

## NRC Publications Archive Archives des publications du CNRC

### Fire tests of wood door assemblies Galbreath, M.

For the publisher's version, please access the DOI link below. / Pour consulter la version de l'éditeur, utilisez le lien DOI ci-dessous.

#### **Publisher's version / Version de l'éditeur:**

<https://doi.org/10.4224/40001343>

*Fire Study (National Research Council of Canada. Division of Building Research),  
1975-05*

#### **NRC Publications Archive Record / Notice des Archives des publications du CNRC :**

<https://nrc-publications.canada.ca/eng/view/object/?id=1993fe0d-30fa-460f-9c5e-a2d5167b4921>

<https://publications-cnrc.canada.ca/fra/voir/objet/?id=1993fe0d-30fa-460f-9c5e-a2d5167b4921>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

**Questions?** Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

**Vous avez des questions?** Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

NATIONAL RESEARCH COUNCIL OF CANADA  
DIVISION OF BUILDING RESEARCH

ANALYZED

FIRE TESTS OF WOOD DOOR ASSEMBLIES

by

M. Galbreath

Fire Study No. 36

of the

Division of Building Research

OTTAWA

May 1975

# FIRE TESTS OF WOOD DOOR ASSEMBLIES

by

M. Galbreath

## ABSTRACT

Standard Fire Tests to ASTM E152 were conducted on 26 solid core and particleboard core wood doors in wood and steel frames in order to investigate the behavior of a typical suite door and to develop a door assembly having a 20-min fire-protection rating.

## ESSAIS SUR LA RESISTANCE AU FEU D'UN ASSEMBLAGE DE PORTE EN BOIS

## SOMMAIRE

Des essais standard de résistance au feu jusqu'à ASTM E152 ont été menés sur 26 portes de bois à âme massive et à âme d'aggloméré, dans des cadres de bois et d'acier, afin d'étudier le comportement d'une porte typique de chambre et d'élaborer un assemblage de porte dont le degré de protection contre le feu atteindrait 20 minutes.

# FIRE TESTS OF WOOD DOOR ASSEMBLIES

by

M. Galbreath

The National Building Code of Canada<sup>1</sup> has for many years required that doors in fire separations have a fire protective rating. There has been an exception in that for certain applications, such as entrance doors to suites, no fire test was required for a solid core wood door in a wood frame. The 1970 edition of the National Building Code including revision series No. 2 required a 20-min fire protective rating for door assemblies other than the solid core wood door assemblies in those locations where the solid core wood door had traditionally been accepted. The committees on the National Building Code, wishing to reconsider the exemption from test granted to the solid core wood door assembly, asked for information on the performance of these assemblies to establish whether such a door assembly could be expected to provide a 20-min fire protective rating. The Division of Building Research has therefore conducted a series of 26 fire tests of solid core wood door assemblies in accordance with the provisions of the Standard Method of Fire Test of Door Assemblies ASTM E152-72.<sup>2</sup>

Solid core wood doors and particleboard core doors 1 3/4 in. thick were purchased on the open market and may be regarded as typical of the doors being produced in Canada at this time. The doors were installed in wood and steel frames mounted in wood stud walls. Details of the test specimens and records of observations made during the tests are given in Appendix A.

It is not possible to assign a fire resistance to a door itself. The performance in the Standard Test depends on the contribution of, and inter-relationship between the door, the frame and the hardware. As will be seen from the record of tests of door assemblies, if the solid core wood door assembly is to attain the 20-min fire protective rating, attention must be paid to the manufacture of the door and to the details of its installation in the wall.

## TESTING PROCEDURE

The fire endurance tests were carried out in accordance with ASTM E152-72. The furnace temperature was measured by nine symmetrically distributed thermocouples enclosed in Inconel tubes 13/16 in. O.D. and a 0.035-in. wall thickness. The tubes were equipped with a carbon steel cap at the tip. The hot junction of the thermocouples was placed 6 in. away from the exposed surface of the specimen. Both the individual temperatures at the nine points of the furnace and the average of the nine temperatures were recorded. The fuel input to the furnace was controlled to make the average temperature follow the prescribed temperature versus time curve.

The test standard requires that the clearance between door and frame be  $3/32$  in.  $\pm 1/16$  in. at top and sides and  $3/16$  in.  $\pm 1/16$  in. across the bottom. Temperature rise on the face of the door is not considered to be a cause for failure. Criteria for fire performance are that the door remain in the opening during the fire endurance test and the hose stream test within the following limitations:

The movement of swing doors shall not permit any portion of the edges to move from the original position more than the thickness of the door during the first half of the classification period nor more than  $1\frac{1}{2}$  times the thickness during the entire classification period.

An assembly consisting of a single swinging door shall not separate more than  $1/2$  in. at the latch location.

The test assembly shall have withstood the fire endurance test and hose stream test without developing openings anywhere through the assembly, except that small portions of glass dislodged by the hose stream shall not be considered a weakness.

#### EXAMINATION OF CORES

During the fire test series it was found that failure occurred on several occasions as a result of formation of holes through the door. This type of failure appeared to be associated with the presence of gaps in the core exceeding the  $1/16$  in. that is specified in CSA Standard O132.2.<sup>3</sup>

A number of doors were exposed in the fire test furnace to temperatures on one side up to  $200^{\circ}\text{F}$  and warm areas on the nonexposed face were identified by use of an infrared scanner. It proved difficult to obtain precise information using this technique because of the transitory nature of the phenomenon and because the presence of knots was indistinguishable from the presence of gaps. Some indication was, however, obtained of the location of possible weak points.

The reverse faces of some doors were planed off to expose the core material. Figure 1 shows the face of a door with lines marked on to indicate the presence of warm areas identified by the infrared scanner. Figure 2 shows the reverse side of the same door after the facing had been planed off. Figure 3 compares the results of the infrared scan with the presence of major gaps and knots in the core. A part of another door in Figure 4 shows in more detail the principal gaps which were from  $1/16$  in. to  $1/8$  in. wide. In all of the solid core doors built of natural wood strips the core material was cedar. This is a low density wood having a specific gravity of about 0.29 which may be compared with ponderosa pine, 0.38, and douglas fir, 0.45.

This may be of some significance as the depth of penetration of char would be expected to be greater for woods of lower density, other factors being equal.<sup>4</sup> This may account in part for the difference between the results obtained in this series of tests with those obtained by Eickner<sup>5</sup> of U.S. Forest Products Laboratory in tests of solid core wood door assemblies in which more dense-core wood was employed.

The temperature on the unexposed surface of each door was measured by three thermocouples located on the vertical centre line at the centre and quarter points of the door and covered with standard asbestos pads 6 in. square and 0.4 in. thick. The position of these thermocouples is shown in Figure 5. Temperatures recorded are shown in the graphs referenced for each test in Appendix A.

Because of the short duration of fire exposure (20 min) and the heat contributed by the burning of the exposed wood surfaces, it is difficult to keep close to the standard time temperature curve. It can be seen that in one test where the furnace temperatures were low throughout the period of fire exposure (4A) the fire performance of the assembly was significantly better. This suggests that close control of furnace temperatures may be important if tests are to be reproducible.

#### PRESSURE DIFFERENCES

Pressure differences across doors were not measured for each test but generally followed the same pattern. With the exception of those periods when the burners cut back, the pressure differences across the doors averaged approximately -0.5 mm water gauge at the top of the door, -1.2 mm water gauge in the centre, and -2.3 mm water gauge at the bottom. During periods when the burners were off, which occurred generally between 2 to 4 min after the start of the test, the pressure difference decreased at the bottom and reversed direction at the top of the door.

#### PERFORMANCE IN THE FIRE TESTS

It is evident from the reports of the tests that have been conducted on wood door assemblies by other laboratories that the fire performance depends not only on the behavior of the individual components, door, frame and hardware, but also on the interaction between them. The approach taken in this series was to attempt to identify, by a series of exploratory fire tests, the significant factors and to eliminate progressively the weak parts of the assembly.

Six types of failure in wood door assemblies exposed to the standard fire test can be recognized:

- formation of a hole through the door,
- formation of a hole between door and frame,
- formation of a hole adjacent to a hinge,
- formation of a hole adjacent to the latch set,
- opening of the door into the furnace,
- formation of a hole through the trim between door frame and wall.

The times to failure by each of these criteria are summarized in Table VII.

#### 1. Formation of a Hole Through the Door

The CSA specification for wood doors<sup>3</sup> describes three types of core for a solid core wood door:

- natural wood cores glued to the facing material but not to each other,
- natural wood cores glued to each other and to the facing material, and
- wood particleboard manufactured cores with edge strips of natural wood.

Where the natural wood core pieces are not glued to each other the CSA specification permits gaps in the core not exceeding 1/16 in. In wood doors of this type obtained on the open market, gaps were found to exceed this limit (see Figure 2). In Table I are shown the times at which char marks first appeared on the unexposed surface over gaps in the core and the time at which holes first appeared for those doors that had natural wood cores. One of these doors, No. 8A, had edge glued core pieces and presumably no gaps. Another, No. 13A, was specially produced by the manufacturer in an attempt to eliminate gaps over 1/16 in. wide. In door 11A there was an early formation of a hole at 8 min. This can be explained in part by the fact that the latch cylinder was directly in the centre of a wide gap and the initial holes occurred over the gap immediately above and below the latch cylinder. If this door is neglected holes through the doors occurred at 11 min and over in 6 tests and in 5 doors, two of which are assumed to be of better quality, no such failure occurred during the period of fire exposure, 21 min.

#### 2. Formation of a Hole Between Door and Frame

Where a wood door is installed in a wood frame, destruction of the wood surfaces takes place in the gap between door and frame leading to the formation of a hole directly through the assembly. In Table II the times

at which holes appeared between door and frame are summarized. For door assemblies without any special treatment holes occurred at 13 and 15 min. For door assemblies in which the edge of the door and the edge of the frame were given two coats of an intumescent paint listed by Underwriters' Laboratories of Canada, <sup>6</sup> failure occurred on only one occasion, No. 13A at 18 min. It was observed, however, that the coat of intumescent paint was very thin and subsequent application of a blow torch to undamaged portions of the surface showed little or no intumescence.

For a wood door installed in a steel frame a hole between door and frame was recorded at 17 min (door 10B) but this particular point of failure occurred immediately beside a hole over a gap in the core that developed at the same time (see Figure A-60, Appendix A). Door 10A, without intumescent paint, showed no signs of failure between door and frame at 21 min.

### 3. Formation of a Hole Adjacent to a Hinge

The occurrence of a hole close to a hinge appears to be due in part to conduction of heat through the metal to the wood surface. A secondary effect of holes beside the hinges is that the screws holding the door may fail allowing the door to fall from the frame. A hole beside a hinge occurred in door 7B at 14 min (see Table III). This was, however, a particleboard core door that had a significant gap between the core material and the narrow wood style. In door 1B a hole was observed at 15 min, but for other doors with normal installation no failure occurred in 20 min. Asbestos paper was installed under hinges in a number of assemblies and no holes occurred when this precaution was taken in 6 doors.

### 4. Formation of a Hole at the Latch Set

The times when holes first appeared at the latch set are shown in Table IV. Three types of latch set were used:

- a standard duty latch set having 3/8-in. latch throw, and a drum-shaped cylinder closely fitted to the hole drilled through the wood door,

- a standard duty latch set having a 1/2-in. latch throw and in which the cylinder was spool-shaped leaving a gap between cylinder and wood,

- a heavy duty latch set having a 1/2-in latch throw and in which the cylinder was drum-shaped and of heavier metal than in the other latch sets.



In some of the doors asbestos paper was wrapped around the cylinder to protect the wood from heat transmitted through the latch set. As can be seen from Table IV, for doors in wood frames both with and without asbestos paper, the minimum time to the occurrence of a hole through the door was 19 min with the exception of door 11A in which a gap in the core contributed to earlier failure. There was also a hole through door 3A at 16 min. This was in a steel frame assembly, and the hole occurred over the barrel of the latch set between the knob and the edge of the door.

#### 5. Opening of Door into Furnace

Tables V and VI show the times of failure by opening of door into the furnace. In door assemblies incorporating steel frames failure due to warping of the frame occurred in 2 and 3 min. Where this was prevented by adequate blocking between frame and stud wall, and using latch sets with 1/2-in. throw, no failure occurred in 20-min exposure.

In assemblies incorporating wood frames and latches having 3/8-in. throw, in the initial tests no door assembly lasted more than 17 min. In door assemblies having latch sets with 1/2-in. throw, failure occurred between 11 min and 20 min because of failure of the screws holding the strike plate to the frame. Corrective measures such as use of 1/4-in. asbestos cement board under the strike and 1 1/4-in. screws were effective in ensuring that the latch strike did not fail in 21 min. In two door assemblies, 11A and 11B, the strike plate held but the door opened during the hose stream because the latch cylinder fell out of the door. In another door assembly, 12B, the particleboard door twisted and fell out of the frame during the hose stream though the strike plate stayed in place.

#### 6. Formation of a Hole Through the Trim

Where steel frames were used there was no indication of possible penetration between frame and wall because the frame overlaps the gypsum wallboard wall membrane. With wood frames there is a gap between frame and studs covered on each face by wood trim which may be only 5/16 in. thick. Holes developed through the trim over an unprotected gap between frame and doors 4A and 4B at about 22 min. In other wood door assemblies mineral wool insulation was included between door frame and studs.

#### Particleboard Core Doors

Only three tests were conducted on assemblies that included particleboard cores. In each of these the core was extruded and contained horizontal 1-in. diameter tubular holes at about 1 1/2 in., on centre, in the middle of the door. In door 6A failure of the frame did not permit the

contribution of the core to be assessed. In doors 7B and 12B failure at about 15 min appeared to be caused by warping of the door allowing a hole to develop across the top between door and frame.

MINIMUM REQUIREMENTS FOR A DOOR ASSEMBLY  
WITH 20-MIN FIRE PROTECTIVE RATING

It appears from the results of this series of tests that certain features in the design of a wood door assembly are essential if a 20-min fire protective rating is to be achieved. These are:

The solid core door should be without gaps exceeding 1/16 in. and should conform to the provisions of CSA O132.2, Wood Doors, for an exterior grade solid core door having natural wood core strips.

A wood frame should be of pine or more dense wood with a 1/2-in. rebate to provide the door stop.

A steel frame should be of 16 ga steel having four U-shaped anchors 18 ga thick on each jamb as described in UL 63-1968 Standard for Steel Door Frames. <sup>7</sup>

When a wood door is installed in a wood frame some precautions should be taken to minimize the possibility of penetration between door and frame. This may be achieved by application of intumescent paint to the edge of door or frame. British and Belgian studies <sup>8, 9</sup> suggest that keeping the gap between door and frame to a minimum is also beneficial. It is noted in the British study that with gaps up to 1/8 in. between door and frame it is not possible to satisfy the integrity requirements for 20 min and it is suggested that an intumescent paste inserted in a groove on the edge of the door can be effective for up to 30 min.

The strike plate fastened to a wood frame should be protected to ensure that it will hold for the period of fire exposure. This can be done by the insertion of asbestos cement board under the strike plate, or by the use of three 1 1/4-in. screws to anchor the strike plate.

A steel frame should be secured against warping. In a wood stud wall this can be done by use of wood blocking tightly fitted against the inside of the frame. The U-shaped wood stud anchors normally used bend under the stresses imposed by the rapid heating of the frame during exposure to the standard test. In a masonry wall the usual practice of filling between frame and masonry with cement mortar should prevent any movement of the frame.

The latch set should comply with the provisions of CGSB 69 GP 4a-1968 Standard for Lock and Latch Sets Bored Standard Duty<sup>10</sup> and have a latch throw of at least 1/2 in.

A number of additional measures appear to improve fire performance but the results of the series of tests suggest that they may not be essential features. Further investigation may prove that with a well designed installation these additional procedures may be avoided. These are:

Additional protection to the latch set by use of asbestos paper wrapped around the cylinder. The effectiveness of this measure appears to depend on the design of the latch cylinder. In a number of tests without the use of asbestos paper a 20-min fire protective rating was achieved.

Additional protection to the hinges by use of asbestos paper between hinge and wood. This appears to reduce the probability of holes occurring at this point, but there were examples of hinges without this protection where no holes developed in 20-min fire exposure.

Additional protection of the space between wood frame and stud. Penetration at this point depends on the nature and thickness of the trim. Careful specifications may eliminate the need to fill the space with mineral wool though this does appear to limit the possibility of penetration through the trim.

#### COMPLIANCE WITH CONDITIONS OF STANDARD TEST

Two door assemblies in this series can be considered as having met all of the conditions of the Standard Method of Fire Test of Door Assemblies, ASTM E152-72, <sup>2</sup> for a fire protective rating of 20 min. These are:

Door Assembly 10A: Solid core wood door in a steel frame. The door remained in place during fire exposure and application of the hose stream. Following the hose stream, a hole of about 3/4 sq in. in area was observed beside the knob.

Door Assembly 12A: Solid core wood door in a wood frame. The door remained in place during fire exposure and application of the hose stream. A hole beside the latch set was observed at 21 min. A correction of -0.8 min is applicable to this time. Following the hose stream the area of the hole was about 1 1/2 sq in.

Three door assemblies met the conditions of the Standard Method of Fire Test of Door Assemblies, ASTM E152-72 during a period of 20 min except for the development of small holes through the assembly. These are:

Door Assembly 10B: Solid core wood door in steel frame. The door remained in place during fire exposure and application of the hose stream except that a hole through the door was observed at 17 min. Following the hose stream the area of the hole was about 1 1/2 sq in.

Door Assembly 13A: Solid core wood door in wood frame. The door remained in place during fire exposure and application of the hose stream except that holes developed between door and frame at 18 min. Following the hose stream the area of the holes was about 3 1/4 sq in.

Door Assembly 13B: Solid core wood door in wood frame. The door remained in place during fire exposure and application of the hose stream except that a hole developed beside the knob at 19 min. Following the hose stream the area of the hole was about 2 sq in.

#### REFERENCES

1. National Building Code of Canada 1970. Associate Committee on the National Building Code, National Research Council of Canada, Ottawa.
2. Standard Method of Fire Test of Door Assemblies, ASTM E152-72, American Society for Testing and Materials, Philadelphia, Pa.
3. Standard for Wood Doors CSA O132.2-1967, Canadian Standards Association.
4. Schafer E. L., Charring Rate of Selected Woods--Transverse to Grain. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wis., April 1967.
5. Eickner, H. W., Fire Resistance of Solid Core Wood Flush Doors. Forest Products Journal, Vol. 23, No. 4. April 1973.
6. List of Equipment and Materials. Vol. 11. Building Construction. Underwriters' Laboratories of Canada, 7 Crouse Road, Scarborough, Ontario.
7. Fire Door Frames. U.L. 63, Underwriters Laboratories Inc., Chicago, Illinois.

8. Morris, W.A., An Investigation into the Fire Resistance of Timber Doors. Fire Research Note No. 855, January 1971. Dept. of the Environment and Fire Offices' Committee, Joint Fire Research Organization, Fire Research Station, Borehamwood, Herts., England.
9. La résistance au feu des éléments de construction, Centre Scientifique et Technique de la Construction, rue de la Violette 5, 1000 Bruxelles, December 1971.
10. Standard for Lock and Latch Sets: Bored, Standard Duty CGSB 69-GP 4a. Canadian Government Specifications Board.

Table I

## FORMATION OF HOLE THROUGH DOOR

Door Identification	Char Observed On Surface, min	Hole Through Door, min	Notes
11A	6	8	Hole occurred over gap on centre line of latch cylinder
9A	-	11	
7B	9	13	Particleboard core
12B	-	16	
10B	10	17	
11B	10	19	
8A	-	20+ *	Door that had edge glued core
10A	18	21+	
13B	-	21+	
12A	-	21+	
13A	-	21+	Door specially manufactured to avoid gaps in core
4A	20 $\frac{1}{2}$	24 $\frac{1}{2}$	Fire endurance period corrected as required by ASTM

\* No hole through the door occurred up to listed time.

Table II

## FORMATION OF HOLE BETWEEN DOOR AND FRAME

Door Identification	Door and Frame Untreated, min	Edge of Door or Frame Finished with Intumescent Paint, min	Notes
<u>Wood Frames</u>			
1A	13		
1B	13		
7B	15		Particleboard core door that showed early signs of warping
13A		18	Intumescent paint was very thin
8B		20	
12B		20+*	
11B		20+	
13B		21+	
12A		21+	
4A		24+	
<u>Steel Frames</u>			
10B	17		The hole between door and frame occurred close to a hole through the door (see Table 1)
10A		21+	

\* No hole occurred between door or frame up to listed time.

Table III

## FORMATION OF HOLE CLOSE TO HINGE

Door Identification	Standard Installation of Hinges, min	Asbestos Paper Placed Under Hinges, min	Notes
<u>Wood Frames</u>			
7B	14		Particleboard core door
1B	15		
8B	20		Door opened at 19 min (see Table V)
8A	20+		
12B		20+*	Particleboard core door
12A		21+	
13A		21+	Intumescent paint coat was thin
13B		21+	
4A	24+		Furnace temper- atures were below standard curve
<u>Steel Frames</u>			
10A		21+	
10B		21+	

\* No hole close to hinge occurred up to listed time.



Table IV  
FORMATION OF HOLE AT LATCH SET

Door Identification	Cylinder Installed Without Asbestos Paper, min	Cylinder Installed With Asbestos Paper, min	Type* of Latch Set	Notes
<u>Wood Frames</u>				
11A	-	8	12	Hole occurred over gap in core (see Table I)
13B		19	12	
13B	19	-	12	
12A		21	12	
13A		21	12	
11B		20+ **	12	Latch set fell out during hose stream
12B		20++	12	
13B	21+		13	
10B		21+	12	
4A	24+			Furnace temperatures were below standard curve
<u>Steel Frames</u>				
3A	16		11	Hole occurred between knob and edge of door
10A		21+	12	One in. diameter hole above knob after hose stream

\* Latch sets 11 and 13 had drum type cylinders fitted closely to hole in door. Latch set 12 had spool-type cylinder leaving a space between cylinder and wood.

\*\* No hole at latch set occurred up to listed time

Table V

## DOOR OPENED INTO FURNACE

(Wood Frames)

Door Opened, min

<u>Door Identification</u>	<u>3/8-in. Latch Throw</u>	<u>1/2-in. Latch Throw</u>	<u>1/2-in. Latch Throw at Strike Plate Reinforced</u>	<u>Notes</u>
7A	11			
5A	11½			
9A		11½		
5B	15			
9B		16½		
4B	17			
8B		19		
11A			19½	Strike plate held but latch fell out (see Table I).
11B			20	Strike plate held but latch fell out.
8A		20		Strike plate observed to be free after test.
12B			20	Door fell from frame during hose stream.
12A			21+*	
13A			21+	
13B			21+	
4A	24+			Furnace temperature below standard curve.

\* Door did not open up to listed time.

Table VI

DOOR OPENED INTO FURNACE  
(Steel Frames)

<u>Door Identification</u>	<u>Door Opened, min</u>		<u>Notes</u>
	<u>3/8-in. Latch Throw</u>	<u>1/2-in. Latch Throw</u>	
2A	2		Frame warped, frame was restrained only by steel anchors
6A	3		Frame warped, frame was restrained by anchors and wood blocking but not sufficiently tight fitting
3B	12		Frame warped
10A		21+*	Frame restrained by steel anchors and tight fitting wood blocking
10B		21+	Frame restrained by steel anchors and tight fitting wood blocking

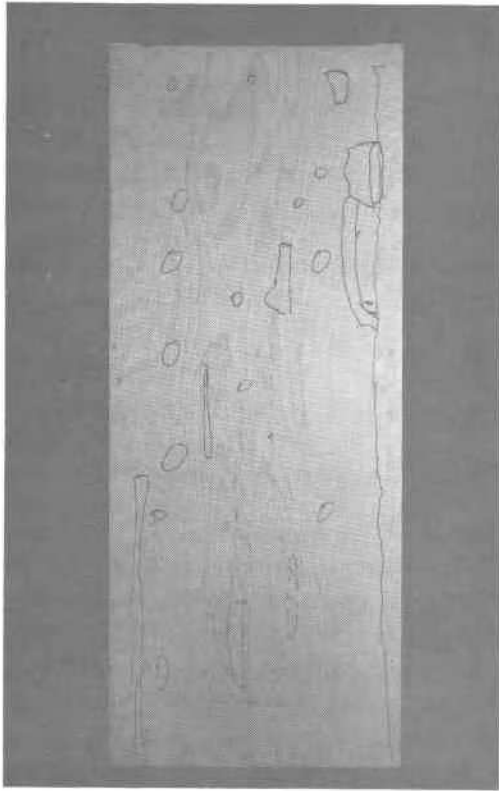
\* Door did not open up to listed time.

Table VII  
SUMMARY OF FIRE PERFORMANCE OF DOOR ASSEMBLIES

Door Identification	<u>Time of Failure* in Minutes Due to:</u>						
	Hole Through Door	Hole Between Door and Frame	Hole Close to Hinge	Hole at Latch Set	Door Opened Into Furnace	Hole Through Trim	Hose Stream**
1A	-	13	-	-	-	-	-
B	-	13	15	-	-	-	-
2A	-	-	-	-	2	-	-
B	-	-	-	-	T	-	-
3A	-	-	-	16	-	-	-
B	-	-	-	-	12	-	-
4A	24½	24+	24+	24+	24+	20½	-
B	-	-	-	-	17	20½	-
5A	-	-	-	-	11½	-	-
B	-	-	-	-	15	-	-
6A	-	-	-	-	3	-	-
B	-	-	-	-	T	-	-
7A	-	-	-	-	11	-	-
B	13	15	14	-	-	-	-
8A	20+	20+	20+	20+	20	20+	-
B	-	20	20	-	19	-	-
9A	11	-	-	-	11½	-	-
B	-	-	-	-	16½	-	-
10A	21+	21+	21+	21+	21+	21+	P
B	17	17	21+	21+	21+	21+	P
11A	8	-	-	8	19½	-	F
B	19	20+	20+	20+	20	20+	F
12A	21+	21+	21+	21	21+	21+	P
B	16	20+	20+	20+	20	20+	F
13A	21+	18	21+	21	21+	21+	P
B	21+	21+	21+	19	21+	21+	P

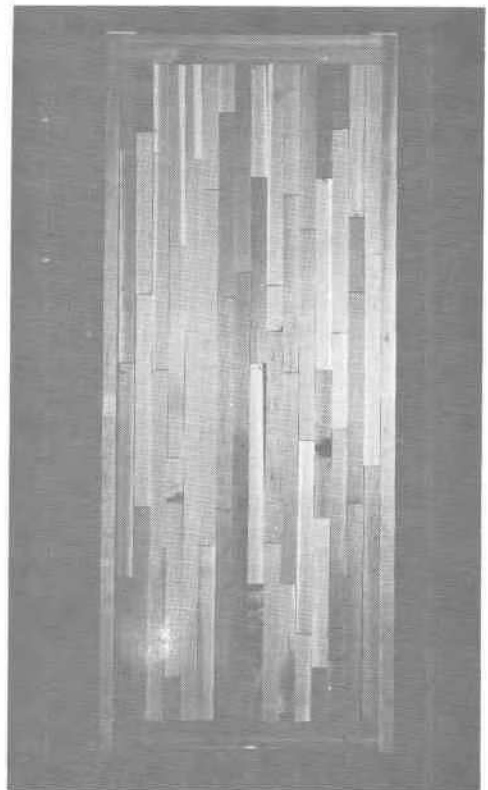
\* 20+, 21+ means no failure occurred up to listed time .

