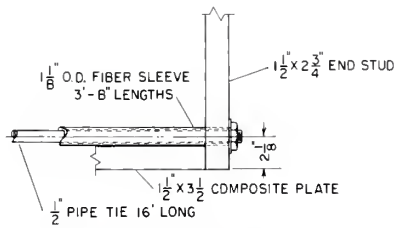
The vigorous burning of the largely combustible walls added much heat to that given off by the gas flames from the burners. This caused the furnace temperature to be higher than intended during part of each test. The fire resistance of each wall was limited by a temperature rise of 325° F above the initial at a single thermocouple on the unexposed surface. The limits, as corrected for the high furnace temperatures, for the individual specimens tested were 44 min for the exterior wall; 57 min for the fire-break double wall. Each wall remained a barrier to the passage of flame for slightly over 1 hour. The deflections, although not large during the fire exposure periods, were increasing rapidly at the end of each, indicating that load failure was imminent.

Figure 1. Construction and mounting details of prefabricated wooden exterior wall.





DETAIL OF PANEL JOINT AT "A"



DETAIL OF PIPE TIE AT "B"

FIG. 1 CONSTRUCTION AND MOUNTING DETAILS OF PREFABRICATED WOODEN EXTERIOR WALL

94716-1

Figure 4. Temperatures observed during fire endurance tests.