\*\* P = passed hose stream test; F = failed hose stream test.



**Figure 1. Solid core wood door marked to indicate warm spots.**

**Figure 2. Reverse side of door shown in Figure 1 with plywood surface.**



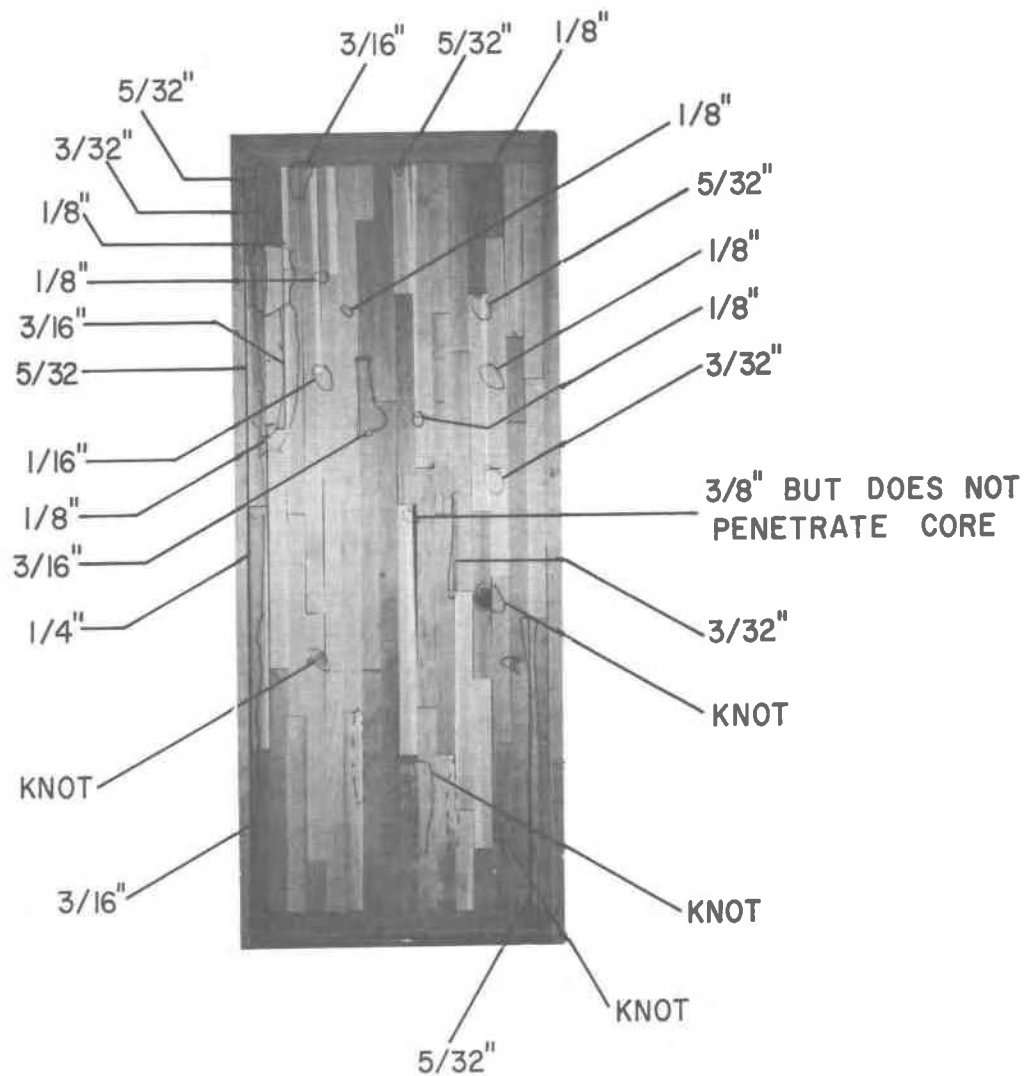


FIGURE 3

SOLID CORE WOOD DOOR 2'8" x 6'8" x 1 3/4".  
 COMPARISON OF HOT SPOTS ON FACE DETECTED BY  
 INFRA RED SCANNER (DOTTED LINES) WITH GAPS IN  
 CORE MEASURED AFTER FACING ON REVERSE SIDE  
 HAD BEEN REMOVED BY PLANER (SOLID LINES).

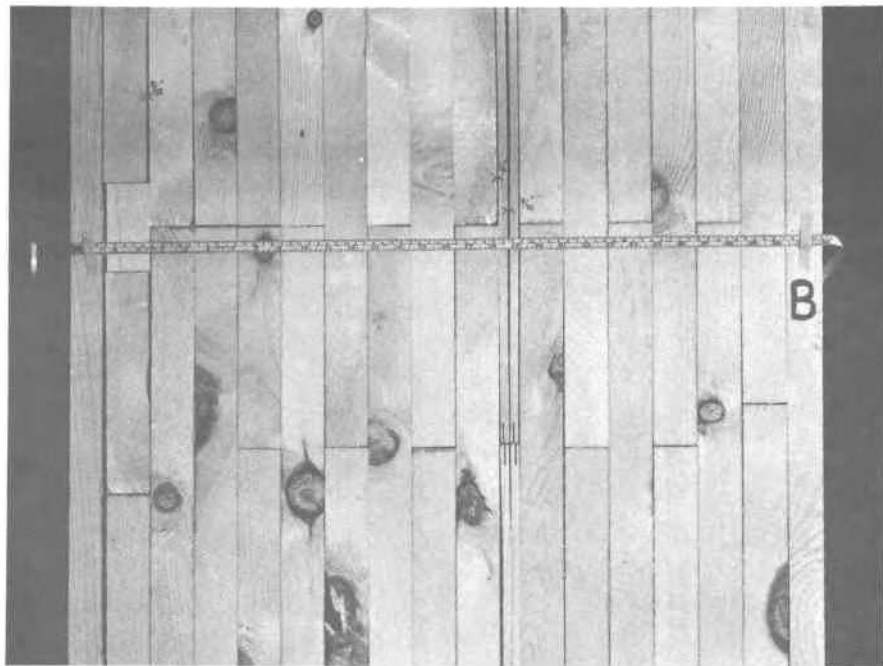


Figure 4. Part of solid core wood door with facing plywood removed.

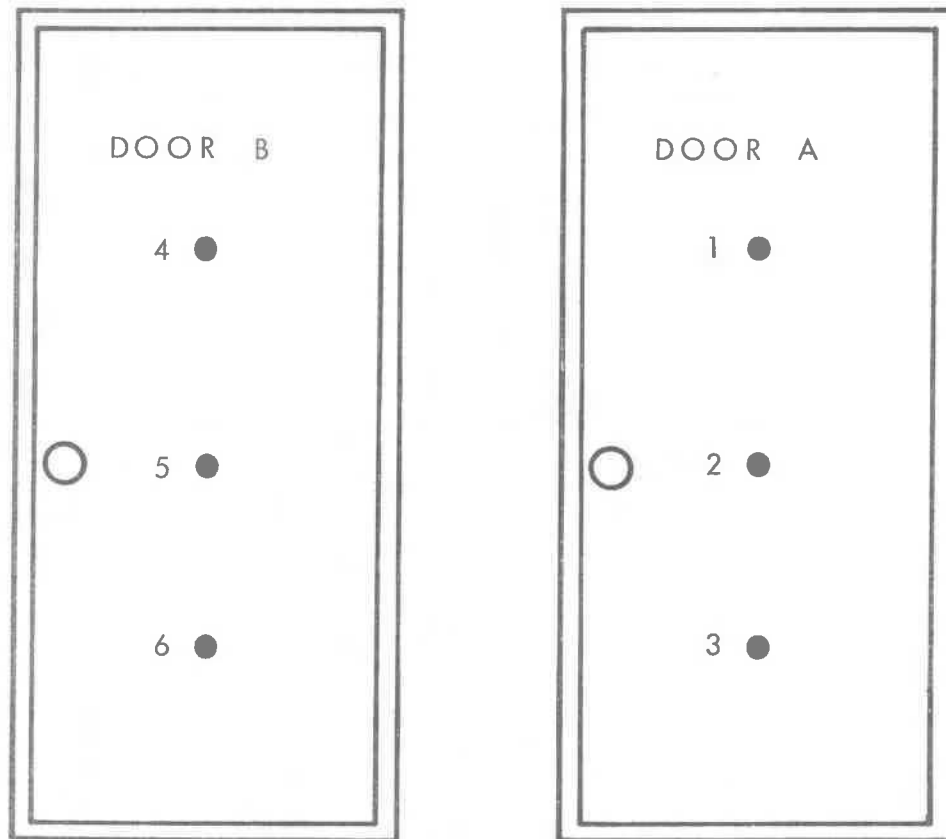


FIGURE 5  
LOCATION OF THERMOCOUPLES ON UNEXPOSED  
FACE



## APPENDIX A

### REPORTS OF STANDARD FIRE TESTS ON DOOR ASSEMBLIES

Part A: Description of Products and Materials  
Used in Tests

Part B: Detailed Description of Door Tests

A. DESCRIPTION OF PRODUCTS AND MATERIALS USED IN TESTS

- Item 1. Flush door: exterior grade, 1 3/4 in. thick by 2 ft 8 in. by 6 ft 8 in. said to conform with CSA O132.2, Standard for Wood Doors.

Core: cedar strips glued to facing plywood but not to each other.

Facing: birch veneer plywood, paint grade, glued to core.

All the doors of this type were obtained on the open market.

- Item 2. Flush door: as described in Item 1 but produced especially for the test series, care being taken to ensure that gaps in the core did not exceed the 1/16-in. limit described in CSA O132.2.

- Item 3. Flush door: exterior grade, 1 3/4 in. thick by 2 ft 8 in. by 6 ft 8 in. said to conform to CSA O132.2, Standard for Wood Doors.

Core: cedar strips glued to each other and to facing plywood.

Facing: birch veneer plywood, paint grade, glued to core.

These doors were obtained on order as they were not readily available.

- Item 4. Flush door: exterior grade, 1 3/4 in. thick by 2 ft 8 in. by 6 ft 8 in.

Core: extruded particleboard core in two panels each having 1-in. diameter tubular holes aligned horizontally.

Edge: approximately 1 1/2-in. wide pine strips on all four edges.

Facing: birch veneer plywood glued to core. The core was installed in two pieces with a horizontal joint near mid-height.

These doors were obtained on order.

Item 5. Wood frame: white pine frame out of 1 5/8-in. material with 1/2-in. rebate for door.

Item 6. Wood frame: pine frame out of 1 5/8-in. material with 1-in. rebate for door.

Item 7. Wood frame: pine frame out of 1 5/8-in. material with 1/2-in. rebate for door and 1/8-in by 1/2-in. steel plate held in place in rebate with 1-in. wood screws at 12-in. o.c.

Item 8. Wood frame: oak frame out of 1 5/8-in. material with 1/2-in. rebate for door.

Item 9. Steel frame: 16 ga steel frame having four U-shaped strap anchors 18 ga on each jamb (Figure A-1).

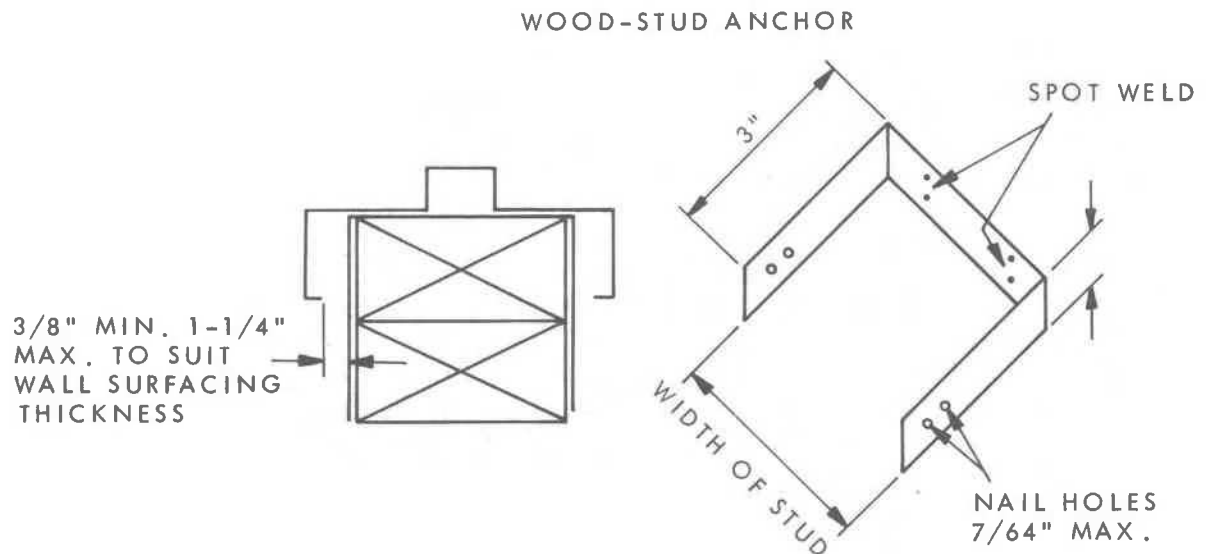


FIGURE A1

ANCHOR FOR STEEL FRAMES (BASED ON FIG. 36 OF  
FIRE DOOR FRAMES, NO. UL 63 CHICAGO, AUGUST 1961)

- Item 10. Hinges: three steel hinges 3 1/2 in. by 3 1/2 in. by 1/16 in. fastened to door and wood frame by 1 1/4-in. wood screws.
- Item 11. Latch set: bored latch set having a latch throw of 3/8 in. The cylinder in these latch sets is approximately the same diameter as the hole formed in the door to receive the latch set.
- Item 12. Latch set: bored latch set said to meet CGSB 69-GP-4, a 20-9-68 Standard for Lock and Latch Sets, Bored, Standard Duty, having a latch throw of 1/2 in. These latch sets have a cylinder reduced in diameter so there is a space between the cylinder and the hole in the door formed to take the latch set.
- Item 13. Bored latch set said to meet CGSB 69-GP-3 24-10-61 Standard for Lock and Latch Sets, Bored, Heavy Duty, having a latch throw of 1/2 in. The cylinder in these latch sets is approximately the same diameter as the hole formed in the door to receive the latch set.
- Item 14. Asbestos paper: 10 lb/100 sq ft, 0.028 in. thick.
- Item 15. Asbestos cement board: 1/4 in. thick.
- Item 16. Intumescent paint: applied in two coats to a total cover of about 240 sq ft per gallon.
- Item 17. Wood stud wall installation

The doors were tested in wood or steel frames mounted so as to swing into the furnace. The frames were installed in framing designed to simulate a typical wood stud partition as follows:

A brick or concrete block wall was built into the concrete test frame leaving two openings approximately 4 ft 6 in. wide by 7 ft 6 in. high. Into these openings wood framing was installed using 1 5/8-in. by 3 5/8-in. wood studs (Eastern spruce) with double studs on each side of the door opening (see Figure A-2). The wall was faced on each side with 5/8-in. thick type X gypsum wallboard fastened to the studs by 1 1/4-in. gypsum wallboard nails. The framing was secured to the masonry by steel bolts, three on each side set into the mortar joints and passing through the studs. A cushion of ceramic fibre was

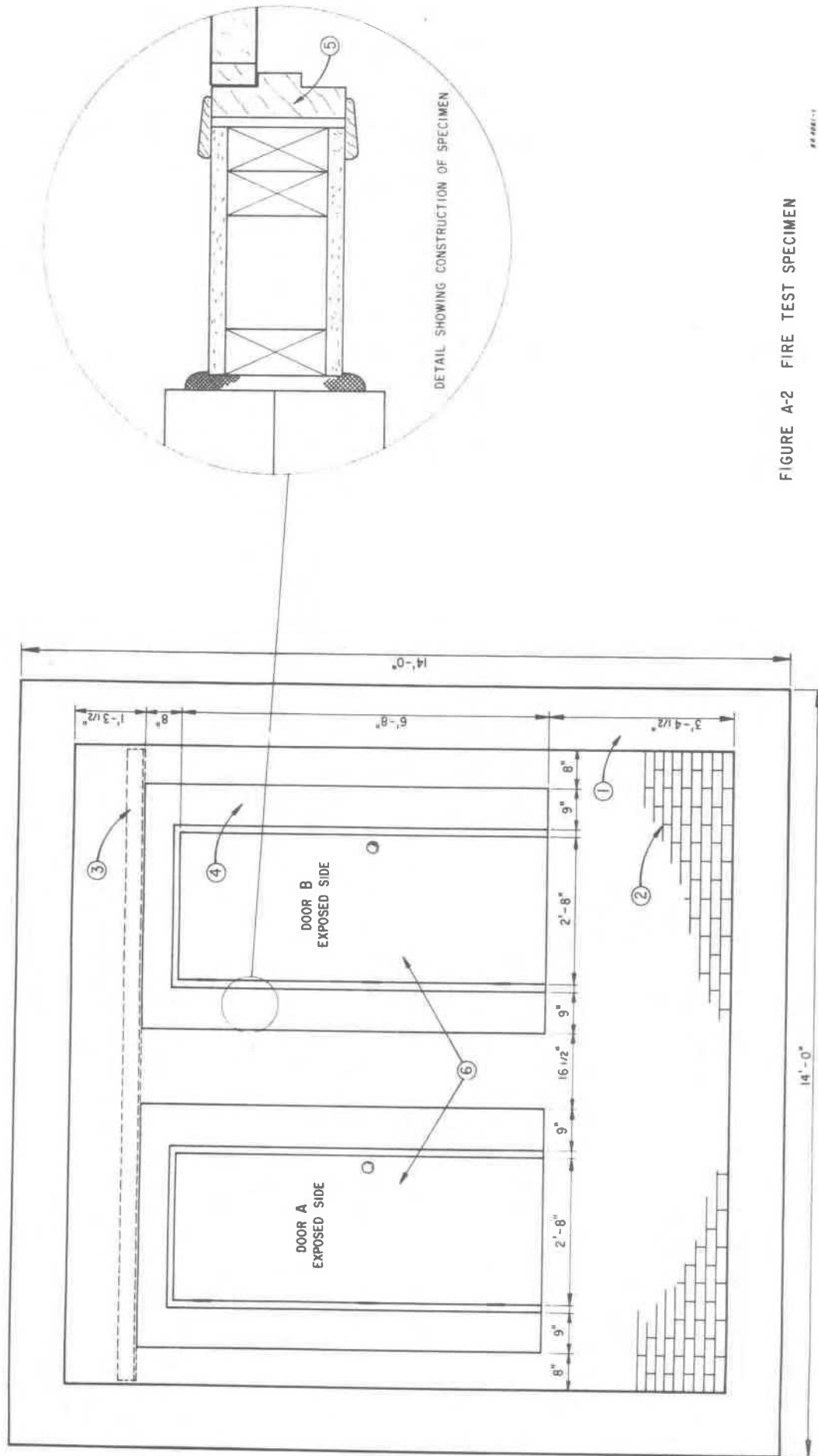


FIGURE A-2 FIRE TEST SPECIMEN

provided between the stud and the masonry to prevent passage of hot gases through the assembly at this point. Short lengths of wood stud (2 in. by 4 in. nominal) were fitted horizontally between the studs at about the mid-height of the wall.

Where wood frames were used, these were installed in the stud opening, spaced out from the studs by three pairs of wood wedges on each side of the frame. Door trim 2 5/8 in. by 7/16 in. was applied to cover the joint between frame and studs.

Where steel frames were used these were installed in the opening before the gypsum wallboard was applied. Each steel frame was secured by four wood stud anchors (see Figure A-1) fastened by 1 1/2-in. common nails to each face of the wood studs.

## B. DETAILED DESCRIPTION OF DOOR TESTS

### Door Test No. 1

#### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17 (Section A ).
- b) Two wood door frames as described in item 5 were built into the stud walls. The space between frame and studs was filled with mineral wool insulation in door assembly A only (see Figures A-3 and A-4).
- c) Doors A and B were as described in item 1.
- d) Hinges and latches were as described in items 10 and 11.
- e) Clearance between door and frame was  $3/32$  in. at top and sides and  $3/16$  in. at bottom.

#### Observations during fire exposure

- a) On unexposed side:
  - 2 min - Top of door A charred (Figure A-5).
  - 8 min - Glow visible at bottom left corner door B.
  - 9 min - Glow visible between top of door B and frame and at bottom left corner door A.
  - 10 min - Glow visible between top of door A and frame (Figure A-6).
  - 11 min - Glow visible on upper left side of door B between door and frame.
  - 12 min - Glow visible on upper right side of door A between door and frame.
  - 13 min - One inch wide opening along top of both doors between door and frame.
  - 14 min - Hole between door and frame at bottom left corner of door B.
  - 15 min - Holes between door and frame at top and sides in the upper half of both doors, at bottom left of doors A and B and at bottom right of door B near the hinge point (Figure A-7).

16 min - Flaming generally between door and frame along top and sides in the upper half of both doors. Door A beginning to warp into furnace at top left (Figure A-8).

b) On fire-exposed side:

1 min - All edges of trim burning.  
1 1/2 min - Faces of both doors burning.  
3 min - Furnace out. No flaming on door faces. Flaming along edges of both doors.  
6 min - Top and sides of both doors flaming.  
8 min - Small pieces of trim falling off.  
13 min - Trim completely off on bottom half of door B.

The test was terminated at 16 min and the flames on the doors were extinguished by a fine water spray. The doors were charred to a depth of about 3/4 in. from the exposed face (see Figures A-9 and A-10). The condition of the fire-exposed and unexposed faces of the doors is shown in Figures A-11 and A-12. The condition of the frames following fire exposure is shown in Figure A-13.

Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-14 and compared with the standard time-temperature curve. The deviation from the standard curve in deg-min was -482.22 deg-min. The correction according to ASTM E119 was -0.3 min. Average and maximum temperatures recorded for the thermocouples on the face of the doors are shown in Figures A-15 and A-16.

Door Test No. 2

Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two steel door frames as described in item 9 were built into the stud walls. The studs were notched to take the sheet steel anchors (see Figure A-17). The space between frame and studs in door assembly B was filled with mineral wool insulation.
- c) Doors A and B were as described in item 1.



- d) Hinges and latches were as described in items 10 and 11.
- e) Clearance between door and frame was  $3/32$  in. at top and sides,  $3/16$  in. at bottom.

Observations during fire exposure

Door A opened into the furnace at 2 min due to warping of frame. Test terminated (see Figure A-18).

The steel anchors in both frames buckled, allowing the frames to spread at the height of the latch.

Door Test No. 3

Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two steel door frames as described in item 9 were built into the stud walls. Door frame A was restrained by wood blocking installed between frame and studs above and below the latch strike and between the hinge points. Door frame B was restrained by a 2-in. by 4-in. stud set in against the frame. Because of the presence of stiffening plates for hinges and latch strike the 2-in. by 4-in. was not in direct contact with the frame at all points.
- c) Doors A and B were as described in item 1.
- d) Hinges and latches were as described in items 10 and 11.
- e) Clearance between door at frame was  $5/32$  in. at top and sides,  $1/4$  in. at bottom.

Observations during fire exposure

On unexposed side:

- 12 min - Door B opened into the furnace.
- 13 min - Charring occurred around latch set door A.
- 16 min - Flaming occurred at hole through door A between latch strike and knob.
- 16 min - Test terminated.

The test was terminated at 16 min (see Figure A-19) and the flames on the doors were extinguished by a fine water spray. Failure was assumed to have occurred at 16 min with formation of a hole through the door beside the latch.

#### Furnace temperature

Average furnace temperatures recorded during the fire exposure are shown in Figure A-20 and compared with the standard time-temperature curve. The deviation from the standard curve was -135.00 deg-min. The correction to be applied to the fire endurance time was -0.1 min.

Average and maximum temperatures recorded on the unexposed face are shown in Figures A-21 and A-22.

#### Door Test No. 4

#### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) The wood door frame for door assembly A was as described in item 5. The wood door frame for door assembly B was as described in item 7.
- c) Doors A and B were as described in item 1 except that steel strips 1/2 in. by 1/8 in. were set into the face of door B (see Figure A-23).
- d) Hinges and latches were as described in items 10 and 11.
- e) Clearances between door and frame in door assembly A were 5/32 in. at the top, 5/32 in. on the hinge side, 3/32 in. on the latch side and 7/32 in. on the bottom. In door assembly B clearances were 5/32 in. at the top, 4/32 in. on the sides and 7/32 in. on the bottom.
- f) Intumescent paint as described in item 16 was applied to top and side edges of door A.

#### Observations during fire exposure

On unexposed side:

1 min - Steam and smoke coming from top of both doors.

- 5 min - Steam and smoke continuing to come from top of door B.
- 6 min - Flames coming from top of door B.
- 12 min - Glow visible on left and right sides of door B between door and frame.
- 18 min - Door B opened into furnace. Latch no longer holding.
- 22 min - Hole through trim on both door assemblies. Char marks appearing over weak points in door A (see Figure A-24).
- 26 min - Hole through door A (see Figure A-25).
- 28 min - Test terminated.

The test was terminated at 28 min. Door B fell from the frame when the furnace was pulled back. Flames were extinguished by a fine water spray. Following the test door A had a hole through the door at the bottom right corner and several char marks on the face indicating the presence of gaps in the core (see Figure A-26).

#### Furnace temperature

Average furnace temperatures recorded during the fire exposure are shown in Figure A-27 and compared with the standard time-temperature curve. The deviation from the standard curve was -2358.9 deg-min. The correction to be applied to the fire endurance was -1.5 min. Average and maximum temperatures recorded on the unexposed face are shown in Figures A-28 and A-29.

#### Door Test No. 5

##### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames were built into the stud wall. The frame for door assembly A was as described in item 6. The frame for door assembly B was as described in item 8. The space between frame and studs was filled with mineral wool insulation.
- c) Doors A and B were as described in item 1.
- d) Hinges and latches were as described in items 10 and 11.
- e) Clearances between door and frame in door assembly A were 5/32 in. at the top, 1/8 in. on the hinge side, 5/32 in. on the

latch side and  $7/32$  in. on the bottom. In door assembly B the clearances were  $5/32$  in. at the top,  $5/32$  in. on the sides and  $7/32$  in. on the bottom.

#### Observations during fire exposure

- 1 min - Smoke and steam coming from top of both doors.
- 8 min - Door A bowed in to furnace. Gap between frame and latch side of door increasing.
- 10 min - Flaming from left side of door A.
- 11 1/2 min - Door A opened into furnace; latch no longer holding.
- 13 min - Flaming at top of door B.
- 15 min - Door B opened into furnace; latch no longer holding.
- 15 min - Test terminated.

The test was terminated at 15 min and the flames on the doors were extinguished by a fine water spray. The condition of the doors following the test is shown in Figure A-30.

#### Furnace Temperature

Average furnace temperatures recorded during the test are shown in Figure A-31 and compared with the standard time-temperature curve. The deviation from the standard curve was  $-2539.4$  deg-min. The correction according to ASTM E119 was  $-0.7$  min. Average and maximum temperatures recorded for the thermocouples on the face of the doors are shown in Figures A-32 and A-33.

#### Door Test No. 6

##### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two steel frames as described in item 9 were built into the stud wall. Wood blocking was fitted into the backs of the frames with cutouts to clear the plates behind hinges and latch strike. Observation following the test showed that there was  $1/4$  in. clearance between blocking and frames on each side of both door assemblies.
- c) Door A was as described in item 4 and weighed 33 kg (73 lb). Apparent density of core plus plywood facing was approximately 28 lb/cu ft. Infrared examination of the door

indicated a horizontal joint at about 1/3 the height of the door. Door B was as described in item 1. Infrared examination of the door indicated a weak point in the top half of the door near the centre.

- d) Hinges and latches were as described in items 10 and 11. The cylinders of the latch sets were wrapped around with asbestos paper as described in item 14.
- e) Clearances between door and frame for both assemblies were 3/32 in. at top and sides, 3/10 in. at bottom.

#### Observations during fire exposure

On unexposed side:

- 3 min - Door A opened into furnace due to bending of frame.  
Flames coming from top of door B.
- 3 min - Test terminated.

The test was terminated at 3 min and the flames on the doors were extinguished by a fine water spray. The condition of the fire exposed face is shown in Figure A-34. It can be seen that the plywood face is partly destroyed on both doors. Examination of door B showed core pieces splayed along the edges in the location indicated by the infrared scanner.

#### Door Test No. 7

##### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames as described in item 5 were built into the stud wall. The space between frame and studs was filled with mineral wool insulation in both door assemblies.
- c) Door A was as described in item 1. Door B was as described in item 4. Door A was warped, being 1/4 in. out of straight measured from corner to corner, and under infrared examination showed a weak point in the upper half near the centre of the door. Door B under infrared examination showed the presence of a horizontal joint at the top third of the door face. Edges of both doors were finished with intumescent paint as described in item 16.

- d) Hinges and latches were as described in items 10 and 11.  
Cylinders of latch sets in both doors were wrapped around with asbestos paper as described in item 14.
- e) Clearances between door and frame in both door assemblies were  $\frac{3}{32}$  in. at top and sides and  $\frac{3}{16}$  in. at bottom.

#### Observations during fire exposure

##### On unexposed face:

- 2 min - Smoke and steam coming from top of both doors.
- 6 min - Smoke and steam from lower right hinge door B.
- 9 min - Char on door face adjacent to centre and lower right hinges of door B.
- 10 min - Char adjacent to top hinge of door B  
(see Figure A-35).
- 11 min - Door A opened into furnace, latch no longer holding  
(see Figure A-36).
- 13 min - Glow along top of door B and hole at top right corner (see Figure A-37) at gap between core and style.
- 14 min - Flaming from near centre hinge door B. Door B warped in to furnace at top left corner.
- 15 min - Flaming along top of door B between door and frame  
(see Figure A-38).
- 17 min - Test terminated.

The test was terminated at 17 min and flames on the doors were extinguished by a fine water spray. The doors remained in the openings though the hinges of door A had separated from the frame and door B had a series of holes along the joint between hinge style and core (see Figure A-39). The condition of door A is shown in Figure A-40 and of door B in Figure A-41.

#### Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-42 compared with the standard time-temperature curve. The deviation from the standard curve was -567.22 deg-min. The correction according to ASTM E119 was -0.5 min. Average and maximum temperatures recorded for the thermocouples on the unexposed face of the doors are shown in Figures A-43 and A-44.

Door Test No. 8

Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames as described in item 5 were built into the stud wall. Between frame and stud on the hinge side of each door assembly 3/8-in. thick plywood was tightly fitted. On the latch side, wedges were inserted at three points between frame and stud and the space filled with mineral wool. The inside of the frame on door assembly A was finished with intumescent paint as described in item 16.
- c) Door A was as described in item 3; door B was as described in item 1. Infrared examination showed a weak point in the centre near the top of door A. Door B was finished on top and side edges with intumescent paint as described in item 16.
- d) Hinges and latches were as described in items 10 and 13. The cylinder of each latch set was wrapped around with asbestos paper as described in item 14.
- e) Clearance between door and frame on both doors was 3/32 in. at top and sides and 3/16 in. at the bottom.

Observations during fire exposure.

On unexposed face:

- 2 min - Puffs of smoke and steam issuing from head of both doors.
- 8 min - Both doors buckled in toward furnace.
- 12 min - Char beside lower hinge door B. Door B offset 1/5 in. at latch.
- 14 min - Glow at lower hinge door B.
- 15 min - Glow 2 in. above bottom left door A  
(see Figure A-45).
- 16 min - Char at upper hinge door A. Char top right door B.
- 17 min - Glow at centre hinge door B.
- 18 min - Char at top hinge door B.
- 19 min - Door B opened into furnace because strike plate no longer holding.
- 20 min - Holes through door B at centre and lower hinges  
(see Figure A-46).
- 21 min - Test terminated.

The test was terminated at 21 min. Following the test, door B was open, door A was in the closed position, but the latch strike was not attached. There were holes visible through door B in the vicinity of the centre and lower hinges.

#### Hose stream

The hose stream was applied to the area of both doors for 35 sec. Both doors opened into the furnace during the hose stream.

Following the hose stream, door A had small holes through the door adjacent to the centre and lower hinges and at the top of the door between core and top rail. Door B had holes through, adjacent to the centre and lower hinges, at intermediate points between the hinges, and across the top between core and top rail. The condition of the latch set in door B is shown in Figure A-47.

#### Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-48 compared with the standard time-temperature curve. The deviation from the standard curve was -295.00 deg-min. The correction according to ASTM E119 was -0.2 min. Average and maximum temperatures recorded for the thermocouple on the face of the doors are shown in Figures A-49 and A-50.

#### Door Test No. 9

##### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames as described in item 5 were built into the stud walls. The space between frame and studs was filled with mineral wool insulation in both door assemblies. Intumescent paint as described in item 16 was applied to the edges of both frames.
- c) Doors A and B were as described in item 1. Edges on top and two sides of door A were finished with intumescent paint as described in item 16.
- d) Hinges and latches were as described in items 10 and 13. Asbestos paper as described in item 14 was wrapped around the cylinders of both latch sets. In door assembly A



asbestos paper was also placed between hinges and wood of door and frame and between latch strike and wood. In door assembly B intumescent paint as described in item 16 was applied to the wood under hinges and latch strike.

- e) Clearance between door and frame was  $3/32$  in. at top and sides and  $3/16$  in. at bottom.

#### Observations during test

- a) On unexposed side:

2 min - Both doors buckling in toward furnace.  
8 min - Glow visible at hinge top left of door B.  
10 min - Glow bottom right door A.  
11 min - Hole through bottom right door A (Figure A-51).  
11 1/2 min - Door A opened into furnace (Figure A-52).  
15 min - Glow top right door B between door and frame.  
16 1/2 min - Door B opened into furnace (Figure A-53).

- b) On fire exposed side:

1 min - Face of doors and paper on wallboard flaming.  
3 min - Face of doors charred. Furnace burners shut down but some flaming around edges of doors.  
10 min - Plywood burned off face of both doors, laminated core charred, some trim off door assembly A.

The test was terminated at 17 min and flames on the doors were extinguished by a fine water spray. Figure A-54 shows the fire exposed face following the test.

#### Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-55 compared with the standard time-temperature curve. The deviation from the standard curve was  $-3406.1$  deg-min. The correction according to ASTM E119 was  $-0.5$  min. Average and maximum temperatures recorded for the thermocouples on the face of the doors are shown in Figures A-56 and A-57.

#### Door Test No. 10

#### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.

- b) Two steel frames as described in item 9 were built into the stud walls. The studs next to the frame were notched to pass the projections on the inside of the frame and fitted tight against the inside of the frame.
- c) Doors A and B were as described in item 1. Edges on top and two sides of door A were finished with intumescent paint as described in item 16.
- d) Hinges and latches were as described in items 10 and 12. Both latch sets were wrapped around with asbestos paper as described in item 14. Asbestos paper was also placed between hinges and wood in both doors.
- e) Clearances between door and frame were  $\frac{3}{32}$  in. at top and sides and  $\frac{3}{16}$  in. at bottom.

Observations during test

a) On unexposed face:

- 1/2 min - Smoke and steam issuing from top of both doors.
- 1 min - Doors slightly bowed into furnace.
- 10 min - Glow at top right door B between door and frame, and vertical char line 1 in. from edge of frame (see Figure A-58).
- 14 min - Glow along top right edge door B between door and frame and extending 4 in. from corner.
- 15 min - Glow on char line 5 in. from top and 1 in. from frame on door B.
- 16 min - Glow at three points on char line door B, right side.
- 17 min - Hole 6 in. by  $\frac{1}{4}$  in. through door B on char line noted above at top right corner and hole between door of frame top right (see Figure A-59).
- 18 min - Char around knob and L-shaped char line bottom right door B. Char line bottom of door A right of centre.
- 19 min - Char top left corner door A.
- 20 min - Char and glow point at knob door A and in door B 12 in. by  $\frac{3}{4}$  in. hole top right between door and frame, and glow at knob door B (see Figure A-60).
- 21 min - Test terminated.

b) On fire exposed side:

- 1 min - Surface of both doors flaming.
- 6 min - Plywood finish burned off both doors.
- 7 min - Both frames buckled but latches holding.

The test was terminated at 21 min. Following the test and before the hose stream test a 5-in. piece of the door fell from the top right corner of door B (see Figure A-61).

Hose stream

The hose stream was applied to both doors for 35 sec. Both doors remained in their frames and the latches held during the hose stream test. Following the hose stream test door A had a hole about 1 in. in diameter adjacent to the knob. Door B had a piece out of the top right corner about 15 in. by 1 in. and gaps between door and frame along the top and extending 4 in. down from the top left corner. The condition of the doors following the hose stream is shown in Figure A-62. The thickness of uncharred wood measured across the mid-height of door A was 13/16 in., 9/16 in. and 11/16 in. (average 11/16 in.) and of door B was 12/16 in., 13/16 in. and 14/16 in. (average 13/16 in.).

Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-63 compared with the standard time-temperature curve. The deviation from the standard curve was -147.78 deg-min. The correction according to ASTM E119 was 0 minutes. Average and maximum temperatures recorded for the thermocouples on the face of the doors are shown in Figures A-64 and A-65.

Door Test No. 11

Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames as described in item 5 were built into the stud walls. The space between frame and stud was filled with mineral wool insulation in both door assemblies. Intumescent paint as described in item 16 was applied to the surface of the rebate in the frame of door assembly A.

- c) Doors A and B were as described in item 1. The edges on top and two sides of door B were finished with intumescent paint as described in item 16.
- d) Hinges and latches were as described in items 10 and 12. Asbestos paper as described in item 14 was wrapped around the cylinders of both latch sets. Asbestos paper was also placed between hinges and wood surfaces of doors and frames in both door assemblies. The latch strike in door assembly A was drilled to provide an additional hole and fastened to the frame by three one-in. screws. In door assembly B, 1/4-in. asbestos board as described in item 15 was let into the frame behind the latch strike and secured by two one-in. wood screws. The latch strike was secured over the asbestos board by two one-in. wood screws.
- e) Clearances between door and frame were 3/32 in. at top and sides, 3/16 in. at bottom.

Observations during test

- 1 1/2 min - Steam issuing momentarily from knob, door A.
- 6 min - Char and glow under knob, door A.
- 7 min - Char above knob, door A.
- 8 min - Holes about 3 in. by 1/8 in. extending above and below knob, door A (see Figure A-66).
- 9 min - Holes about 4 in. by 1/8 in. below and 3 in. by 1/8 in. above knob, door A.
- 10 min - Light char showing at right side at 2/3-height and left side at top corner, door B.
- 12 min - Light smoke issuing from centre hinge, door B.
- 13 min - Char around centre hinge, door B.
- 14 min - Char full height in line with knob, door A. Char at lower left, door B.
- 15 min - Holes 5 in. by 1/2 in. extending above and below knob, door A (see Figure A-67).
- 16 min - Char at top right side, door B.
- 17 1/2 min - Glow at knob, door B.
- 18 min - L-shaped char line centre top, door A.
- 18 1/2 min - Glow at right side 12 in. above centre hinge, door B.
- 19 min - Glow at right side, door B, developing into hole 3 in. by 1/4 in.
- 19 1/2 min - Door A opened into furnace (see Figure A-68).
- 21 min - Glow at lower hinge, door A. Hole 12 in. by 1/2 in. at right and char marks top and bottom left, door B (see Figure A-69).

The test was terminated at 21 min. Following the fire exposure door A had a series of holes extending above and below the knob, a small hole near the lower hinge and an L-shaped char mark near the centre top of the door. Door B had a hole 12 in. by  $\frac{3}{4}$  in. near and above the centre hinge, a char mark extending about 3 ft and two char marks, one at the top, the other at the bottom, near the latch side.

#### Hose stream

The hose stream test was applied to the fire exposed face of both doors for 35 secs. Both doors stayed in their frames, but in both, the doors were not held closed because the latch sets fell out of the doors during the hose stream. Following the hose stream test the latch strikes were still in place on the frames (see Figures A-70 and A-71).

A cross-section of door A is shown in Figure A-72 and of door B in Figure A-73. Measurement of these sections indicated:

- (1) Average thickness of uncharred wood in centre of core pieces was  $\frac{7}{8}$  in. over a tight joint;  $\frac{3}{4}$  in. over a  $\frac{1}{16}$ -in. wide joint; and  $\frac{1}{2}$  in. that was more than  $\frac{1}{8}$  in. wide.
- (2) The average thickness of uncharred material in door A was approximately  $\frac{5}{8}$  in. and in door B,  $\frac{3}{4}$  in.

#### Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-74 compared with the standard time-temperature curve. The deviation from the standard curve was +89.9 deg-min. The correction according to ASTM E119 was -0.2 min. Average and maximum temperatures recorded for thermocouples on the unexposed face of the doors are shown in Figures A-75 and A-76.

#### Door Test No. 12

##### Description of test assembly

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames as described in item 5 were built into the stud walls. The space between frame and studs was filled with mineral wool insulation in both door assemblies.

- c) Door A was as described in item 1. Door B was as described in item 4. The edges of both doors top and two sides were finished with intumescent paint as described in item 16.
- d) Hinges and latches were as described in items 10 and 12. Asbestos paper as described in item 14 was wrapped around the cylinders of both latch sets. Asbestos paper was also placed between hinges and wood surfaces of doors and frames in both door assemblies. In both door assemblies asbestos board as described in item 15 was shaped to fit and installed under the latch strike. The latch strike and the asbestos board were secured to the frame by two 1 1/4-in. wood screws.
- e) Clearances between door and frame were 3/32 in. at top and two sides and 3/16 in. at the bottom.
- f) Before the fire test the faces of both doors were examined by the infrared scanner. This indicated the presence of some vertical joints and possible knots in door A, and in door B the pattern of core holes and joints around the perimeter and across the lower part of the door (see Figure A-77).

#### Observations during test

##### On unexposed face:

- 2 min - Steam issuing from knob, door A. Condensation on knobs in both doors.
- 7 min - Slight glow visible at top right corner of door B at gap between door and frame. Door noticeably bowed into furnace.
- 9 min - Steam issuing from knob, door B.
- 13 1/2 min - Char visible at top left and right corners of door B.
- 15 min - Glow visible top right and left of door B between door and frame (see Figure A-77).
- 16 min - Furnace can be seen through holes about 1 in. by 1/4 in. at top left and right, door B, close to edge of frame.
- 17 min - Holes top left and right, door B, now 1 in. by 1/2 in.
- 18 min - Char lines on left side of door A adjacent to frame, one near top, the other near the bottom of the door.
- 19 min - Char line at lower right side of door A adjacent to frame.

20 min - Holes at top left and right of door B between door and frame now 1 in. by 1 in. and 1 in. by 3/4 in. approximately (see Figure A-78).

21 min - Holes in door B now 1 in. by 1 1/2 in. and 1 in. by 1 in. Hole in door A beside knob about 1/2 in. in diameter (see Figure A-79).

The test was terminated at 21 min. When the furnace cut out, flaming occurred from the holes between door and frame at the top of door B and around the knobs of both doors.

#### Hose stream

The hose stream was applied to the fire exposed side of both doors for 35 secs. During the hose stream test door B showed a marked increase in warping and fell from the frame (see Figure A-80). Door A remained in place and little water appeared to pass through the door. There was, however, a hole beside the door knob about 1 in. by 1 1/2 in. Following the test the thickness of uncharred material in door B was 1/2 in. and that in door A about 1 in., on the average (see Figure A-81).

#### Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-82 compared with the standard time-temperature curve. The deviation from the standard curve was -1218.3 deg-min. The correction according to ASTM E119 was -0.8 min. Average and maximum temperatures recorded for the thermocouples on the face of the doors are shown in Figures A-83 and A-84.

#### Door Test No. 13

##### Description of test specimen

- a) A wood stud wall was installed in the test frame as described in item 17.
- b) Two wood door frames as described in item 5 were built into the stud walls. The space between frame and studs was filled with mineral wool insulation in both door assemblies.
- c) Door A was as described in item 2. Door B was as described in item 1. Intumescent paint was applied to the edges of both doors on top and two sides.

- d) Hinges and latches were as described in items 10 and 12.  
Asbestos paper as described in item 14 was fitted around the cylinders of the latch sets holding the doors closed in both door assemblies. Asbestos paper was also placed between the hinges and the wood surfaces of both doors and frames. Asbestos board as described in item 15 was shaped to fit and installed under the latch strike in both door assemblies. The latch strikes were secured by two 1 1/4-in. wood screws. In door assembly B two additional latch sets were installed 12 in. above and below the latch set described above. The upper latch set was as described in item 13, the lower latch set was as described in item 12. Both of these latch sets were installed without asbestos paper around the cylinder and without a strike place or rebate.
- e) Clearances between doors and frames were 3/32 in. at top and two sides, 3/16 in. at the bottom.
- f) Before the fire test the faces of both doors were examined by the infrared scanner. This indicated the presence of some vertical joints and possible knots in the core (see Figure A.85).

#### Observations during fire exposure

##### On unexposed face:

- 1 1/2 min - Puffs of smoke and two-thirds height left side door A.
- 16 min - Glow above centre hinge between door A and frame (see Figure A-85).
- 16 1/2 min - Second glow 6 in. below centre hinge between door A and frame.
- 17 min - Char at centre knob, door B.
- 18 min - Holes developing at four points on right of door A between door and frame. Glow around rose of lower knob, door B (see Figure A-86).
- 19 min - Glow at top left of door A between door and frame. Two holes close to centre knob, door B. Hole around rose at lower knob, door B.
- 20 min - Four holes between door and frame right side of door A. One hole at top left between door A and frame (see Figure A-87).
- 21 min - Test terminated.

The test was terminated at 21 min. Following fire exposure door assembly A had four holes penetrating diagonally between door and



frame on the hinge side and a smaller hole between door and frame at the top left corner. Door assembly B had two small holes, one beside the centre knob and another narrow gap following the edge of the rose on the lower knob for about two-thirds of the circumference.

#### Hose stream

The hose stream was applied to the fire exposed side of both doors for 35 secs. During the hose stream a limited amount of water penetrated the doors through the holes and the gap along the bottom of the door. Following the hose stream the area of the holes was measured as viewed in a line perpendicular to the door face. The total area of openings between door and frame in door assembly A was about 3.25 sq in. (see Figure A-88). Viewed diagonally the same holes would have totalled about 18 sq in. (see Figure A-89). In door assembly B the area of the hole at the centre knob was about 1.8 sq in. (see Figure A-90). Part of this area may be discounted because the barrel of the latch set occupied some of the hole. At the lower knob there was also a hole of about 0.5 sq in. As these extra latch sets were installed for purposes of comparison, this should not perhaps be taken into account. A cross-section of the doors following the test showed about 3/4 in. of uncharred wood remaining in both doors (see Figures A-91 and A-92). Examination of the intumescent paint on the edge of the doors showed that only a very thin coat had been applied and that little or no intumescence had occurred.

#### Furnace temperature

Average furnace temperatures recorded during the test are shown in Figure A-93 compared with the standard time-temperature curve. The deviation from the standard curve was -520.0 deg-min. The correction according to ASTM E119 was -0.3 min. Average and maximum temperatures recorded from the thermocouples on the face of the doors are shown in Figures A-94 and A-95.

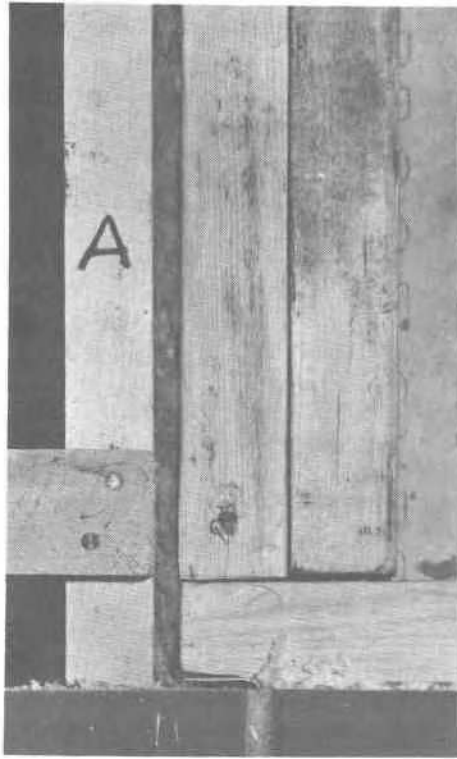
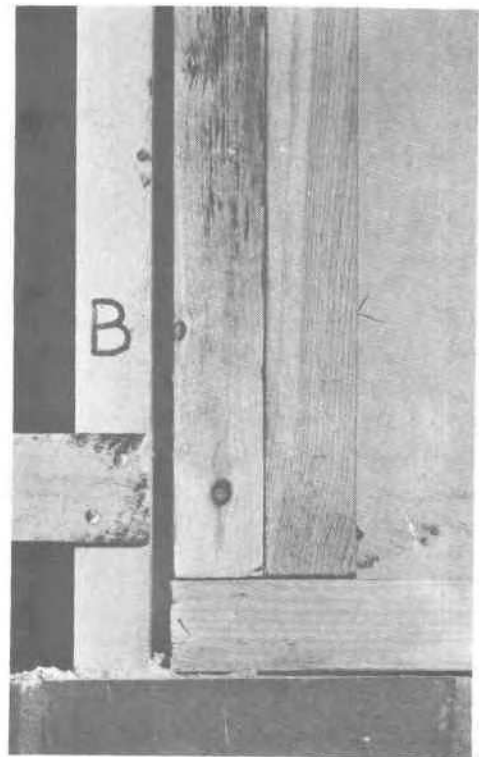


Figure A3. Door Test No. 1.  
Space between frame and stud  
filled with mineral wool.

Figure A4. Door Test No. 1.  
Space between frame and stud  
open.



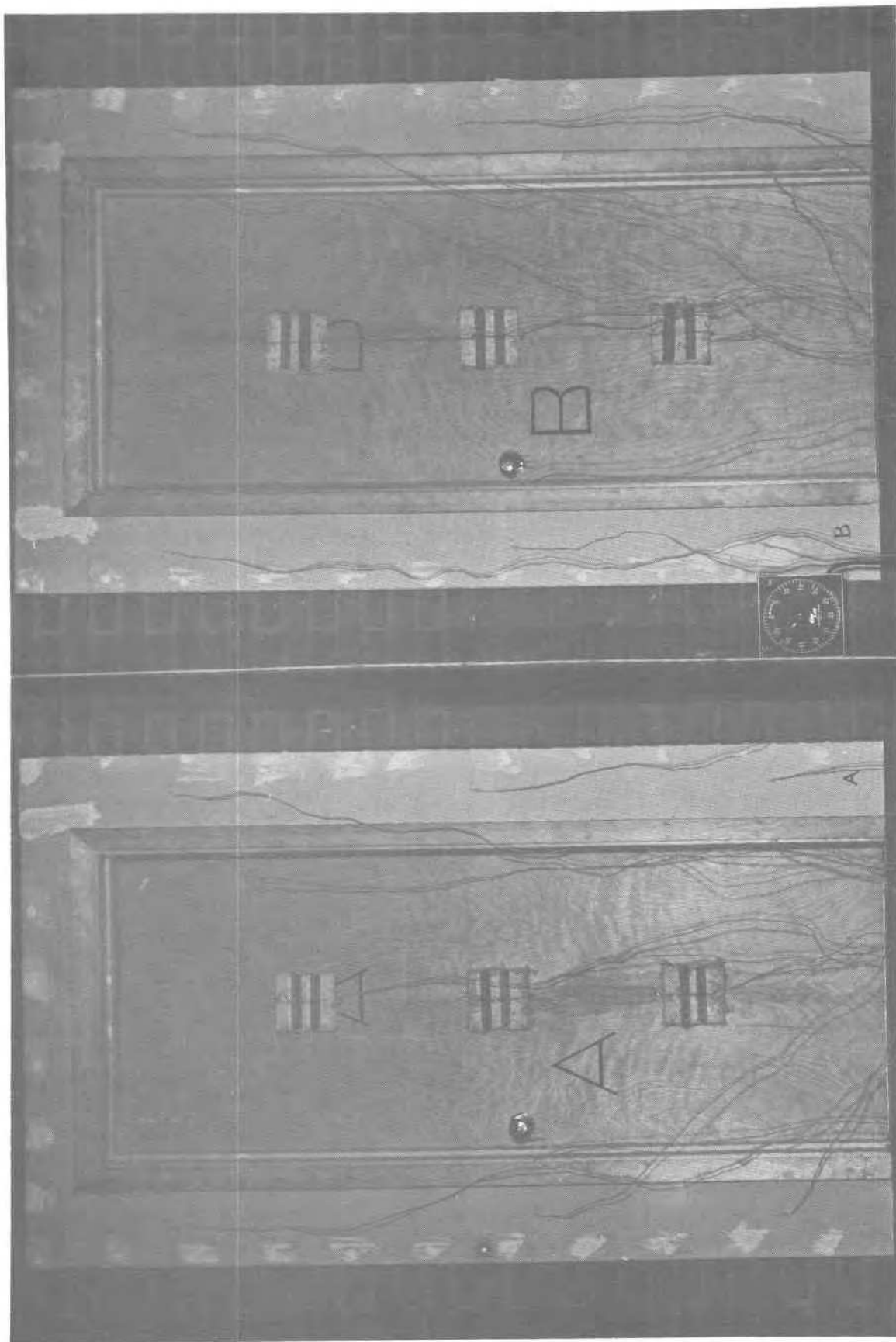


Figure A5. Door Test No. 1. Unexposed face at 4 min.

Note: In Door Test No.1, Door A was on the left, viewed from the non-fire-exposed side, and Door B on the right as shown in this Figure. In the remaining tests, Door A was on the right, viewed from the same side, and Door B on the left as shown in Figure 5.