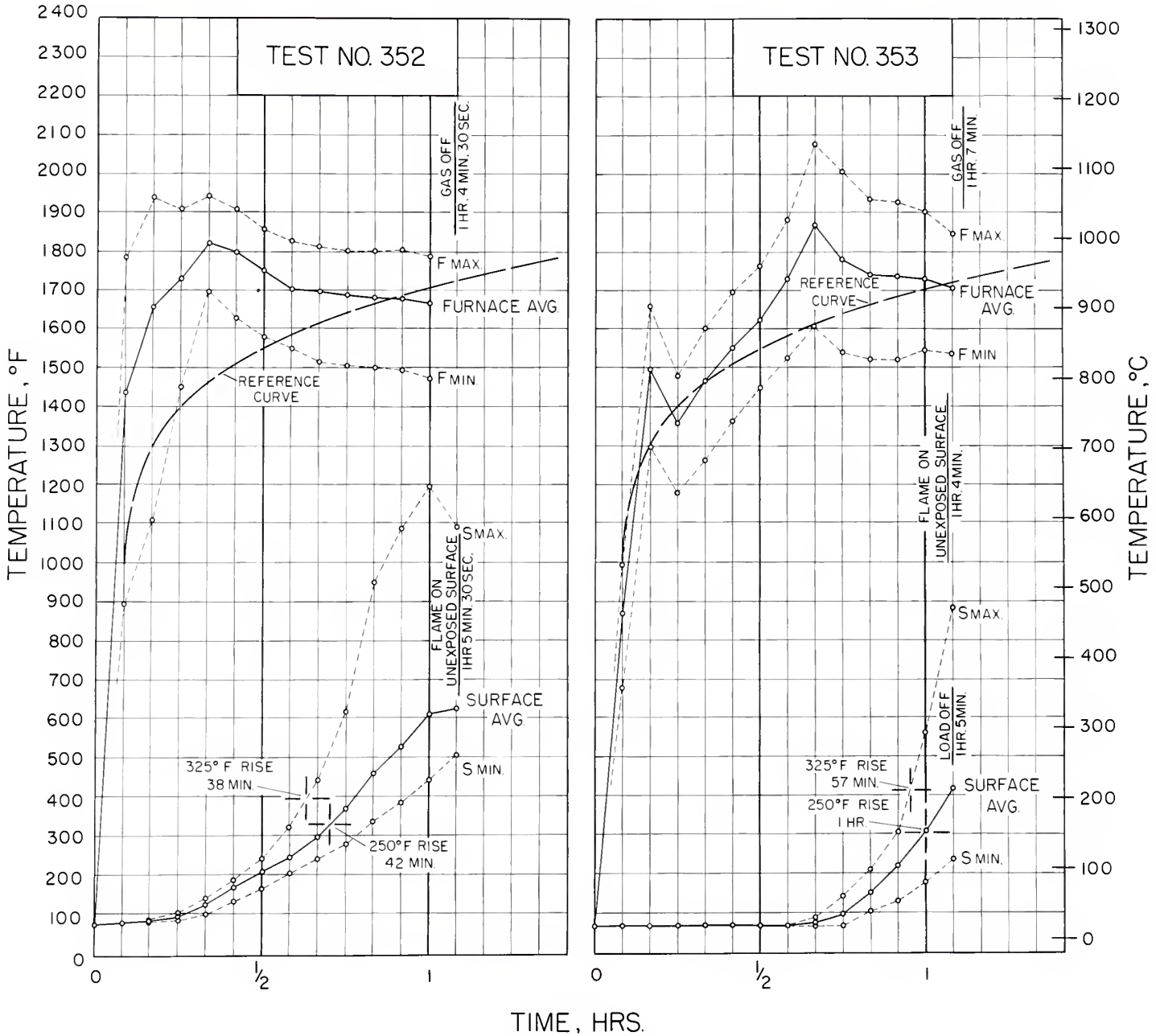
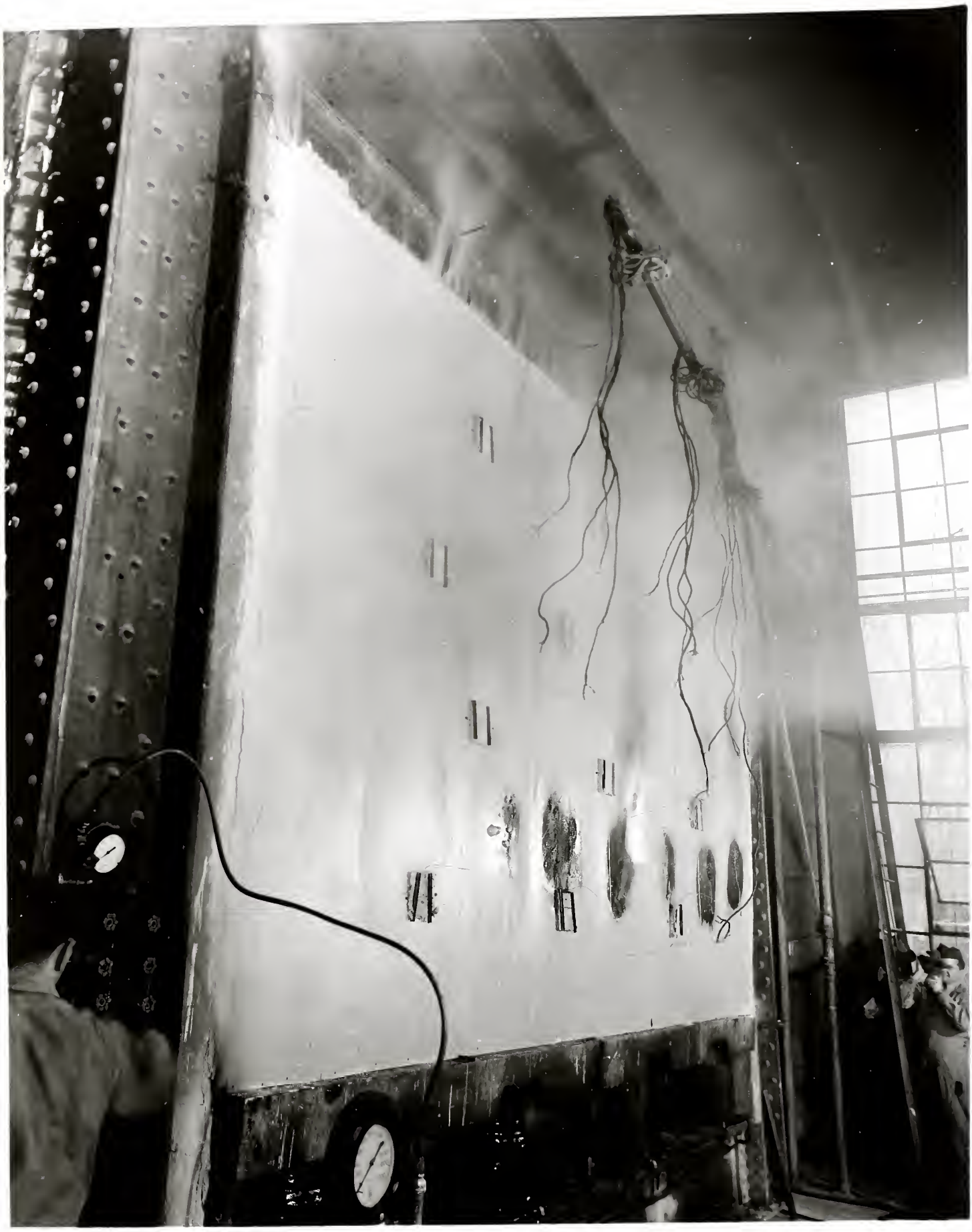


FIG. 2 TEMPERATURES OBSERVED DURING FIRE-ENDURANCE TESTS

24716-2

Figure 3. Exposed surface of exterior wall after fire endurance test 3½.

Figure 4. Exposed surface of fire-break wall as flames started at 1 hr 34 min of fire endurance test [3].



24689-3

Figure 5. Remains of fire-break wall from fire side after test 1½.

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