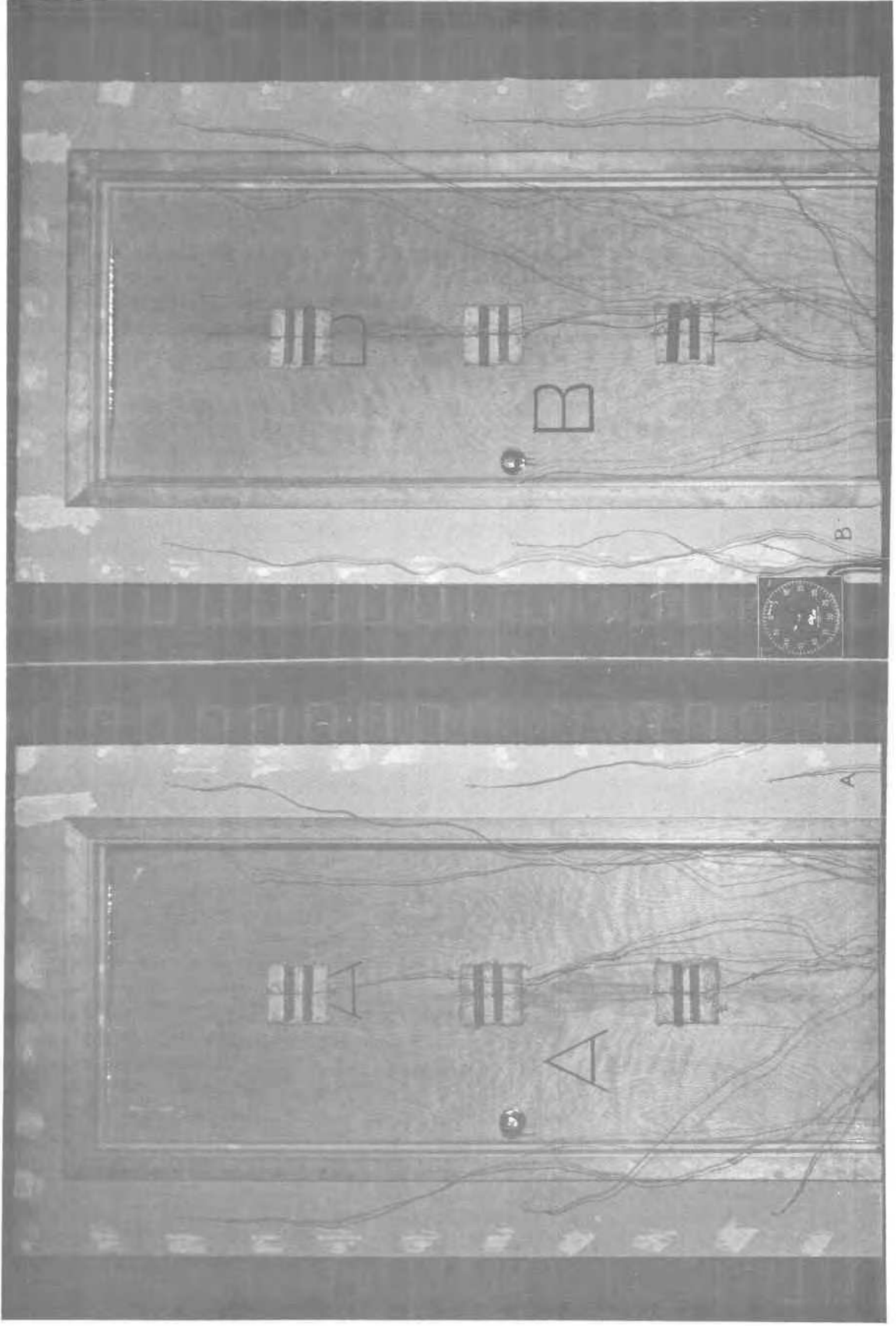


Figure A6. Door Test No. 1. Unexposed face at 10 min.

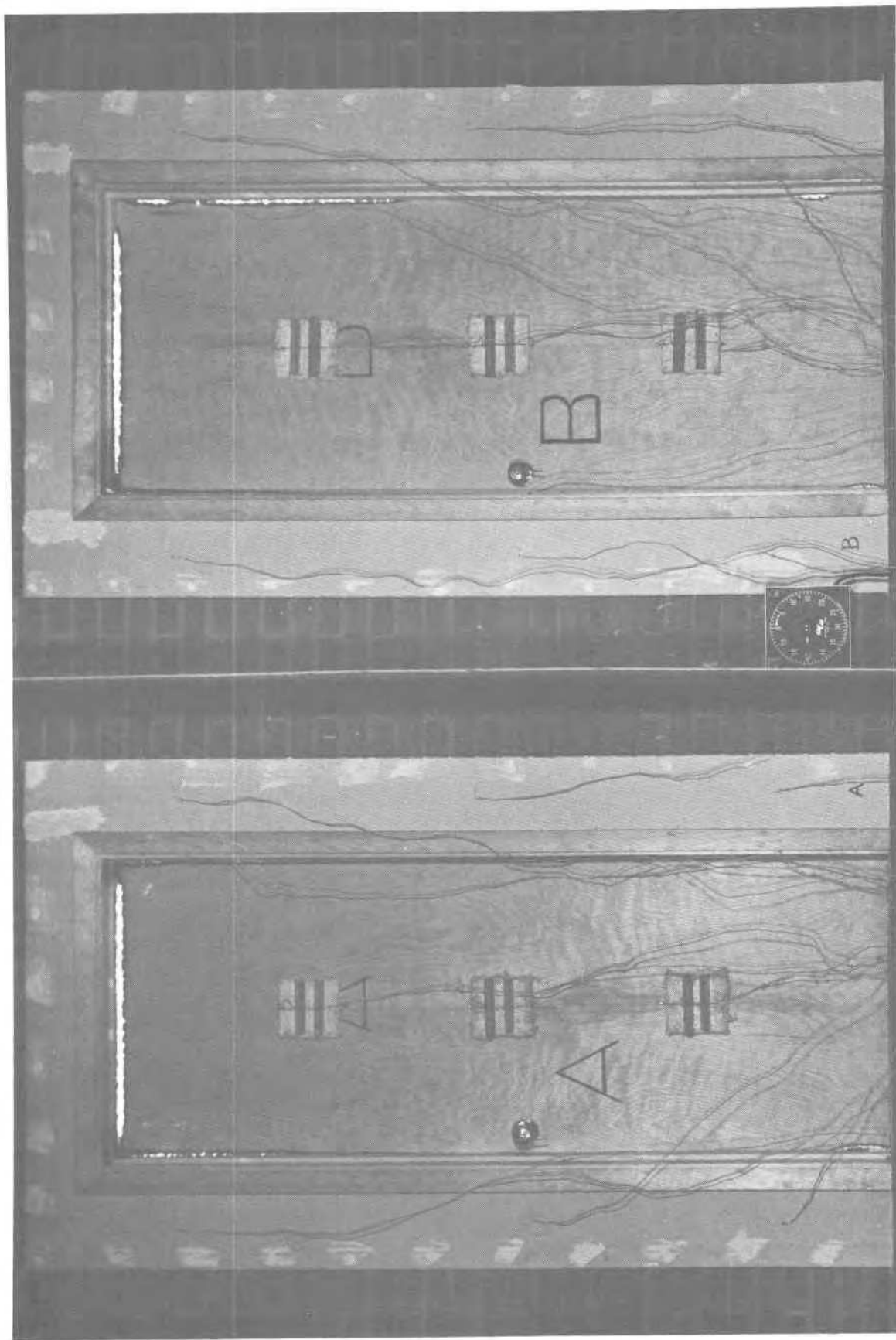


Figure A7. Door Test No. 1. Unexposed face at 15 min.

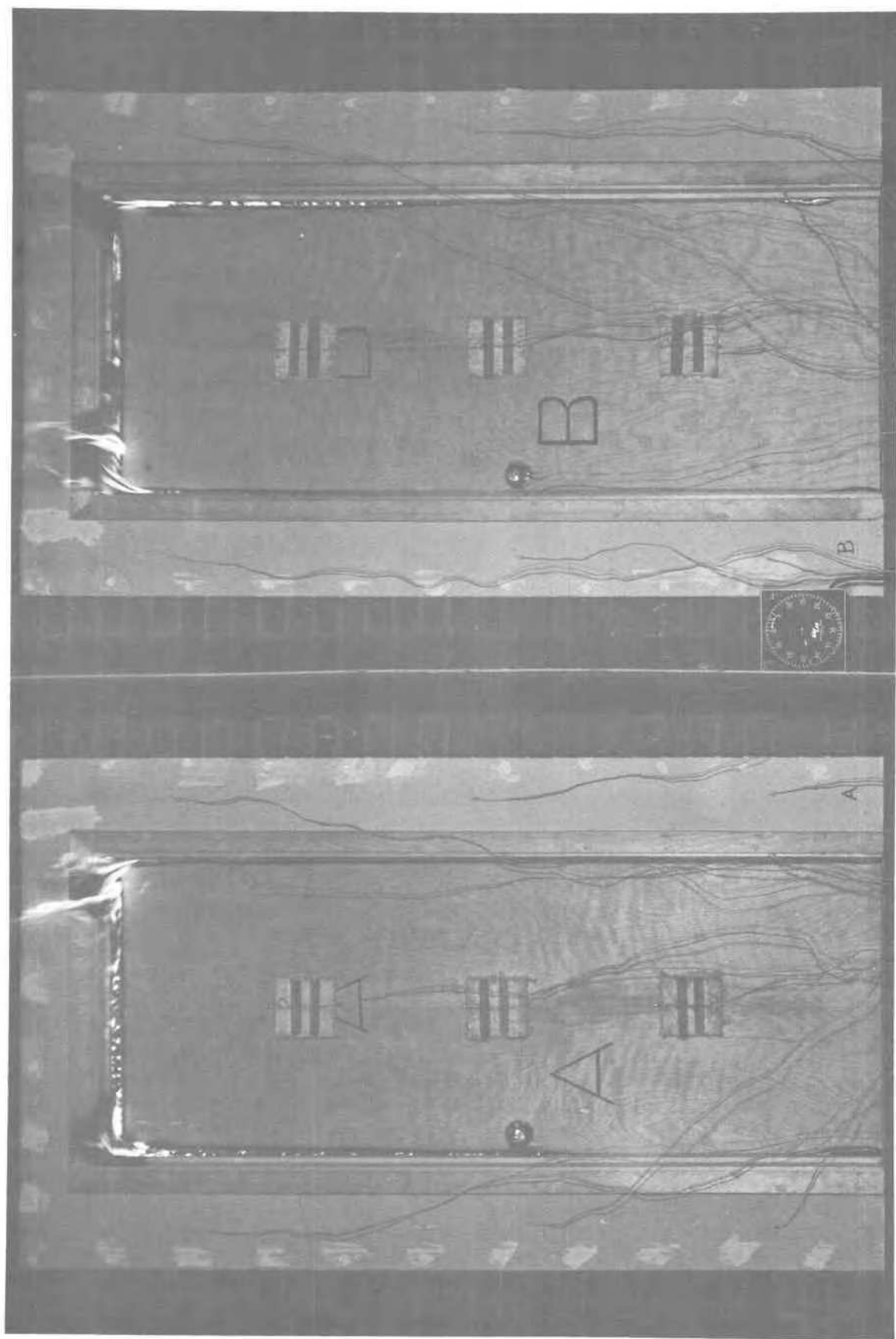


Figure A8. Door Test No. 1. Unexposed face at 16 min.

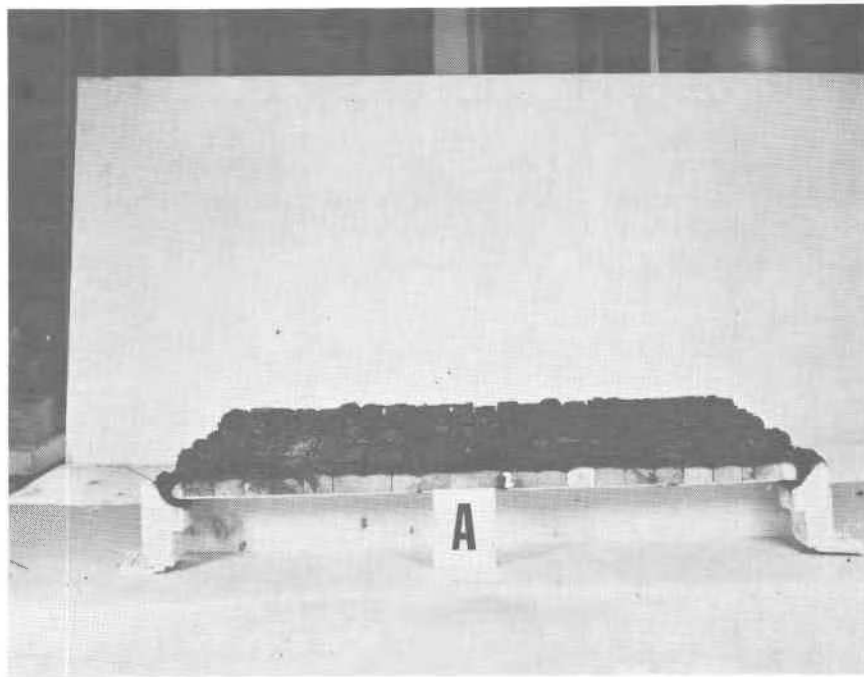


Figure A9. Door Test No. 1. Section of Door A after test.

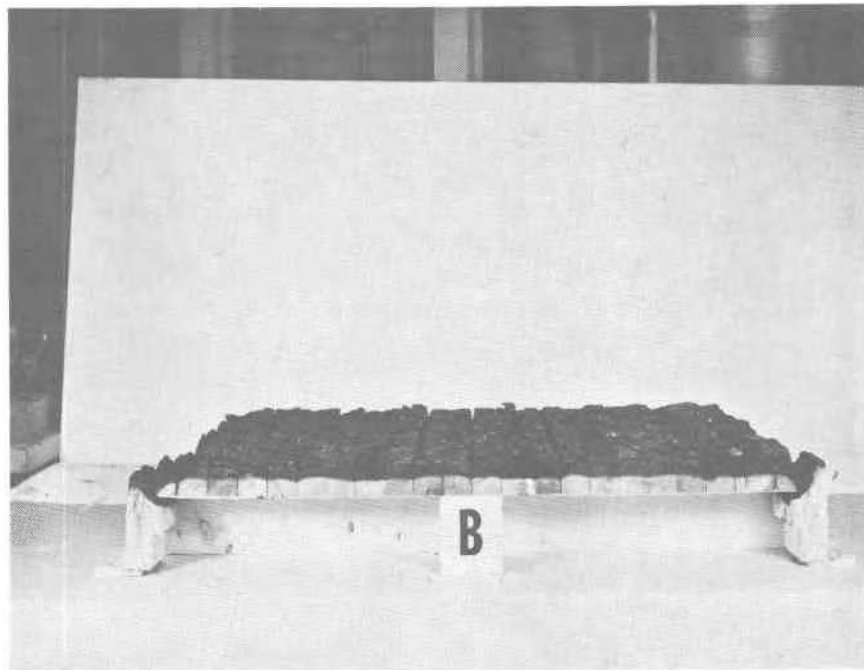


Figure A10. Door Test No. 1. Section of Door B after test.

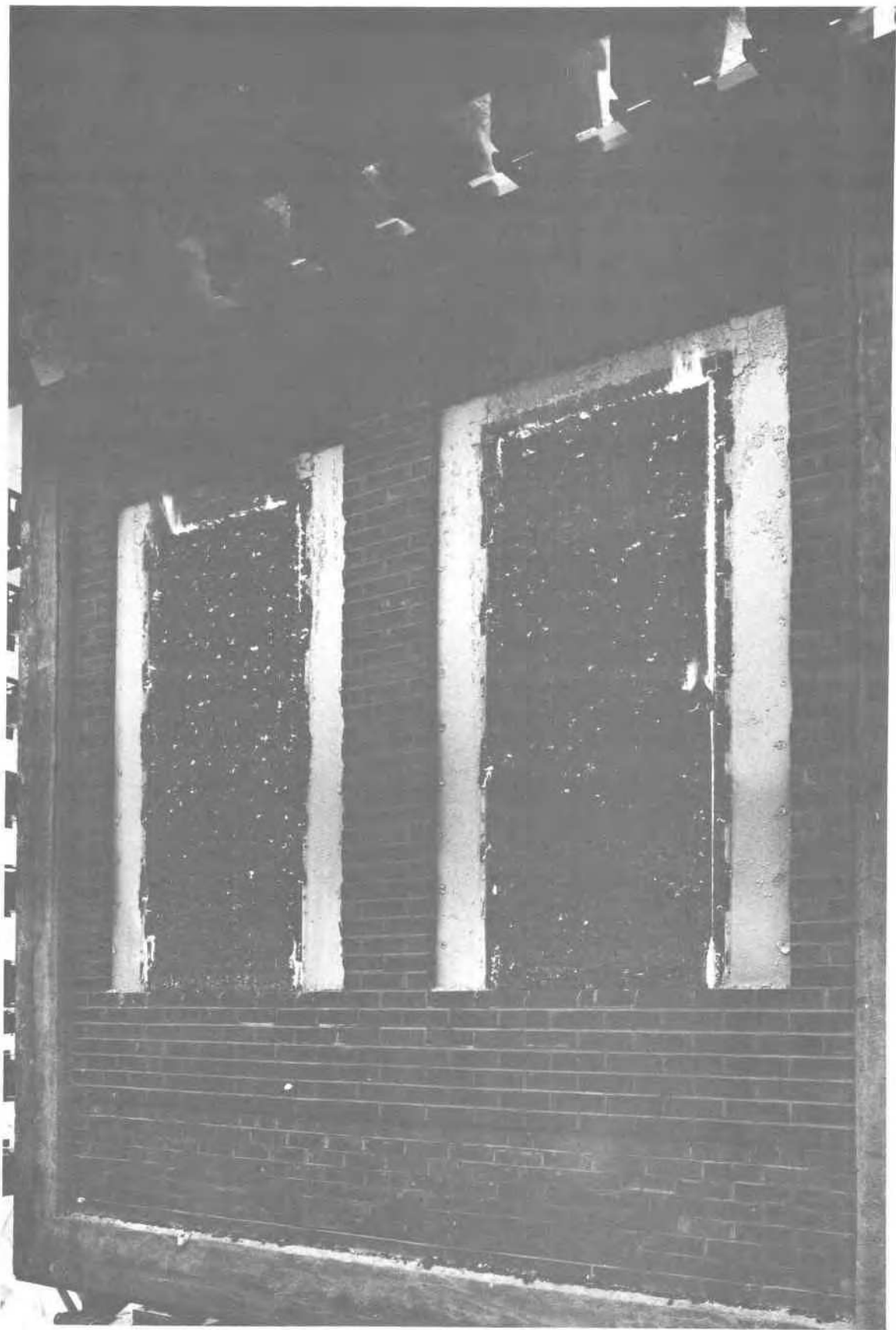


Figure All. Door Test No. 1. Fire exposed face after test.



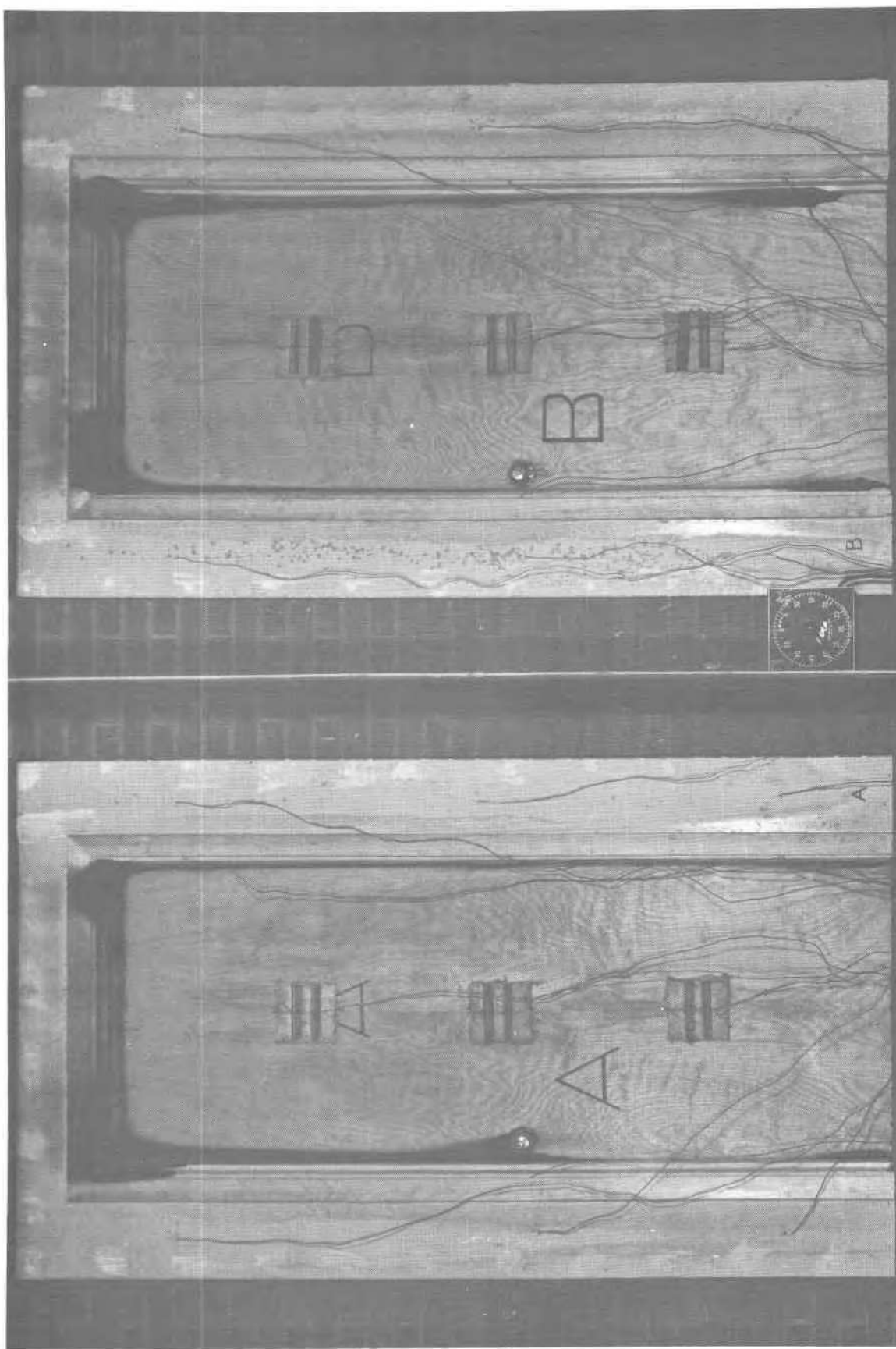


Figure A12. Door Test No. 1. Unexposed face after test.



Figure A13. Door Test No. 1. Condition of frames after test.

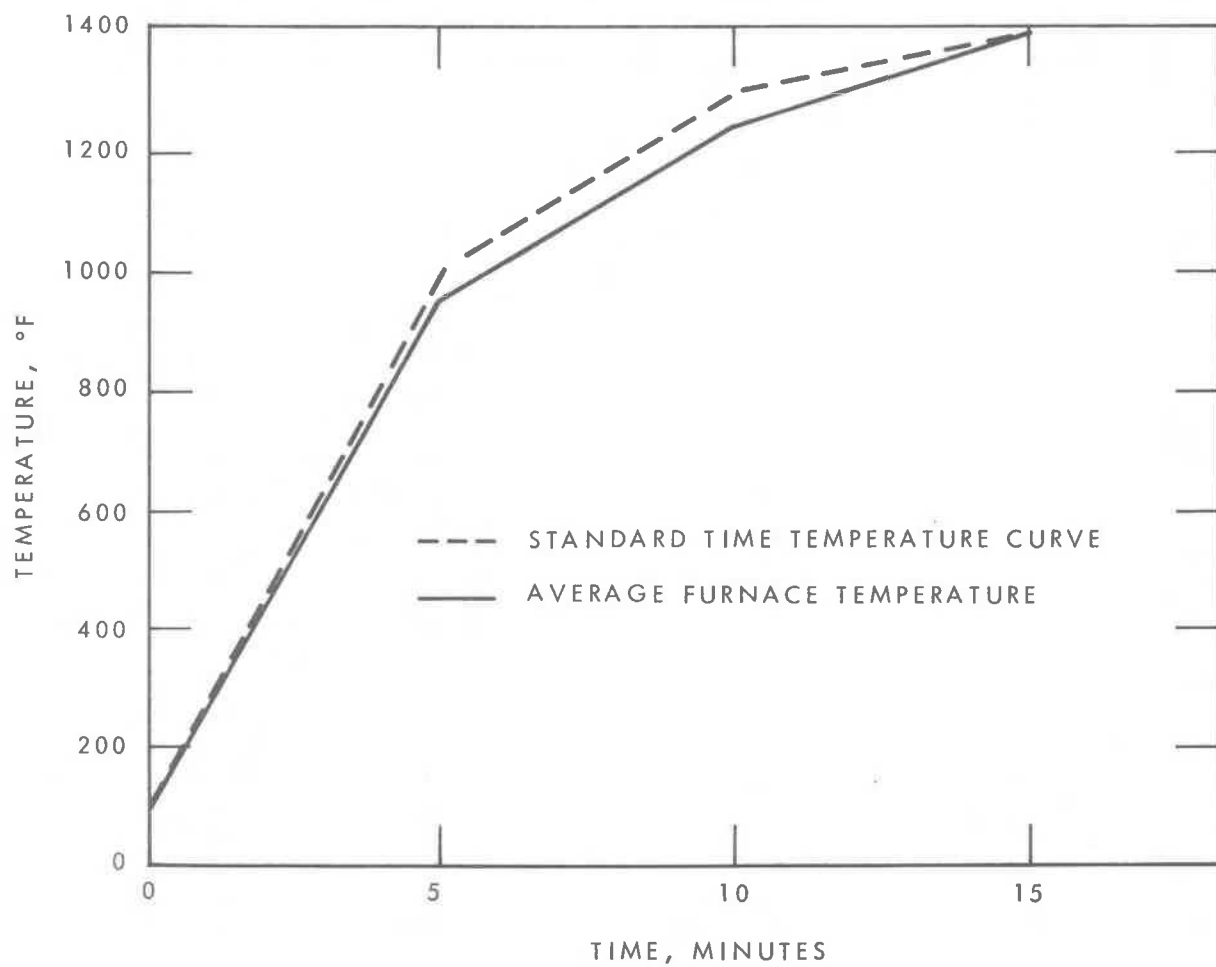


FIGURE A14  
DOOR TEST NO. 1 FURNACE TEMPERATURES

BR 5319-4

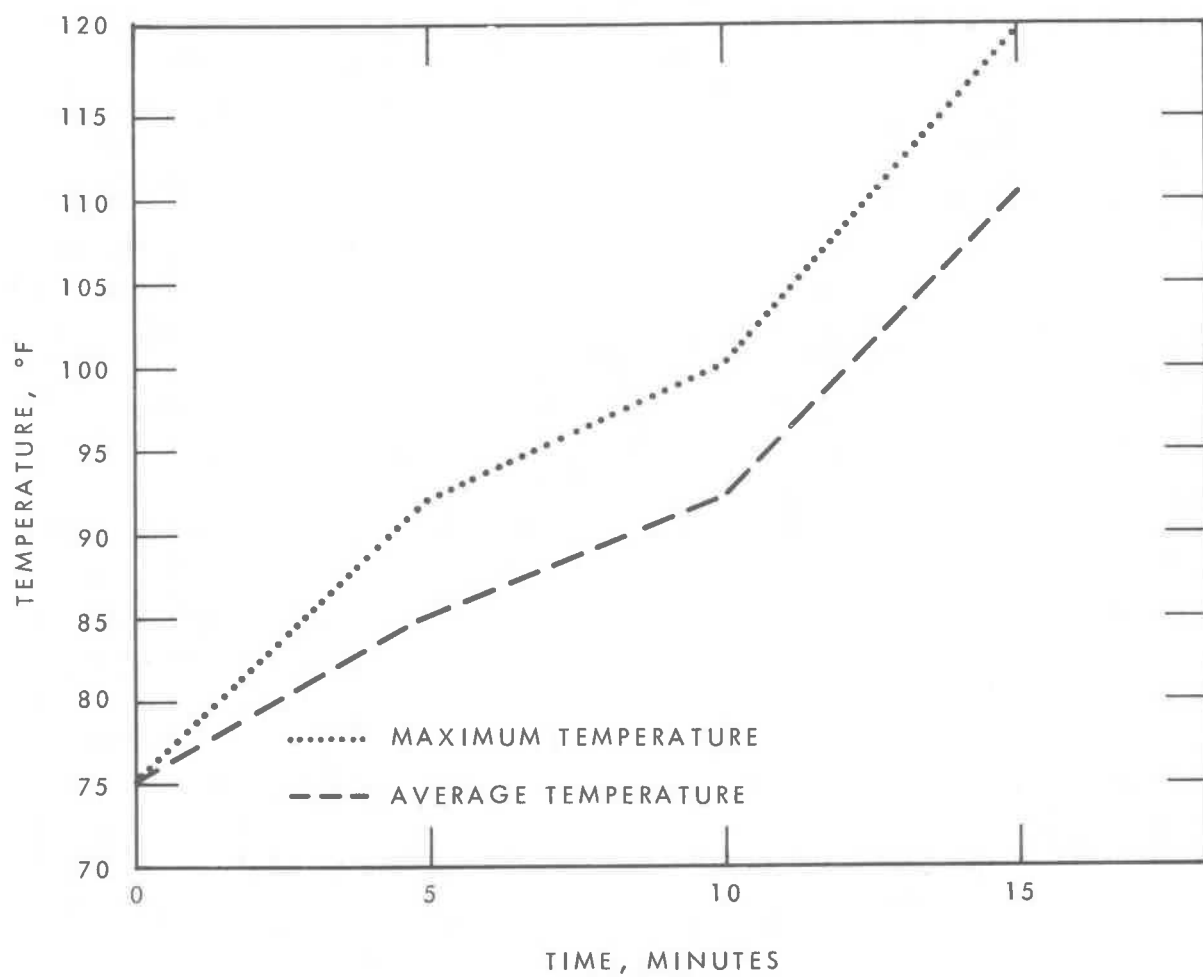


FIGURE A15

DOOR TEST NO. 1 UNEXPOSED SURFACE TEMPERATURES DOOR A

BR 5319-5

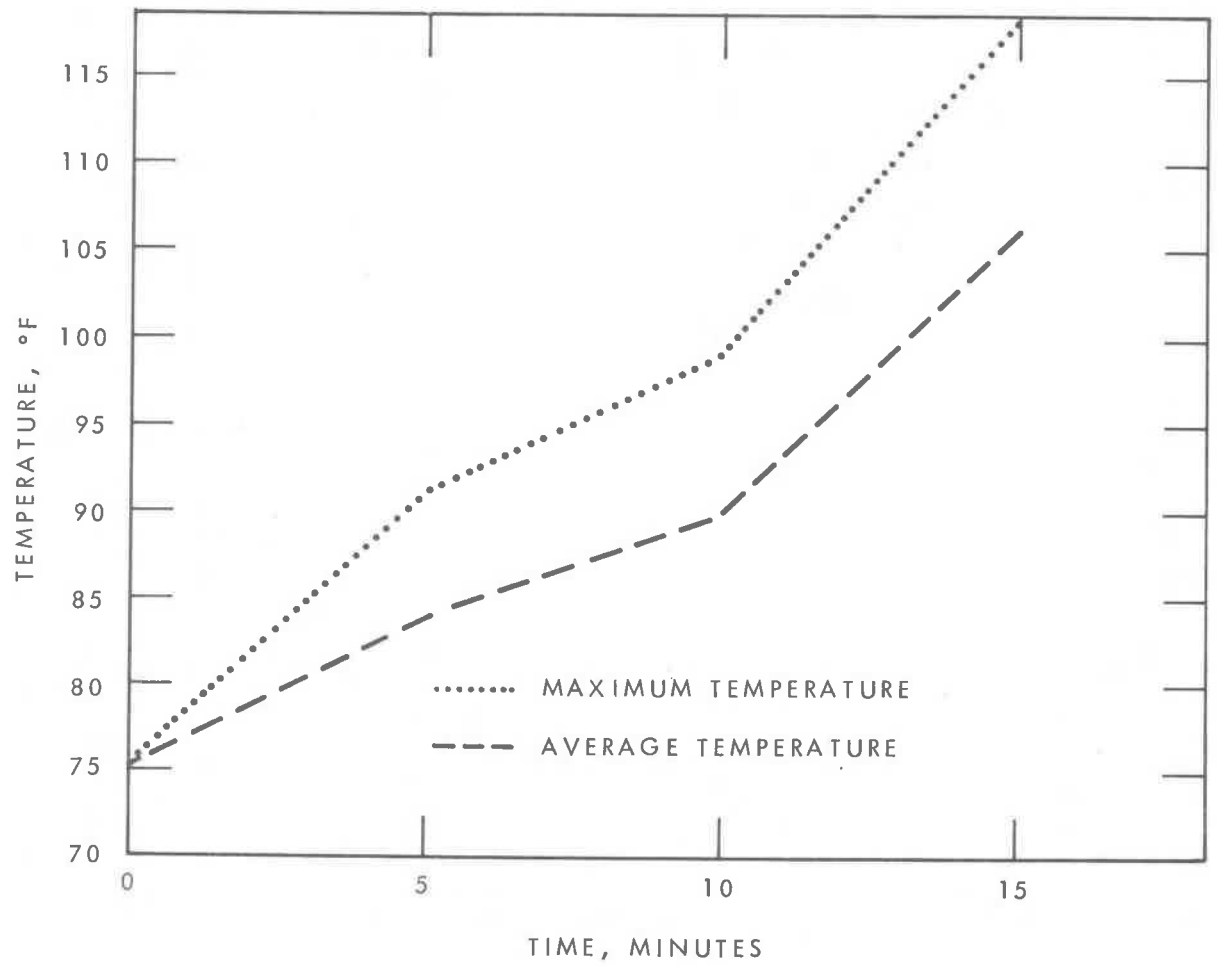


FIGURE A16

DOOR TEST NO. 1 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-6



Figure A17. Door Test No. 2.  
Installation of steel frame.

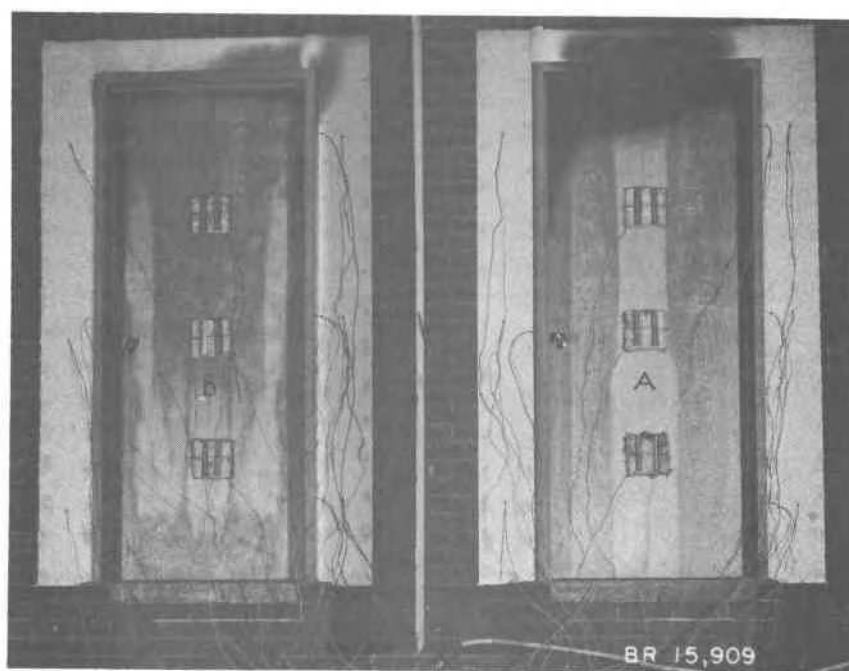


Figure A18. Door Test No. 2.  
Unexposed face after test.

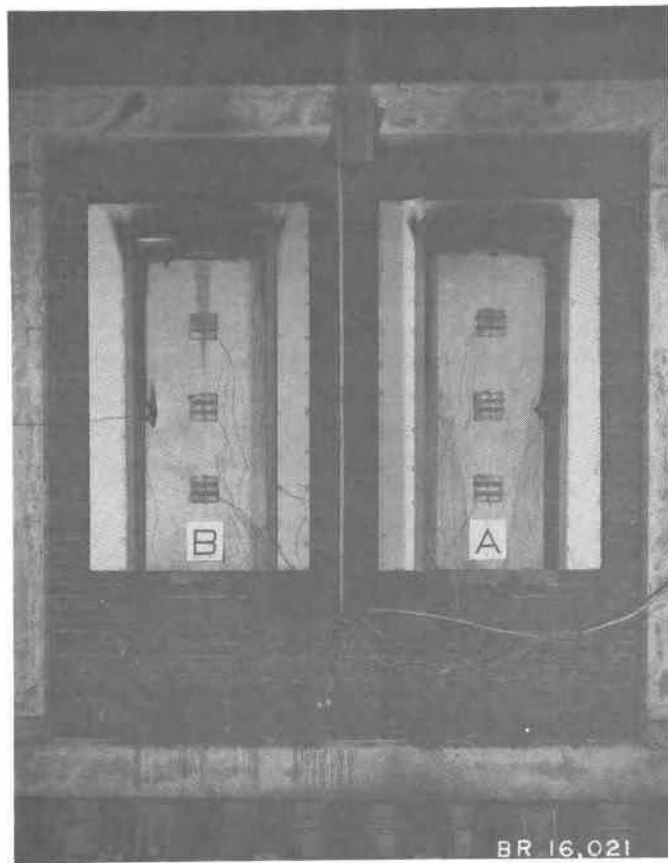


Figure A19. Door Test No. 3.  
Unexposed face after test.

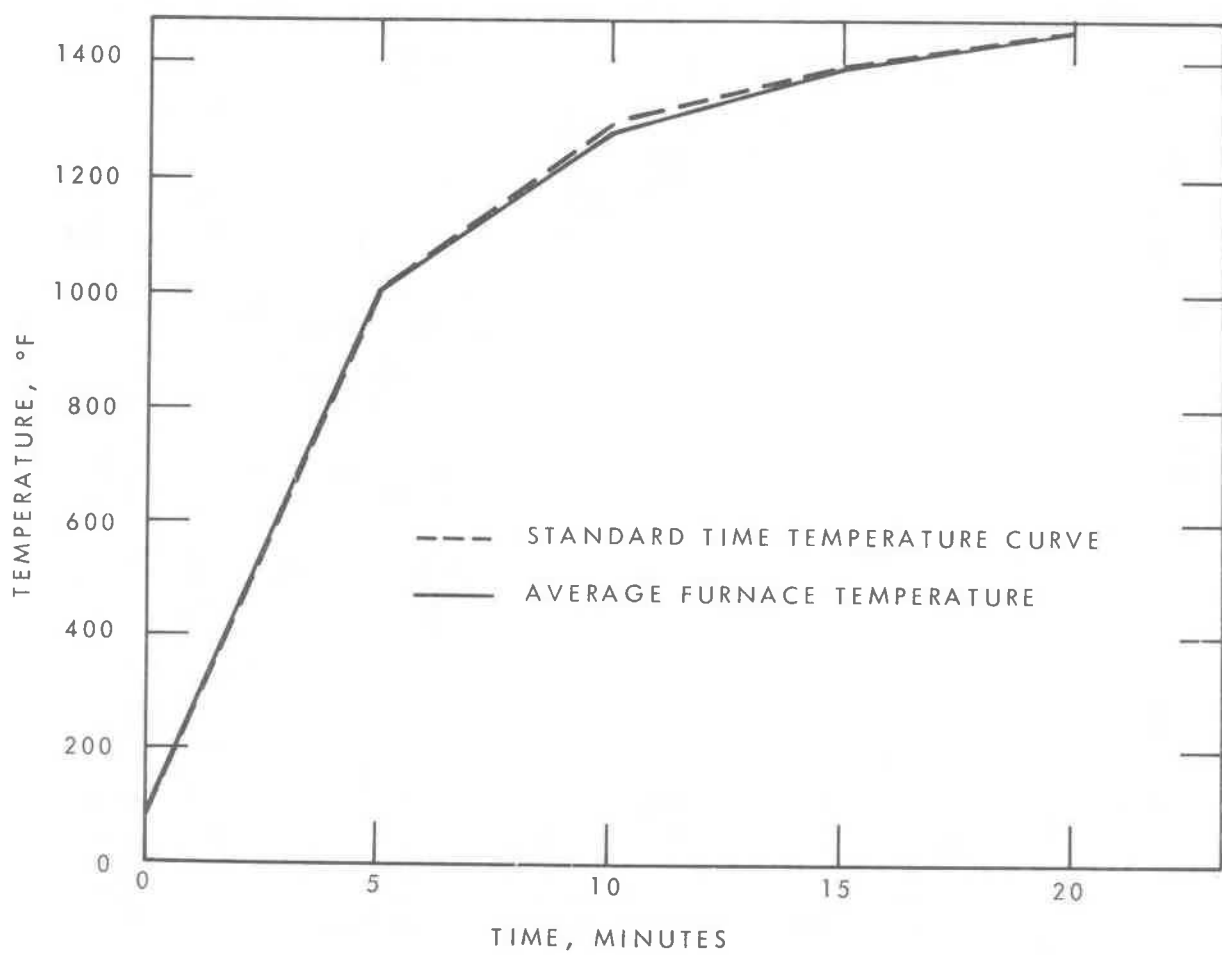


FIGURE A20  
DOOR TEST NO. 3 FURNACE TEMPERATURES

BR 5319-7



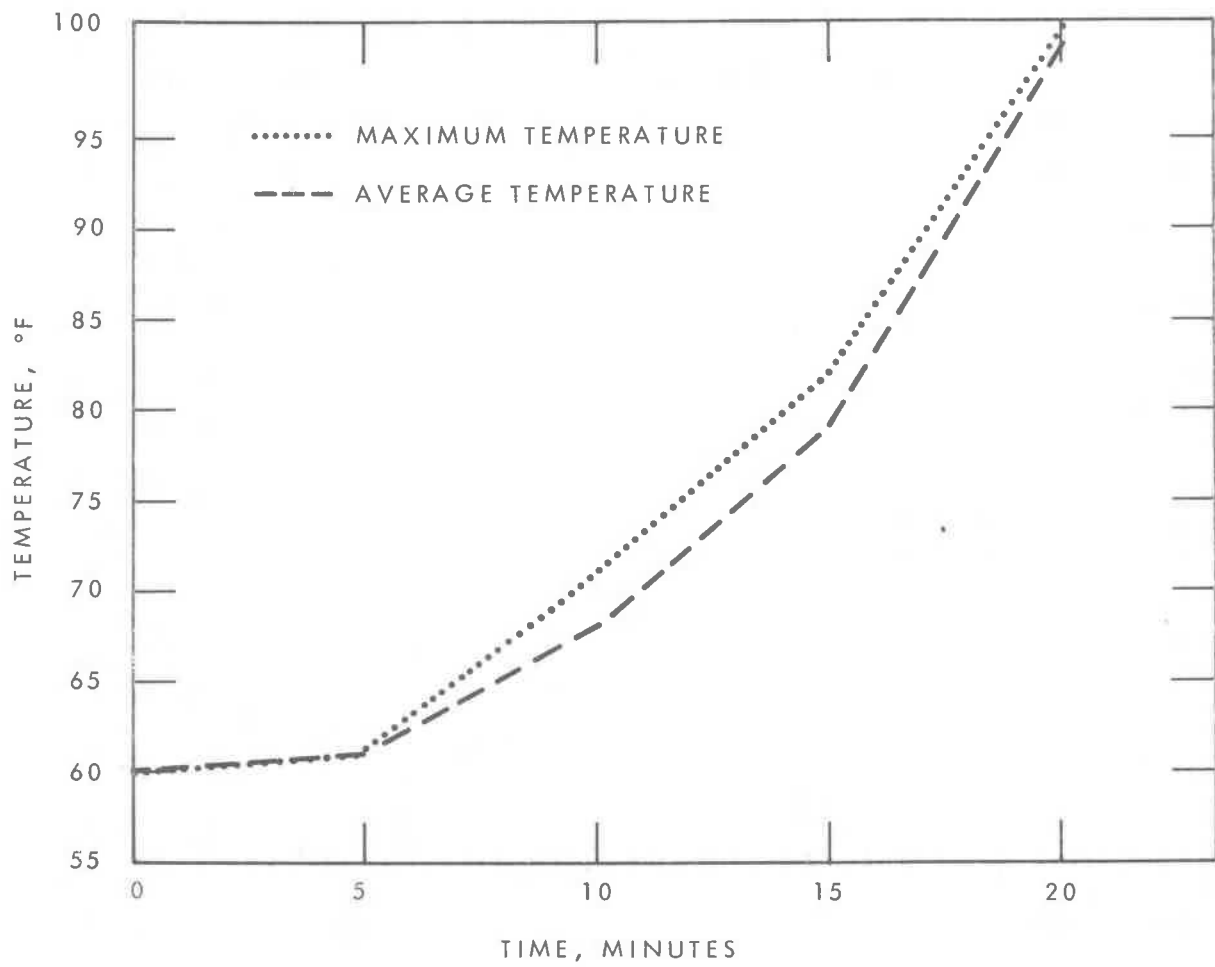


FIGURE A21  
DOOR TEST NO. 3 UNEXPOSED SURFACE TEMPERATURES DOOR A

BR 5319-8

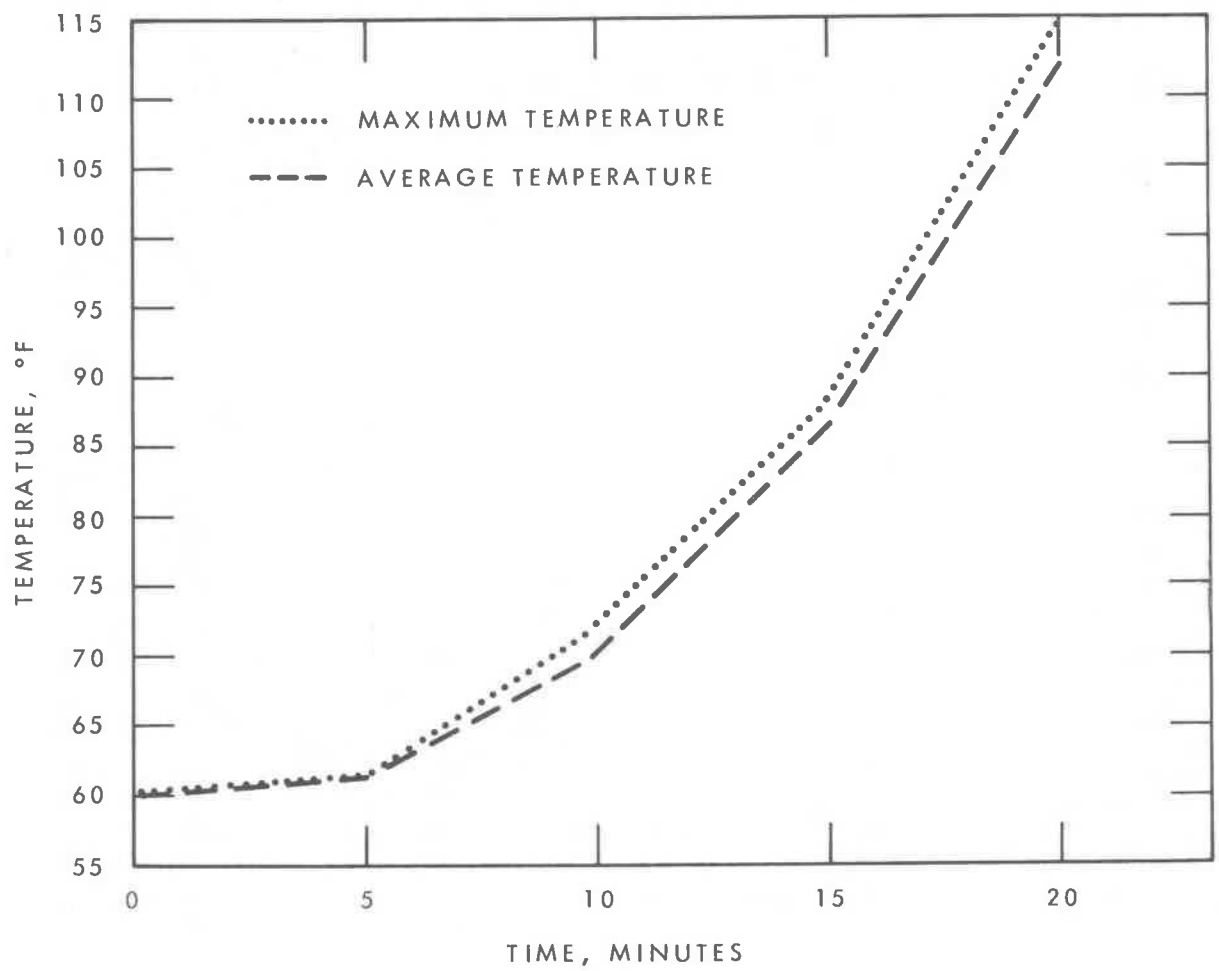


FIGURE A22

DOOR TEST NO. 3 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-9

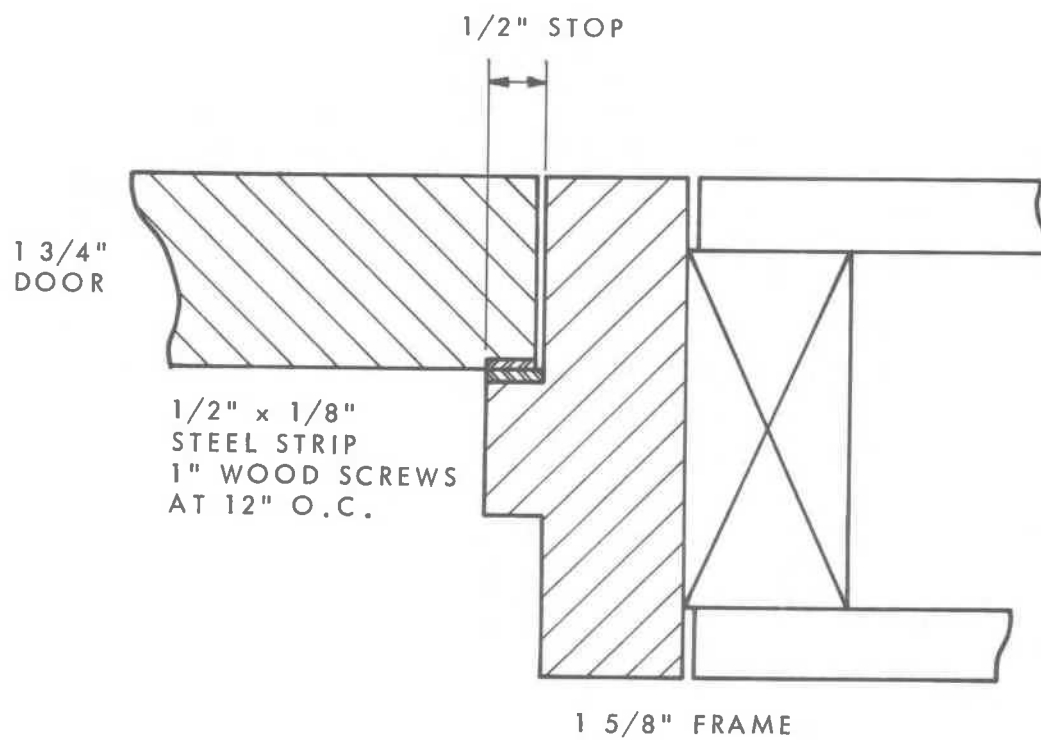


FIGURE A23  
DOOR AND FRAME WITH STEEL ON MEETING EDGES

BR 5319-10

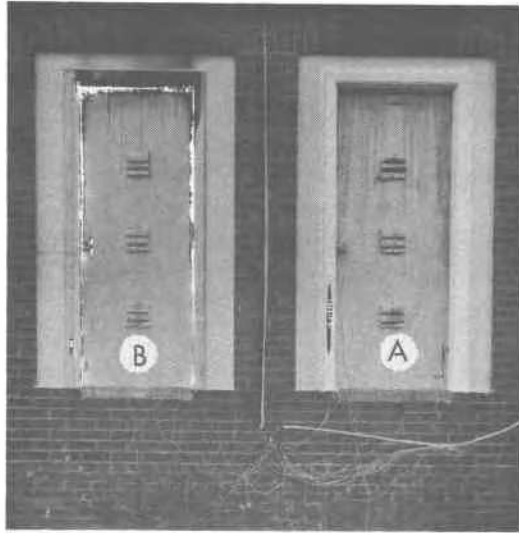


Figure A24. Door Test No. 4.  
Unexposed part at 22 min  
(approx).

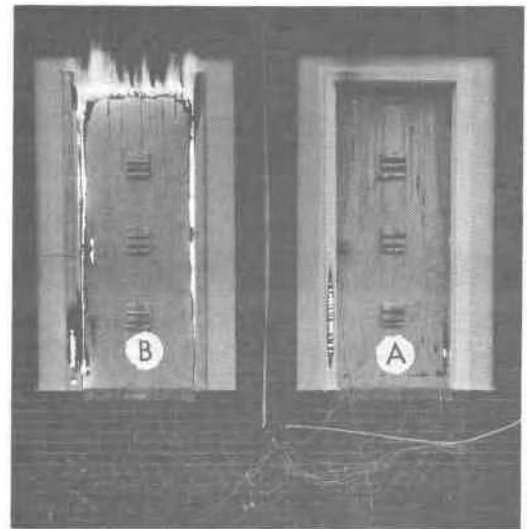


Figure A25. Door Test No. 4.  
Unexposed face at 26 min  
(approx).

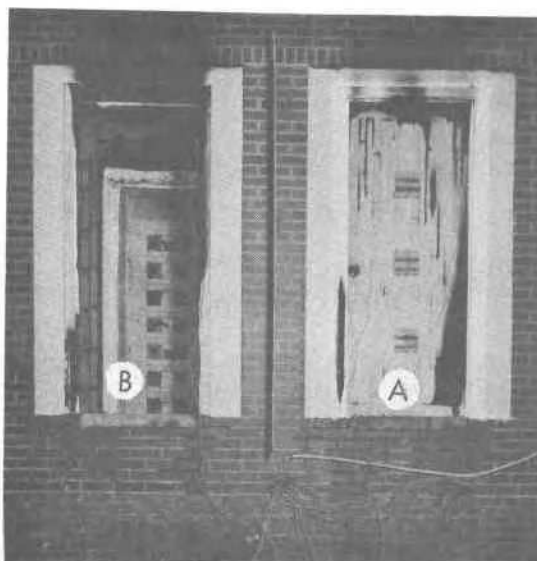


Figure A26. Door Test No. 4.  
Unexposed face after fire test.

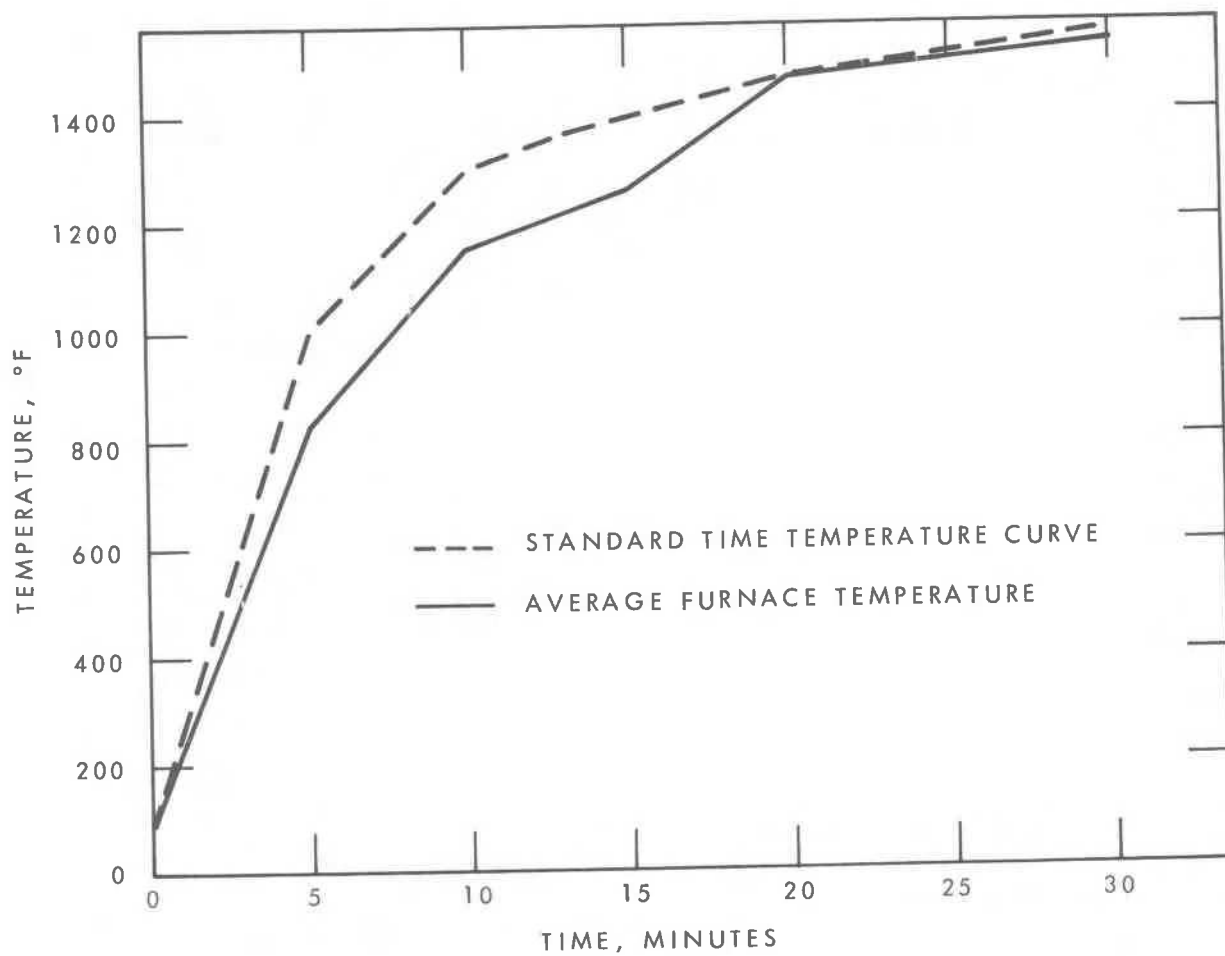


FIGURE A27  
DOOR TEST NO. 4 FURNACE TEMPERATURES

BR 5319 - II

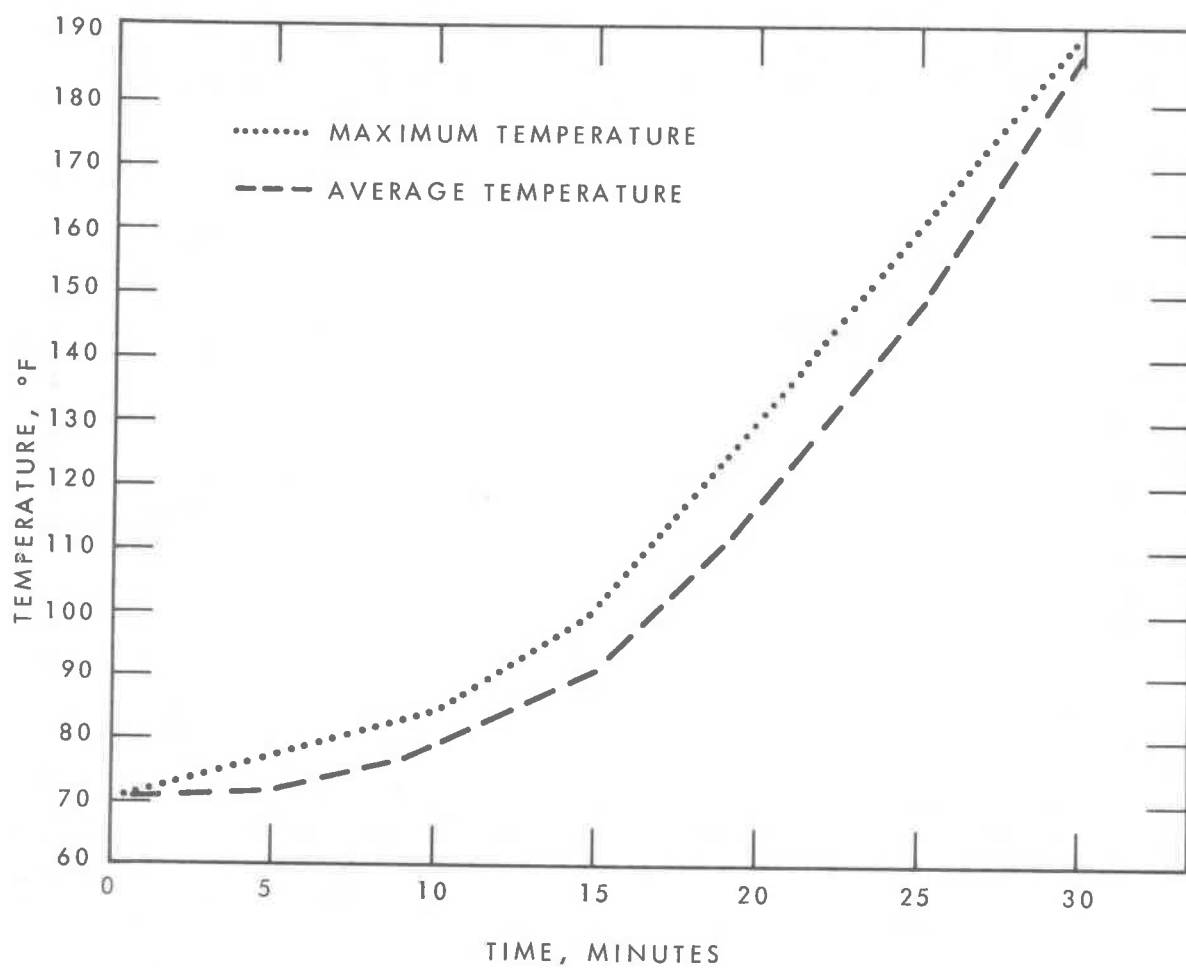


FIGURE A28

DOOR TEST NO. 4 UNEXPOSED SURFACE TEMPERATURES DOOR A

BR 5319-12

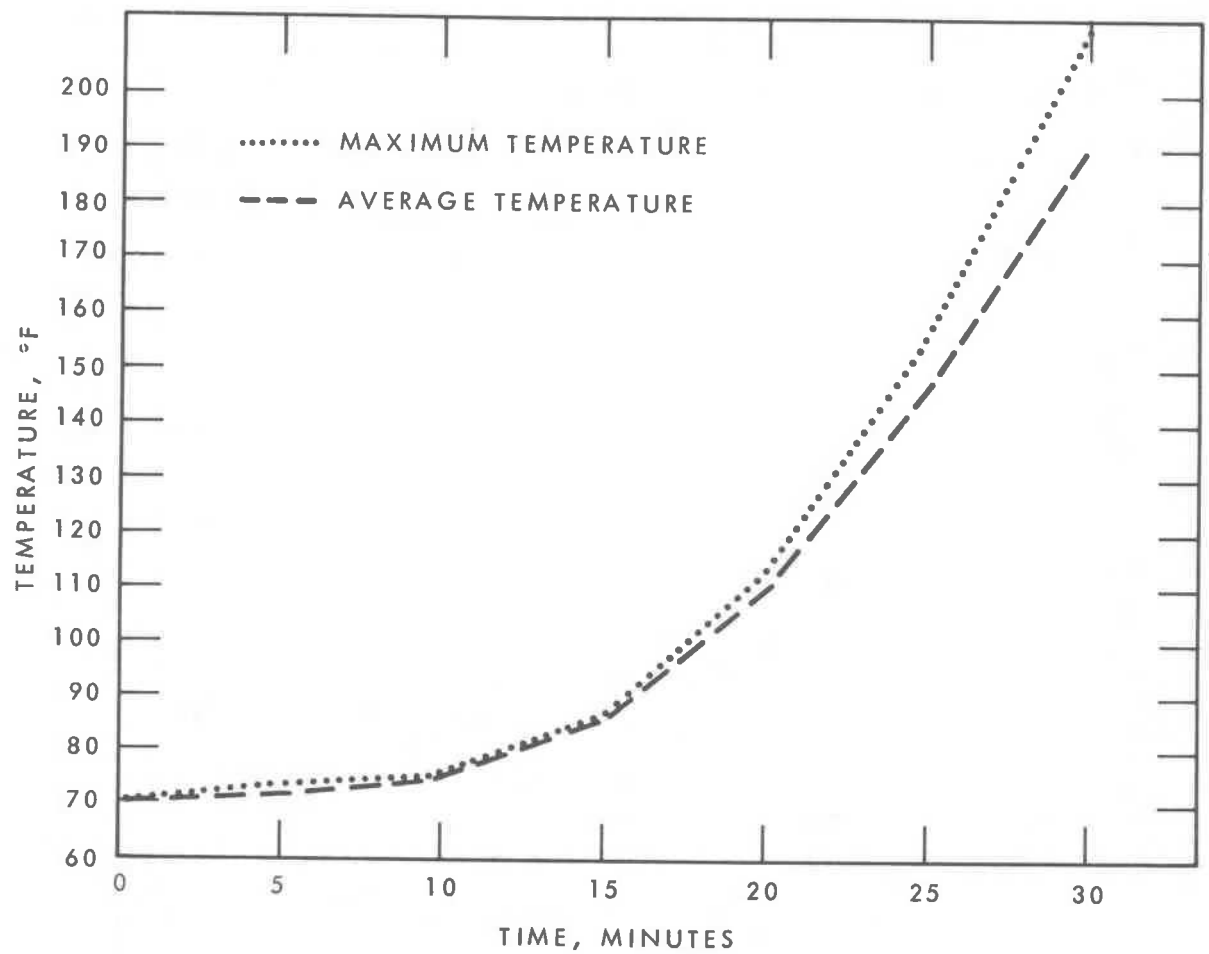


FIGURE A29

DOOR TEST NO. 4 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-13

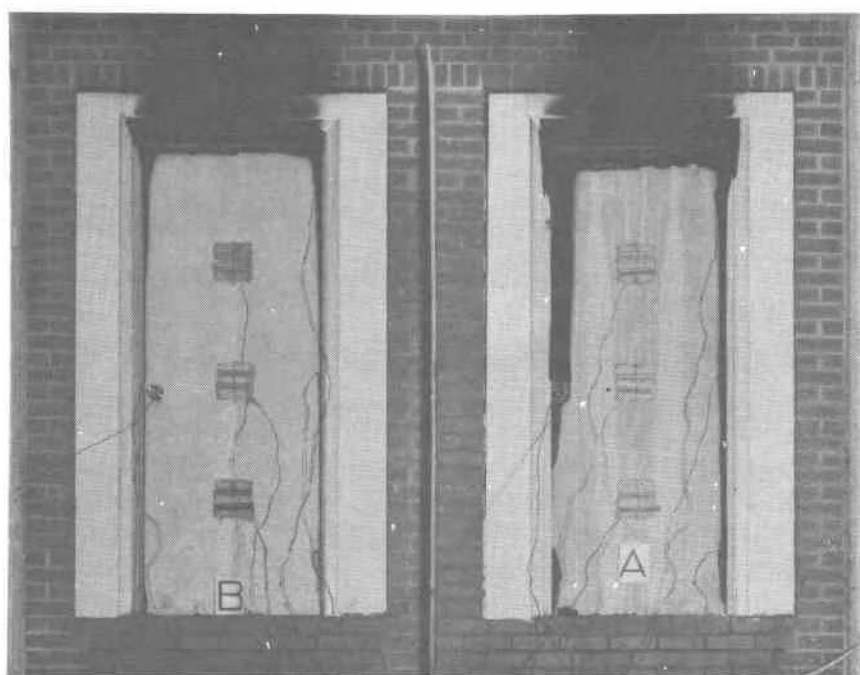


Figure A30. Door Test No. 5. Unexposed face after test.



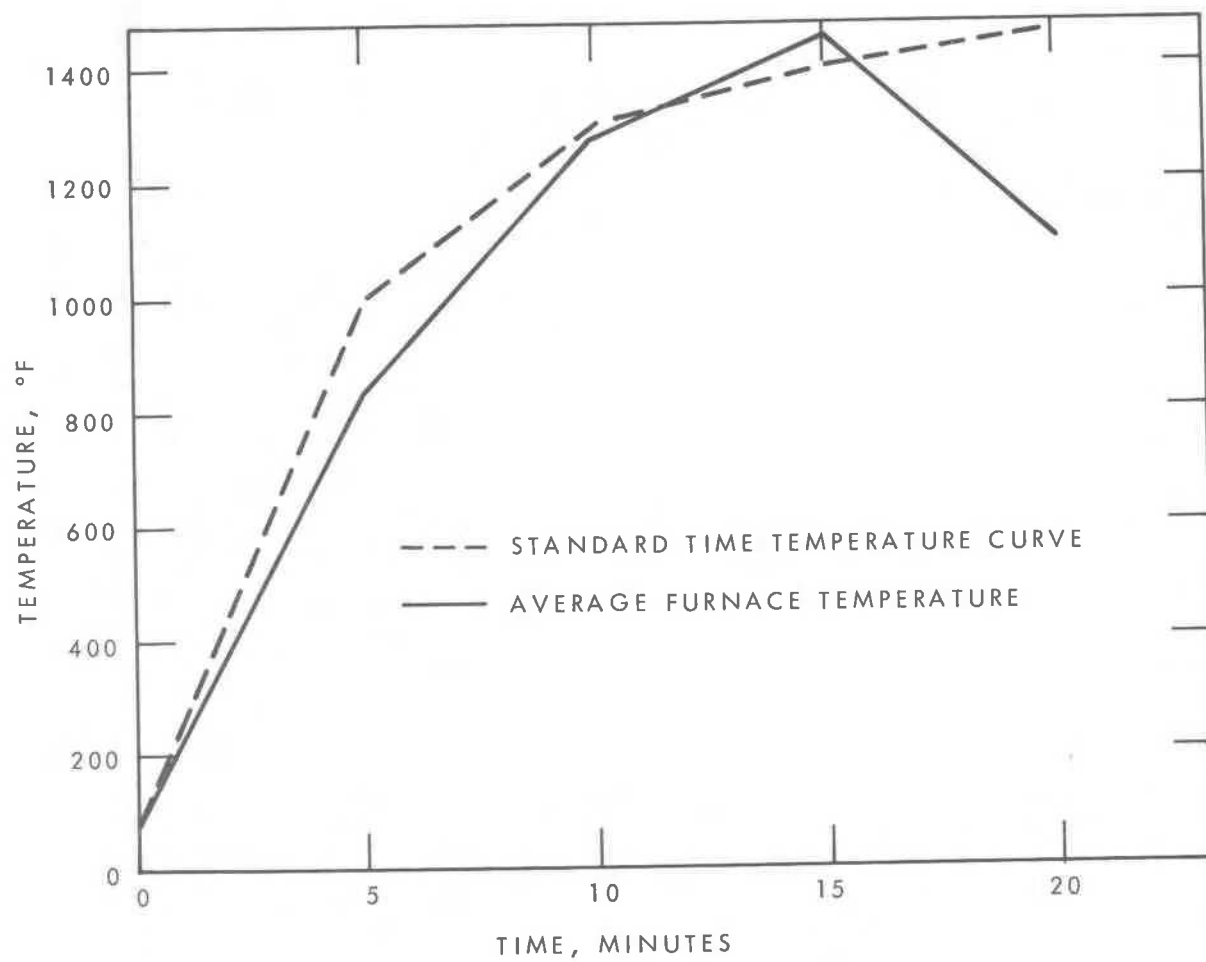


FIGURE A31  
DOOR TEST NO. 5 FURNACE TEMPERATURES

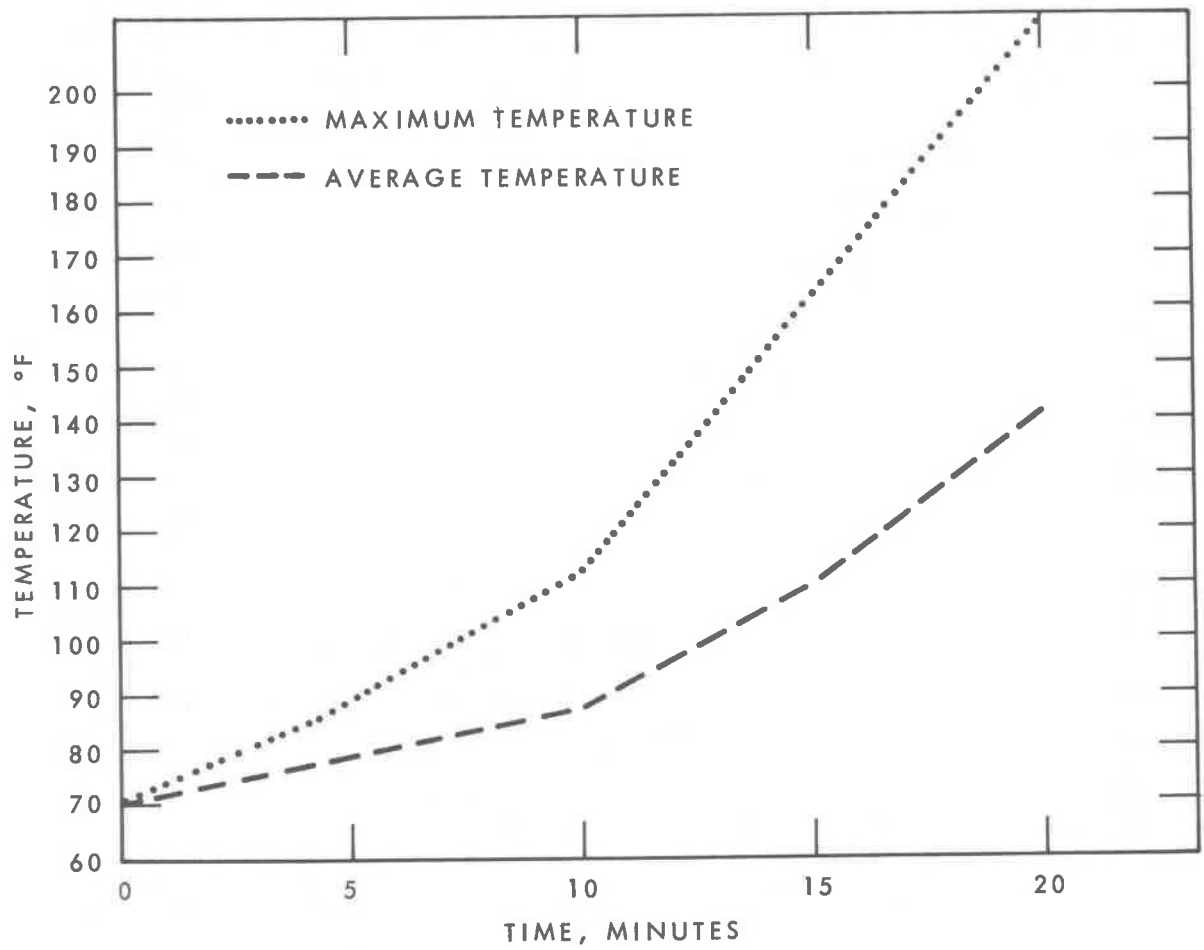


FIGURE A32

DOOR TEST NO. 5 UNEXPOSED SURFACE TEMPERATURES DOOR A

BR 5319-15

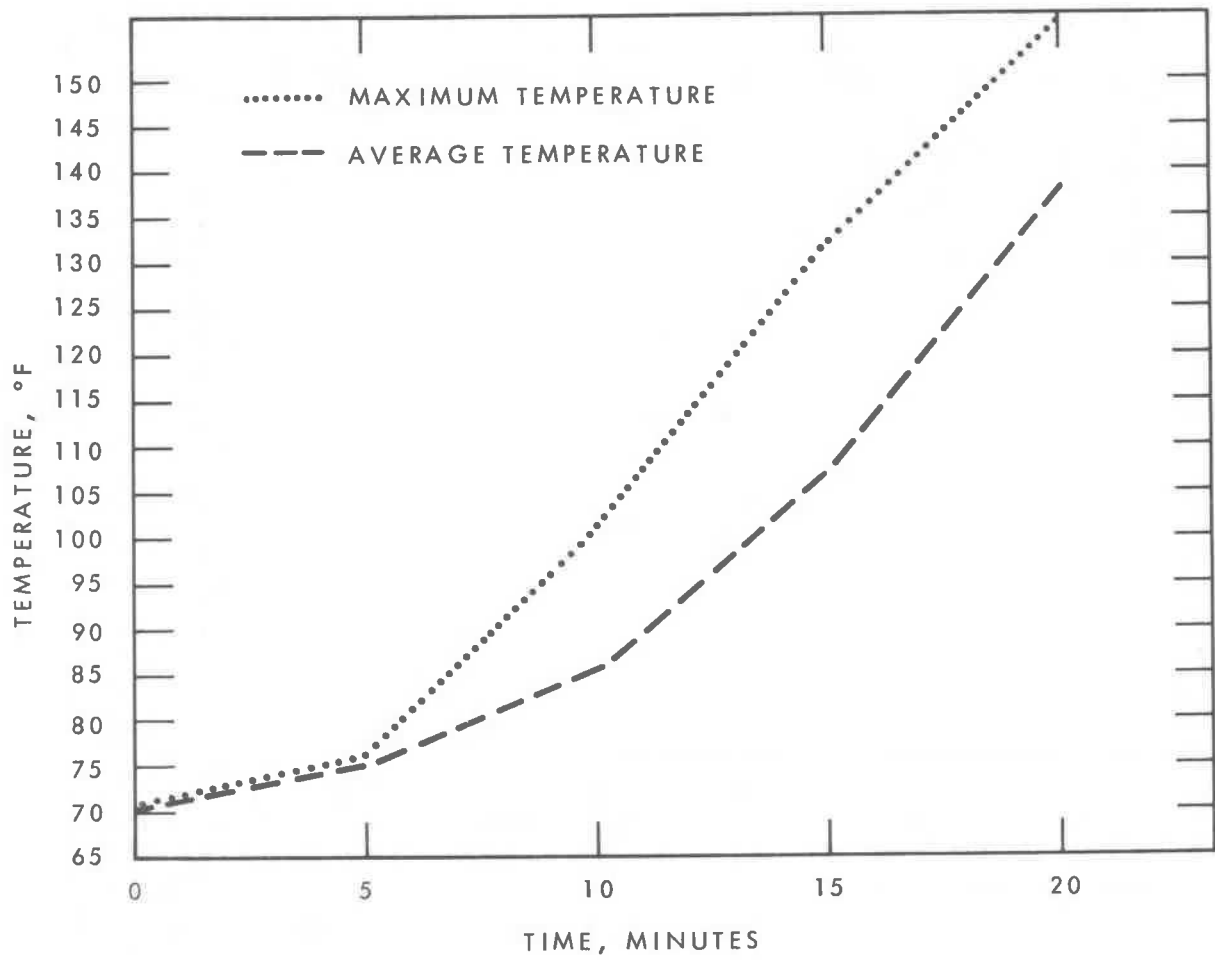


FIGURE A33

DOOR TEST NO. 5 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-16

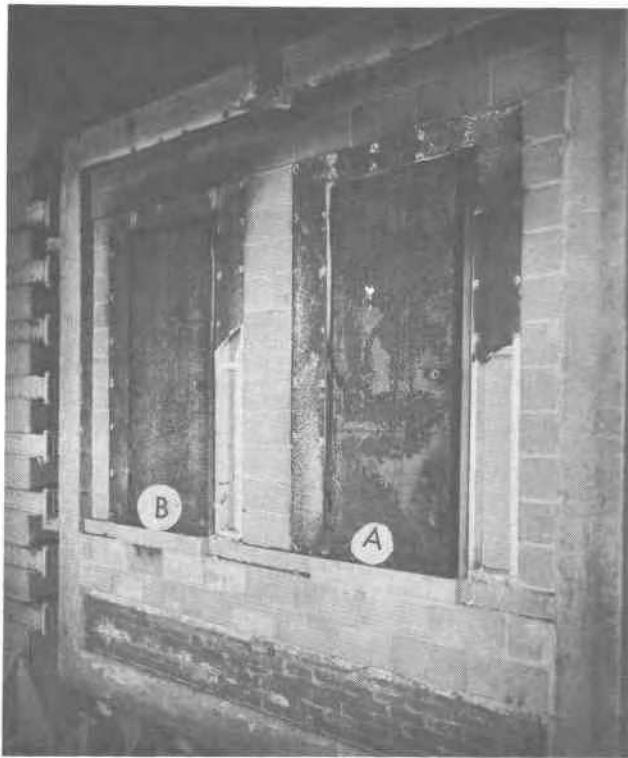


Figure A34. Door Test No. 6.  
Fire exposed face after test.



Figure A35. Door Test No. 7.  
Unexposed face at 10 min.

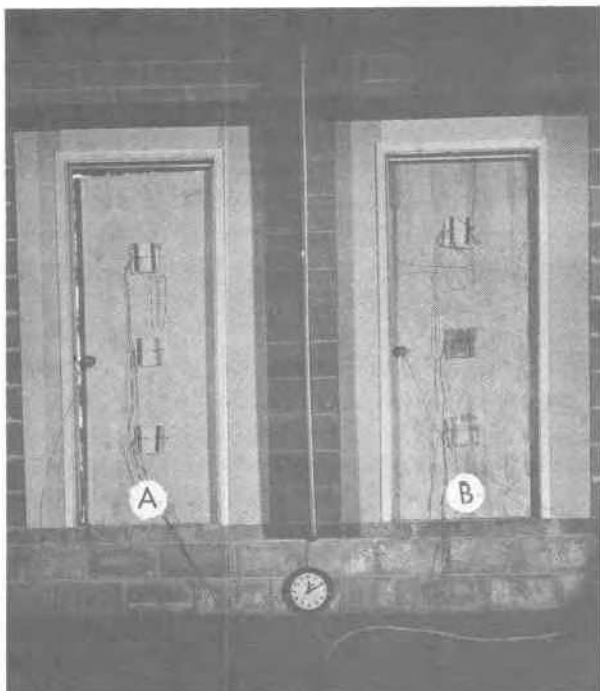


Figure A36. Door Test No. 7.  
Unexposed face at 11 min.

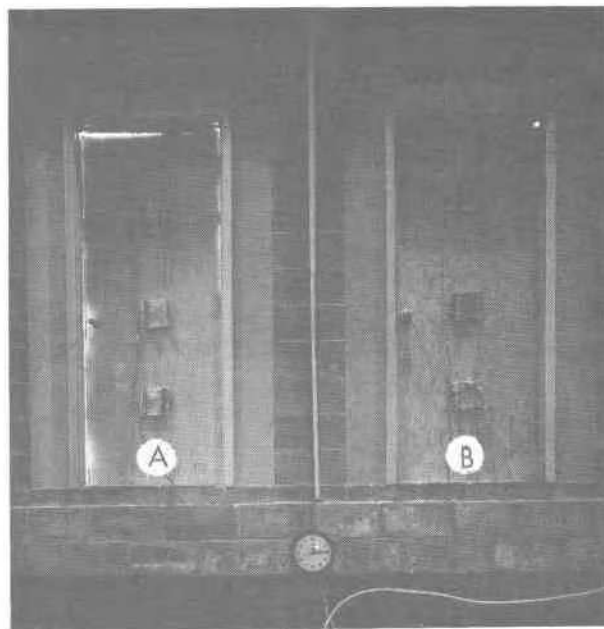
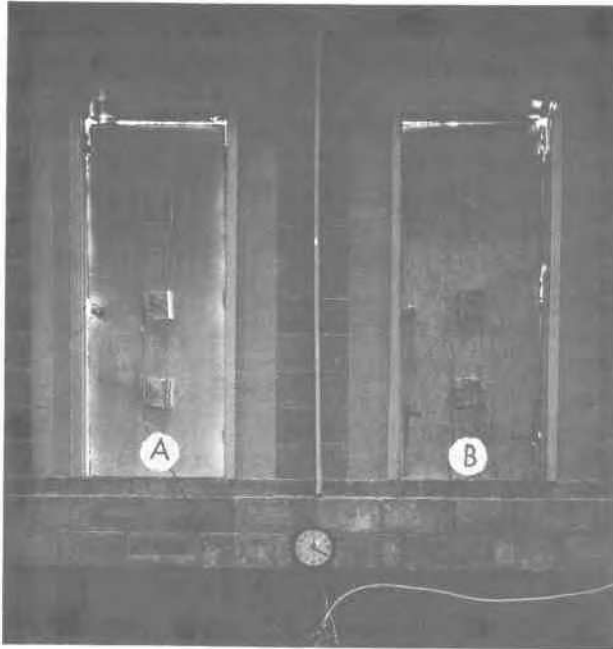
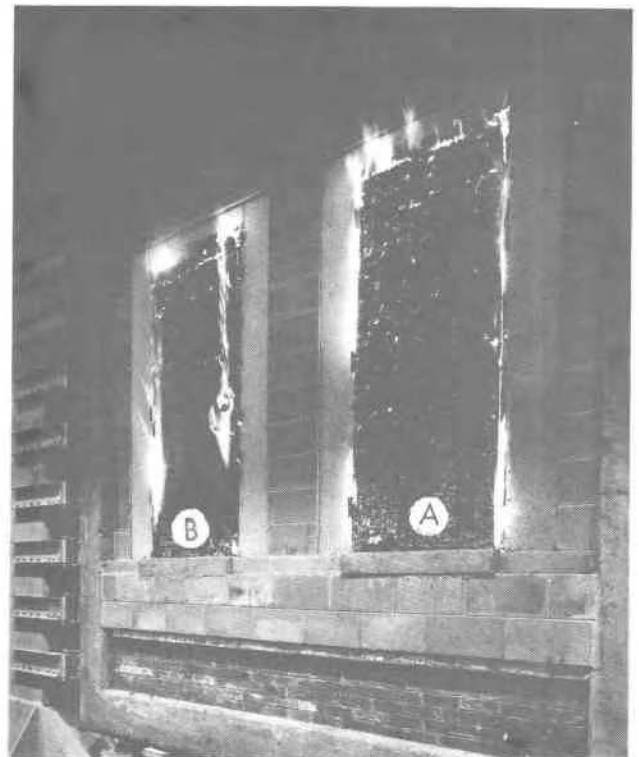


Figure A37. Door Test No. 7.  
Unexposed face at 14 min.



**Figure A38. Door Test No. 7.  
Unexposed face after test.**



**Figure A39. Door Test No. 7.  
Fire exposed side after test.**

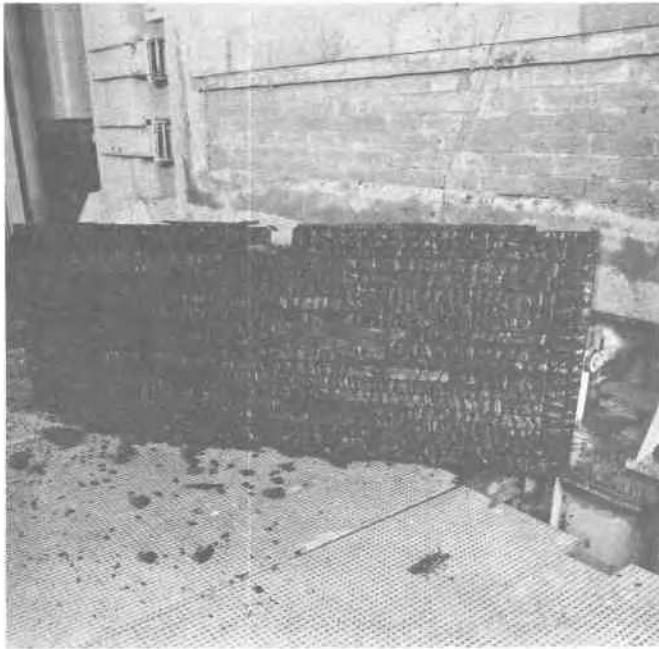


Figure A40. Door Test No. 7.  
Condition of Door A after test.



Figure A41. Door Test No. 7.  
Condition of Door B after test.

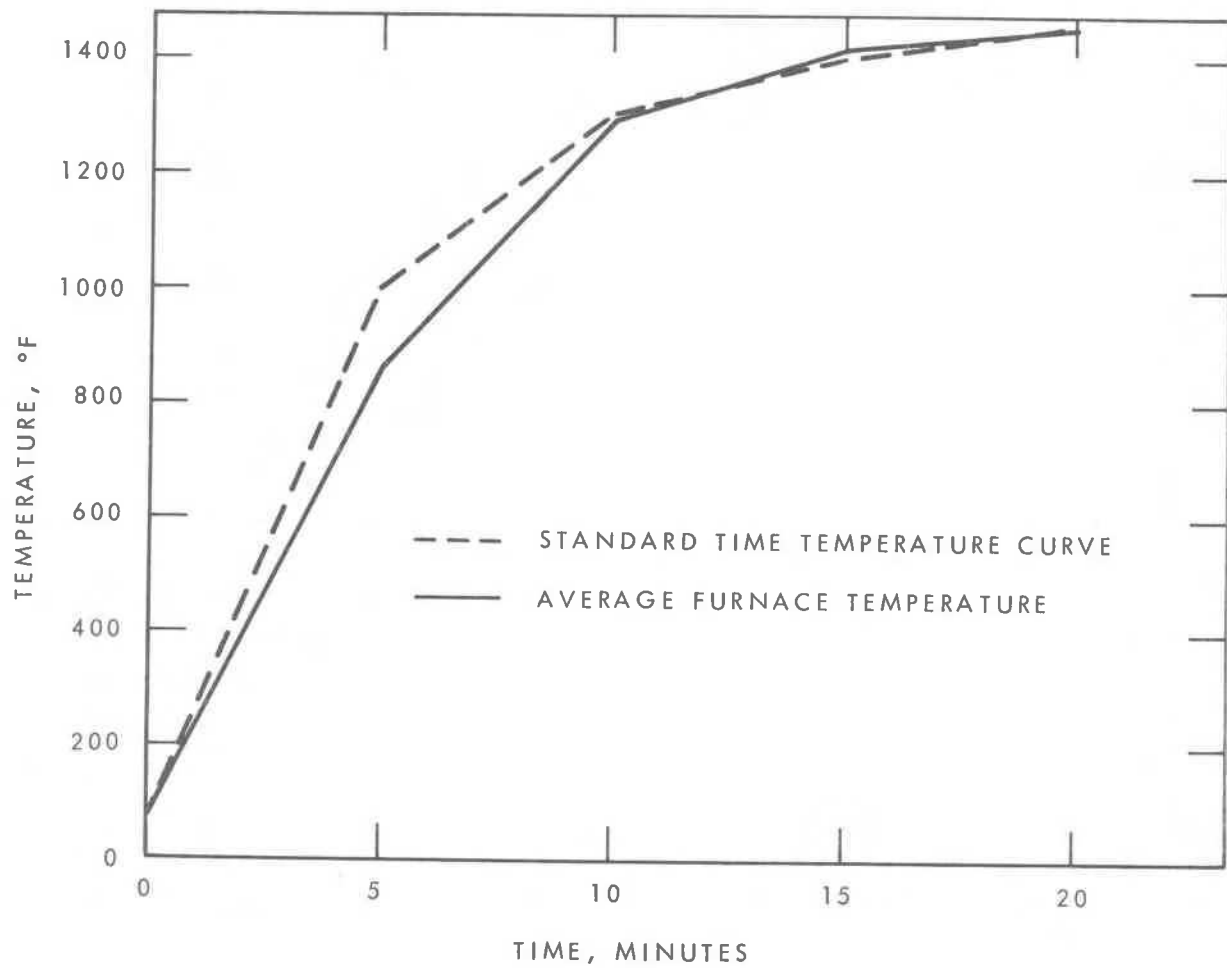


FIGURE A42  
DOOR TEST 7 FURNACE TEMPERATURES

BR 5319-17



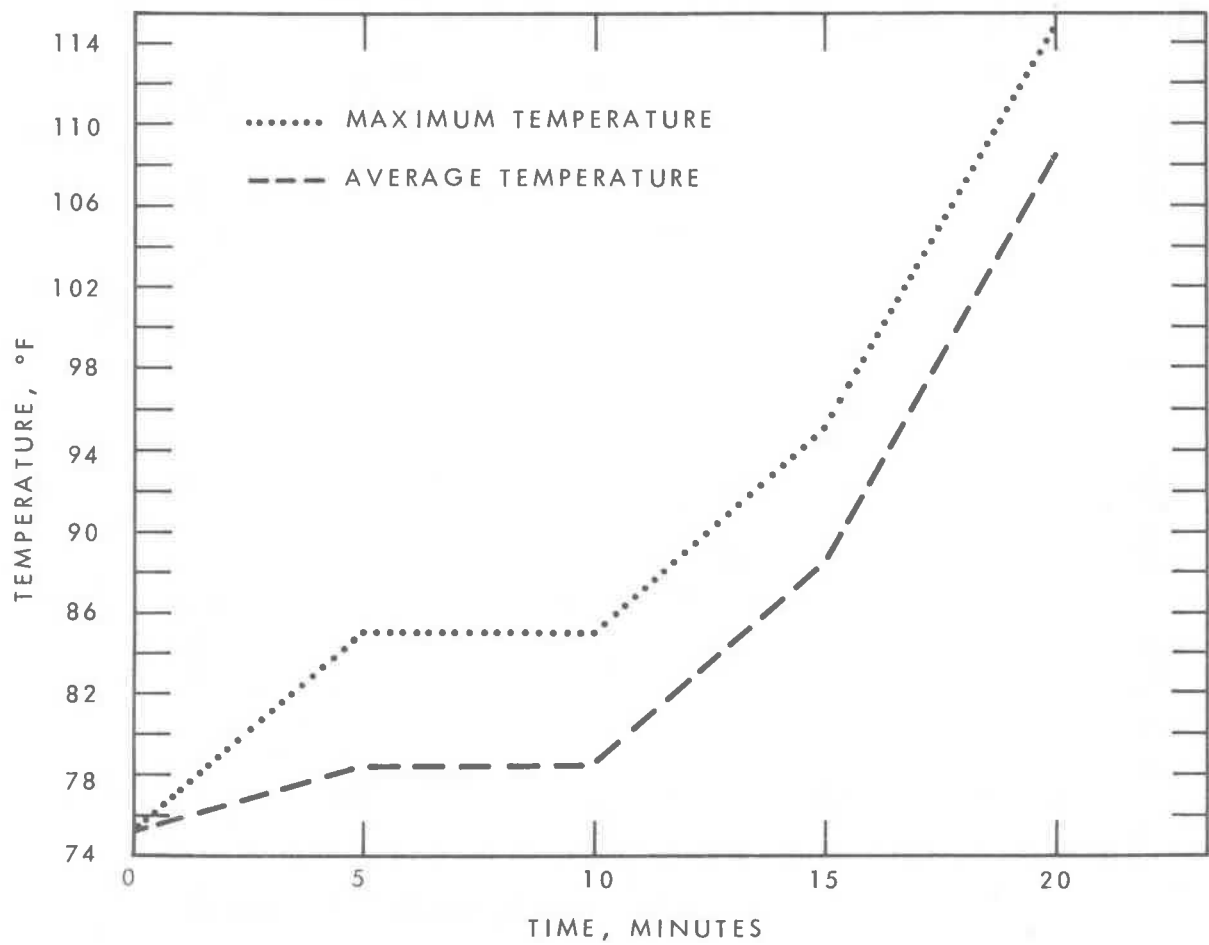


FIGURE A43  
DOOR TEST NO. 7 UNEXPOSED SURFACE TEMPERATURES DOOR A  
BR 5319-18

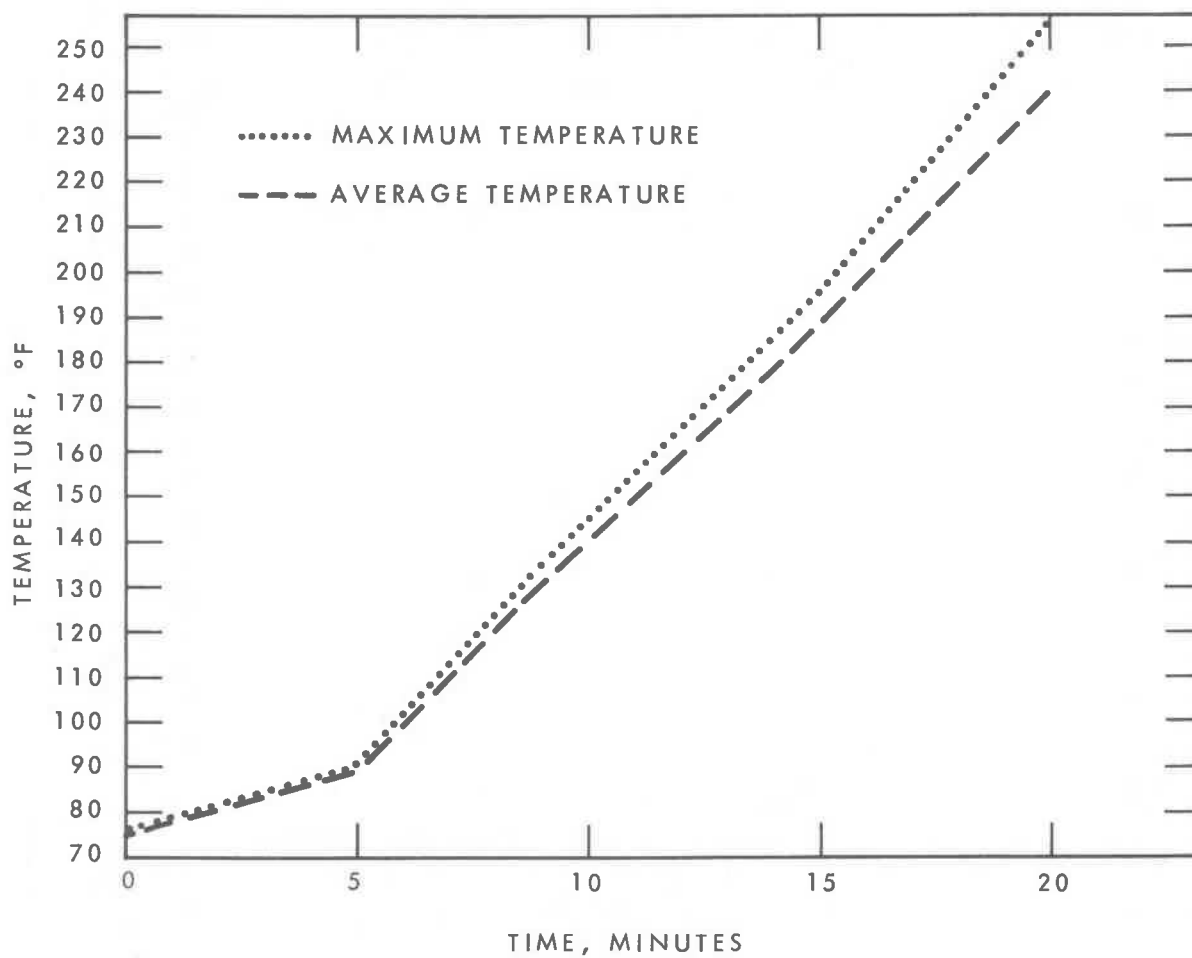


FIGURE A44

DOOR TEST NO. 7 UNEXPOSED SURFACE TEMPERATURES DOOR B

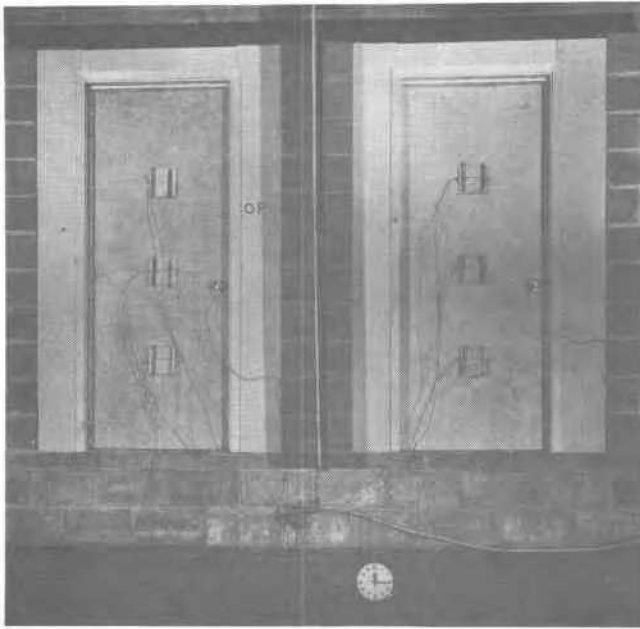


Figure A45. Door Test No. 8.  
Unexposed face at 15 min.

Figure A46. Door Test No. 8.  
Unexposed face at 20 min.

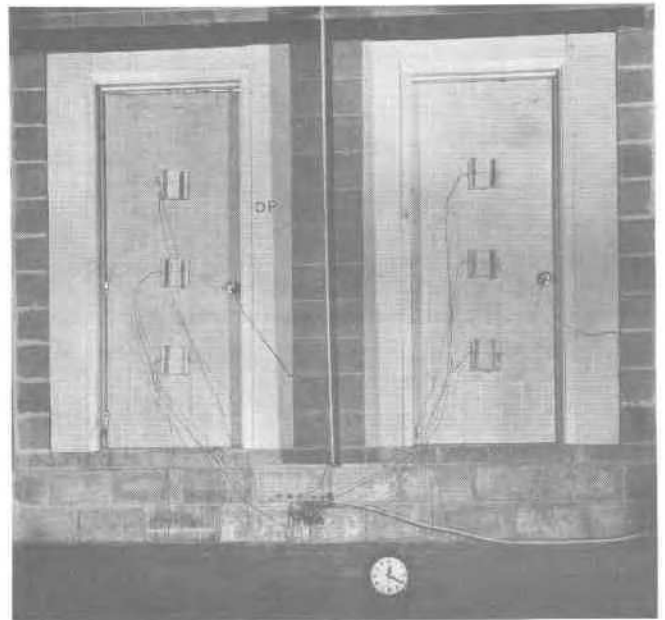


Figure A47. Door Test No. 8.  
Condition of latch set Door B after  
fire test.

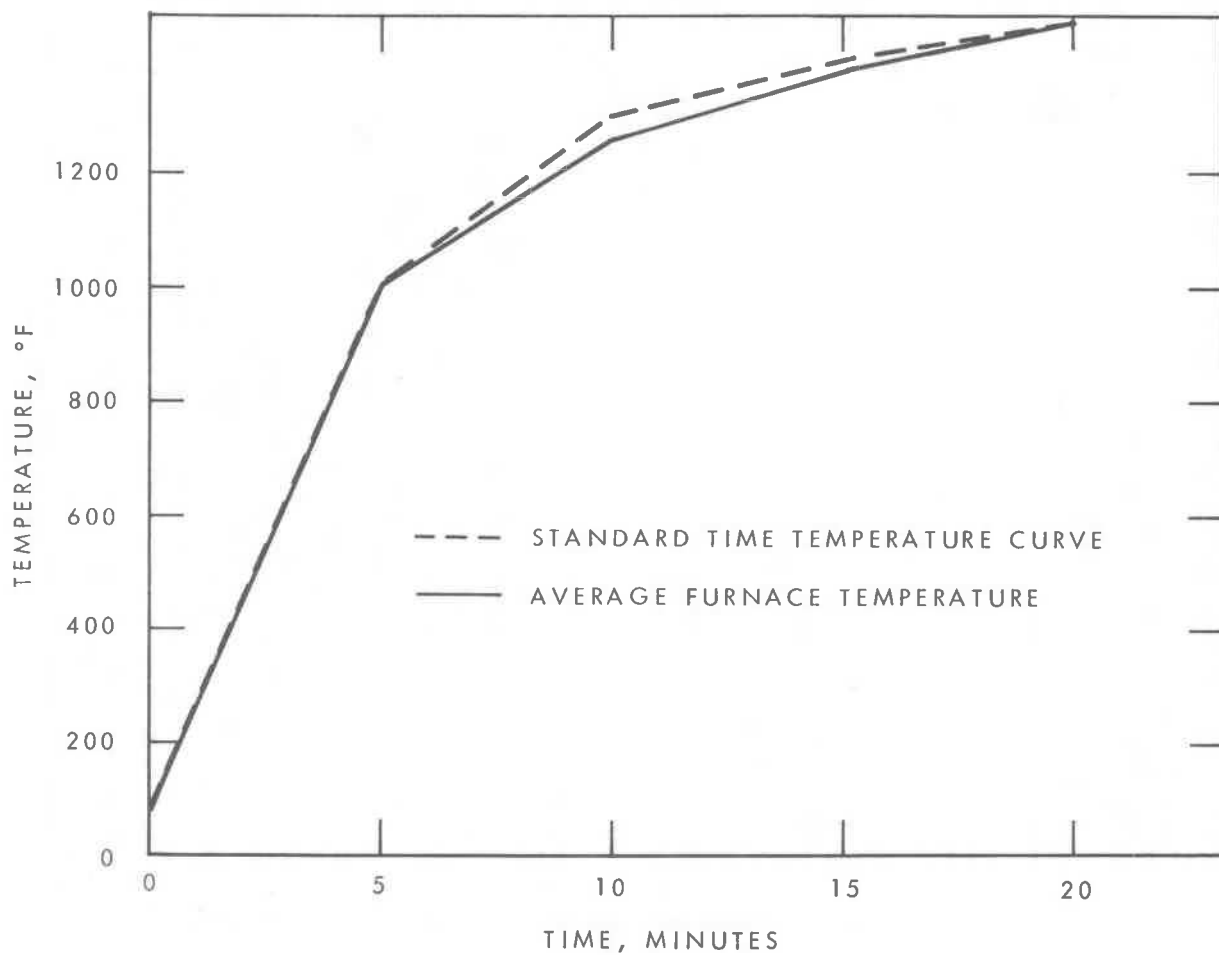


FIGURE A48  
DOOR TEST NO. 8 FURNACE TEMPERATURE

BR 5319 - 20

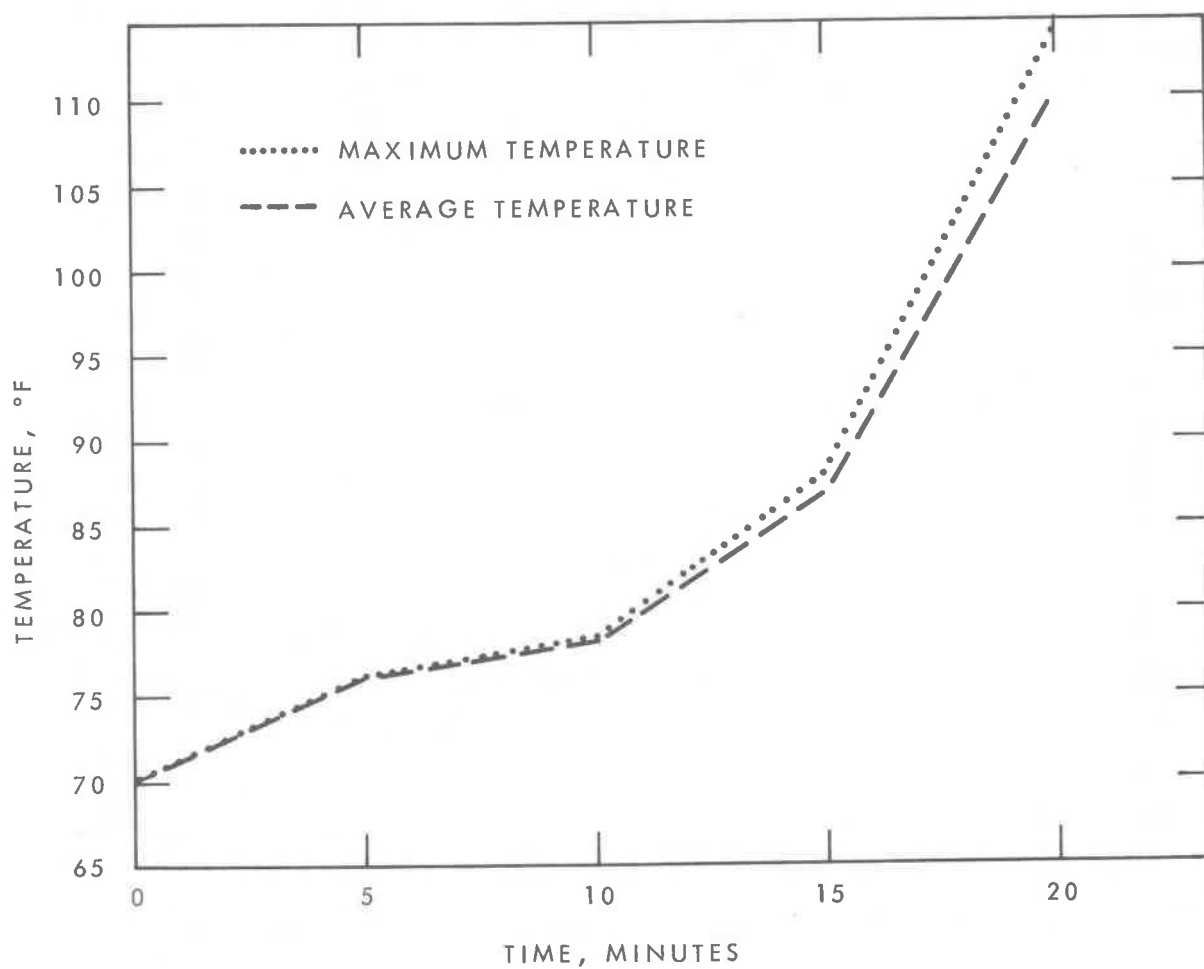


FIGURE A49

DOOR TEST NO. 8 UNEXPOSED SURFACE TEMPERATURES DOOR A

BR 5319-21

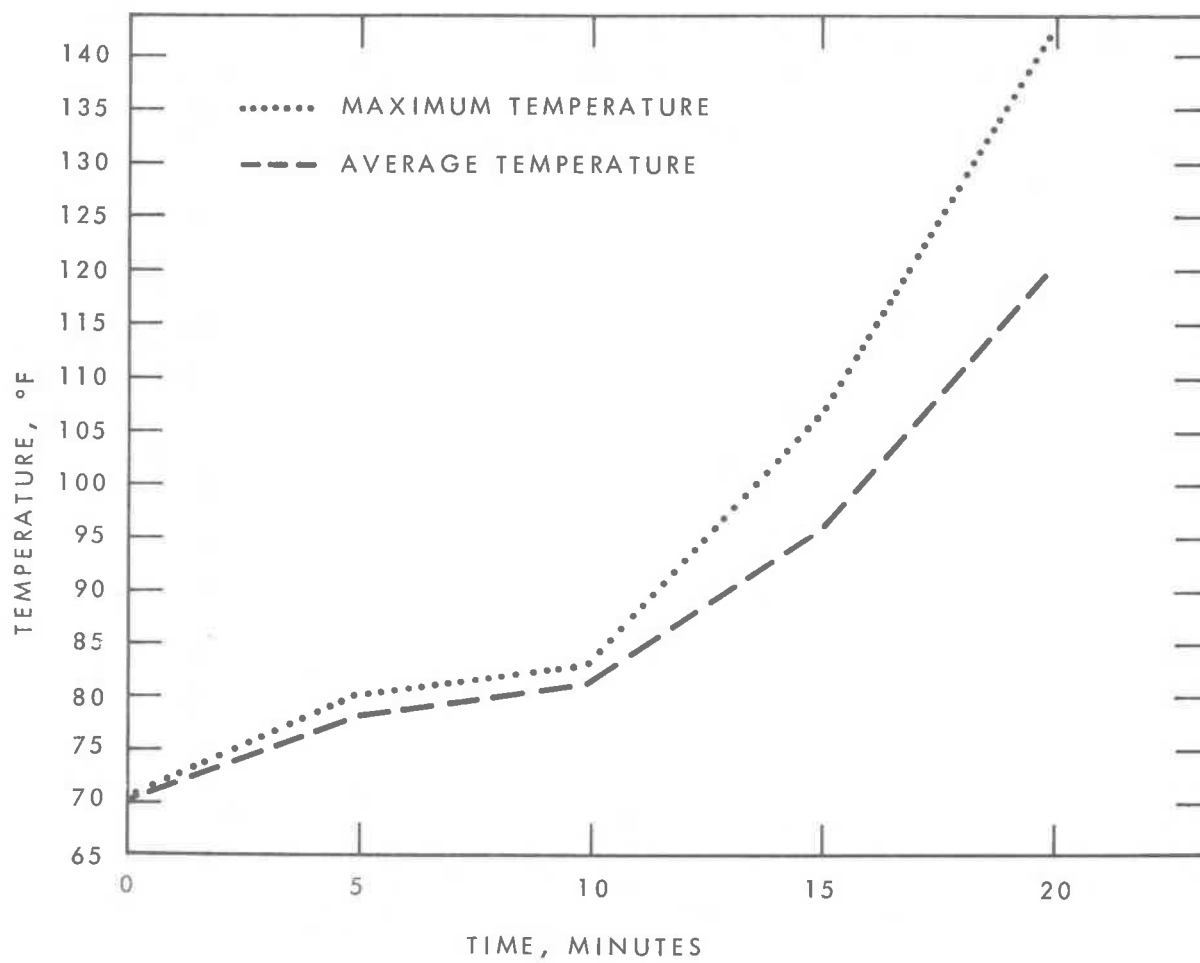


FIGURE A50

DOOR TEST NO. 8 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-22

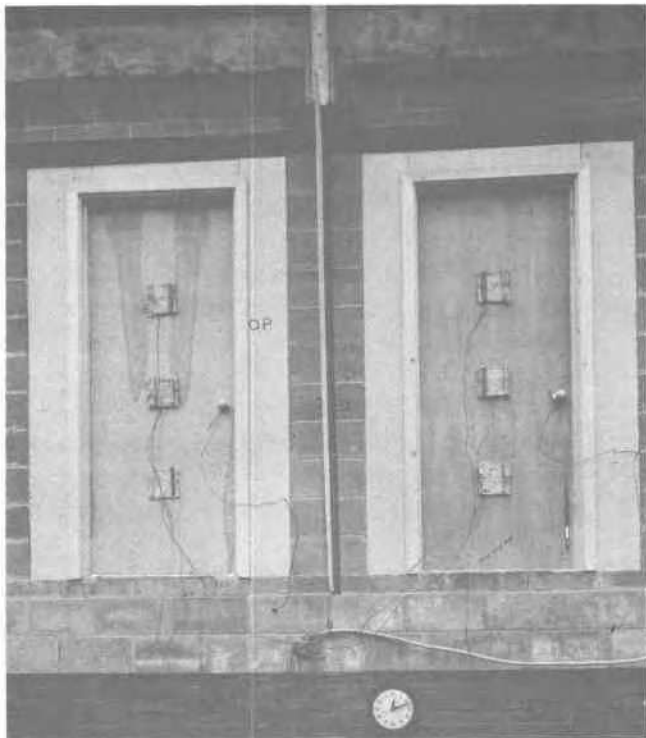
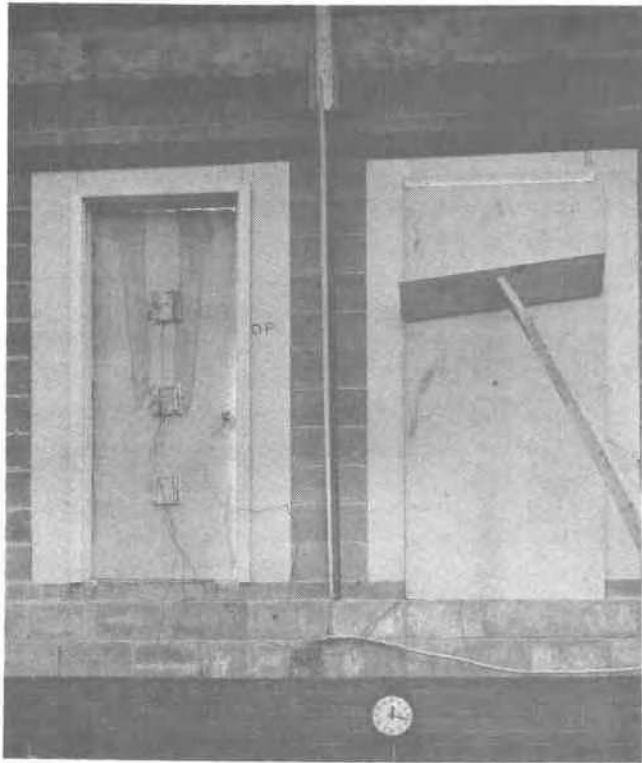


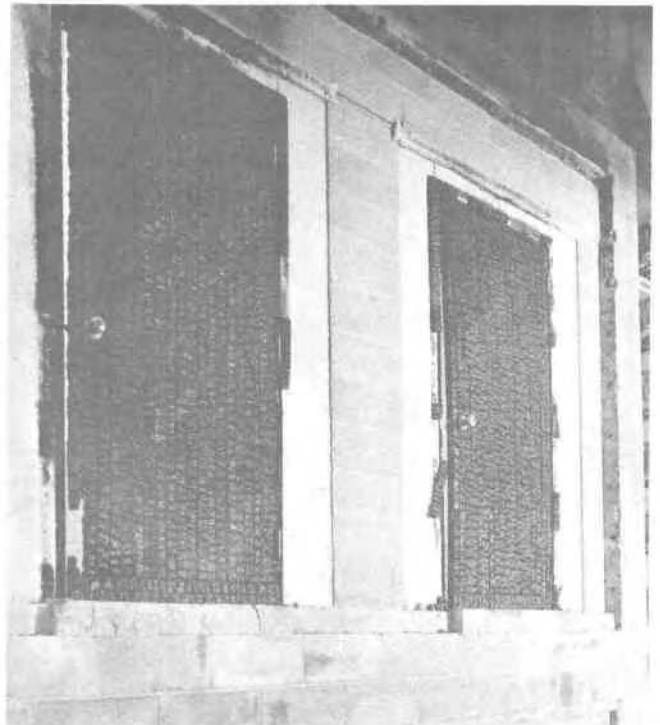
Figure A51. Door Test N o. 9.  
Unexposed face at 11 min.



Figure A52. Door Test No. 9.  
Unexposed face at 11 $\frac{1}{2}$  min.



**Figure A53. Door Test No. 9.  
Unexposed face at 17 min.**



**Figure A54. Door Test No. 9.  
Fire exposed face after test.**



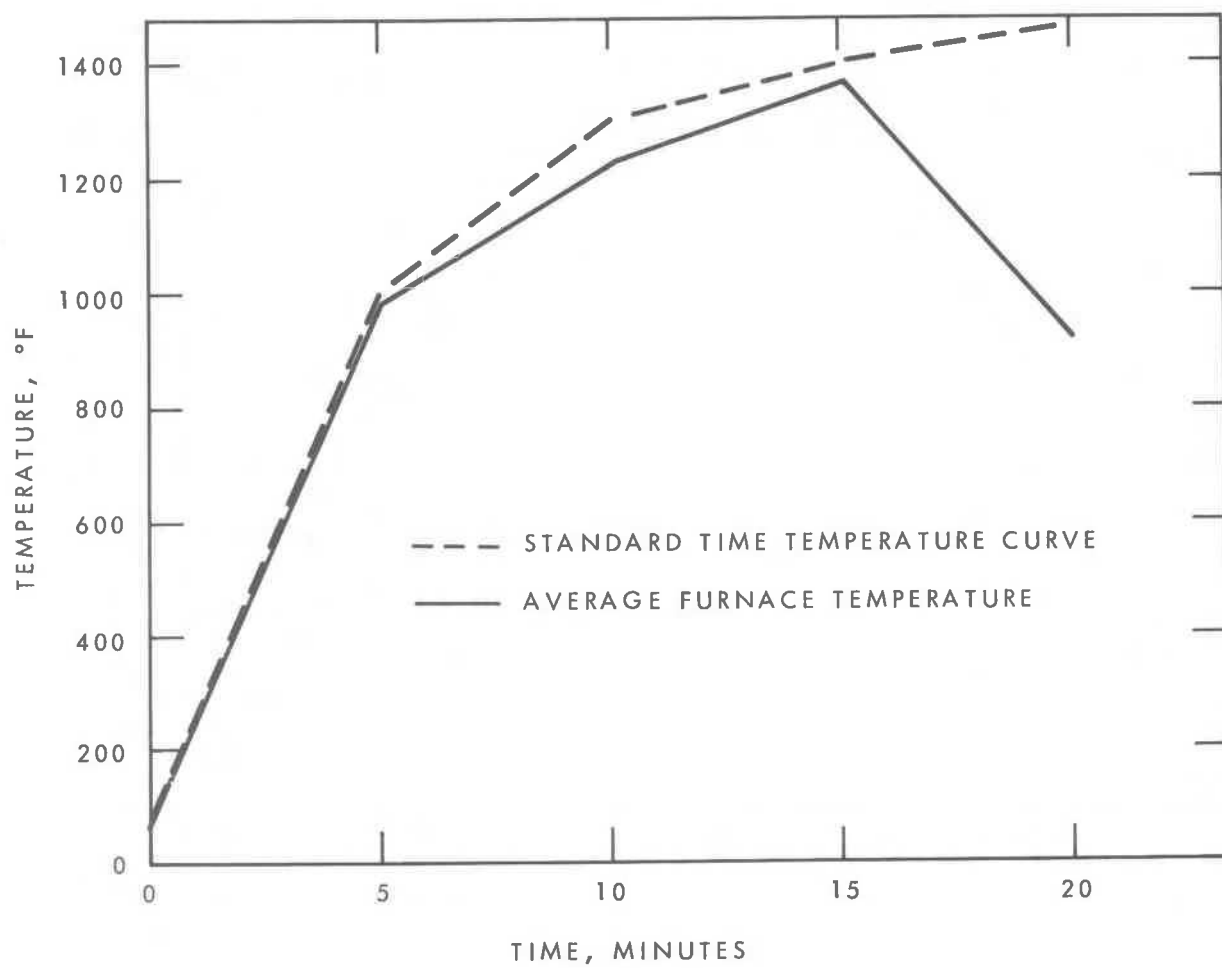


FIGURE A55

DOOR TEST NO. 9 FURNACE TEMPERATURES

BR 5319-23

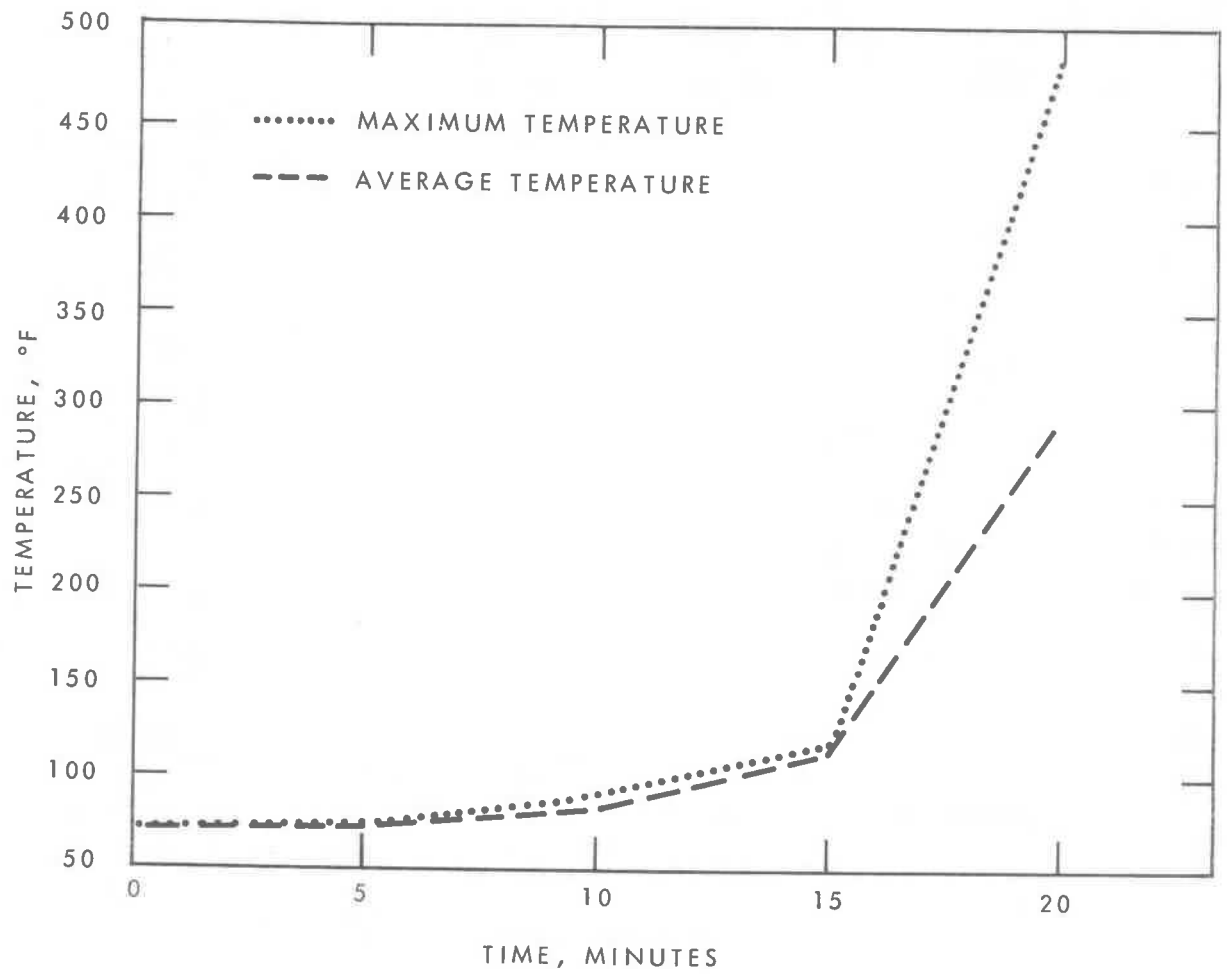


FIGURE A56

DOOR TEST NO. 9 UNEXPOSED SURFACE TEMPERATURES DOOR A

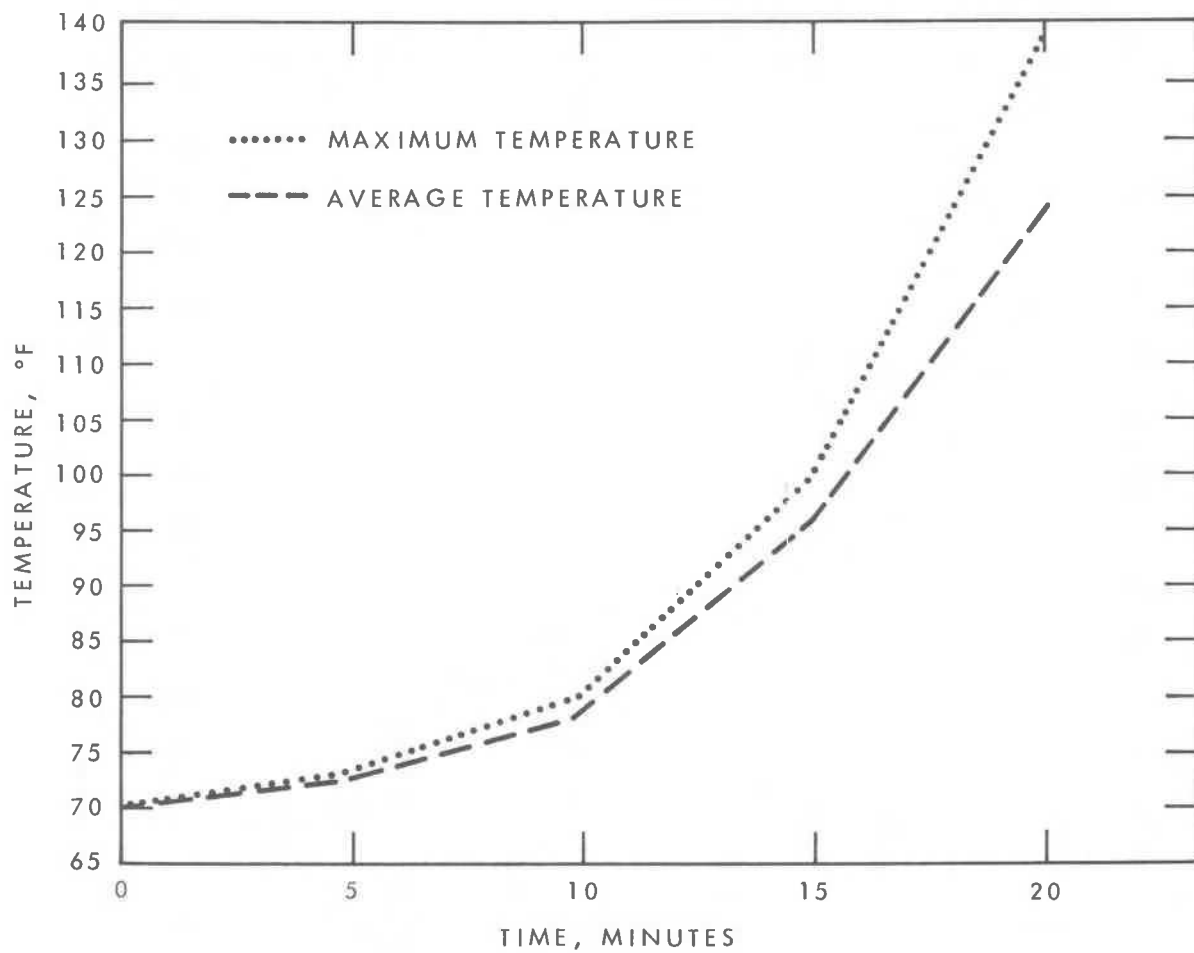


FIGURE A57  
DOOR TEST NO. 9 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-25

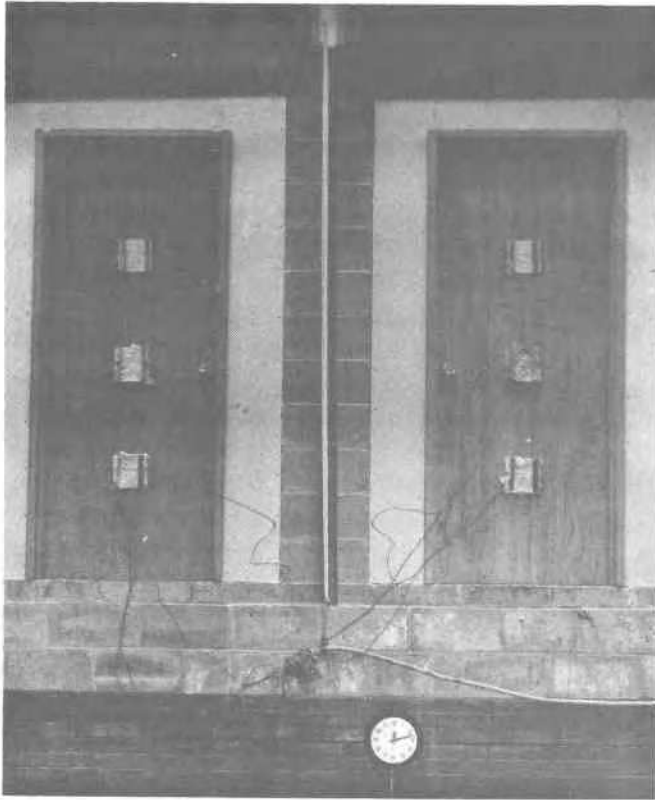


Figure A58. Door Test No. 10.  
Unexposed face at 12 min.

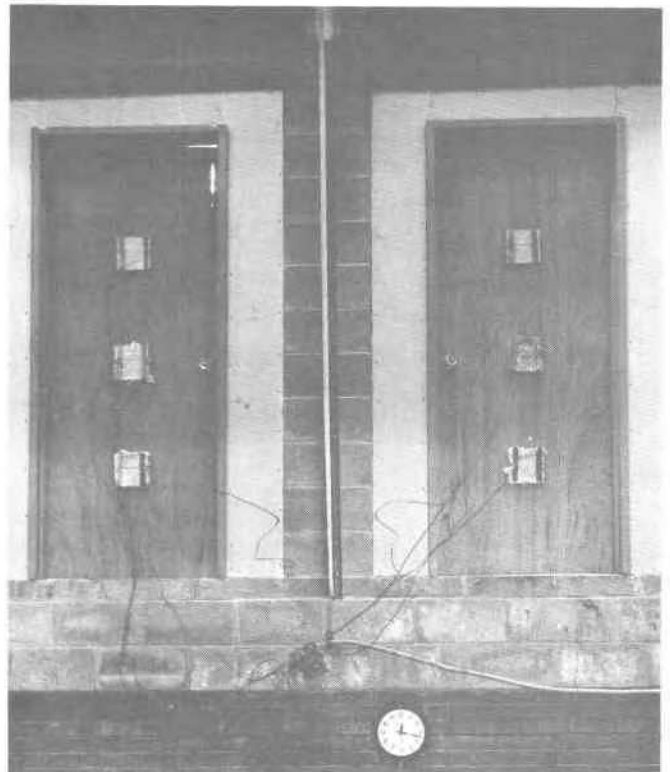


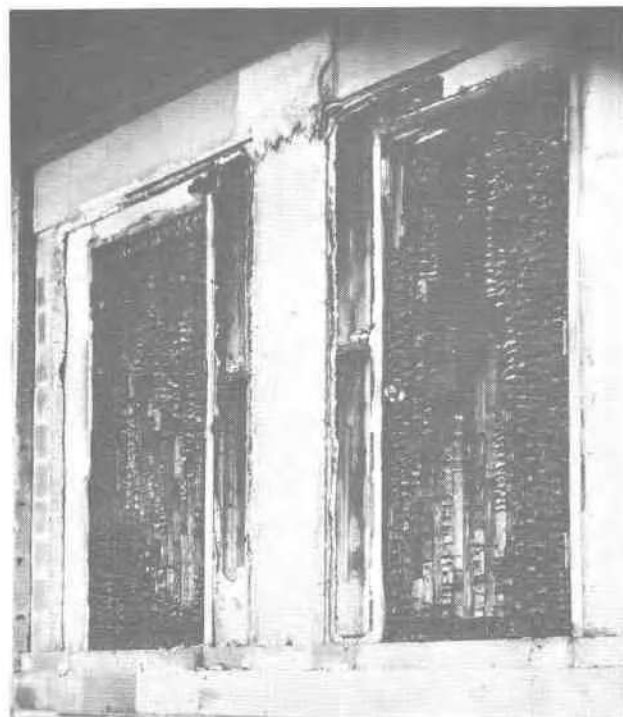
Figure A59. Door Test No. 10.  
Unexposed face at 17 min.

Figure A60. Door Test No. 10.  
Unexposed face at 20 min.



Figure A61. Door Test No. 10.  
Unexposed face following fire  
exposure and hose stream.

Figure A62. Door Test No. 10.  
Fire exposed face after test.



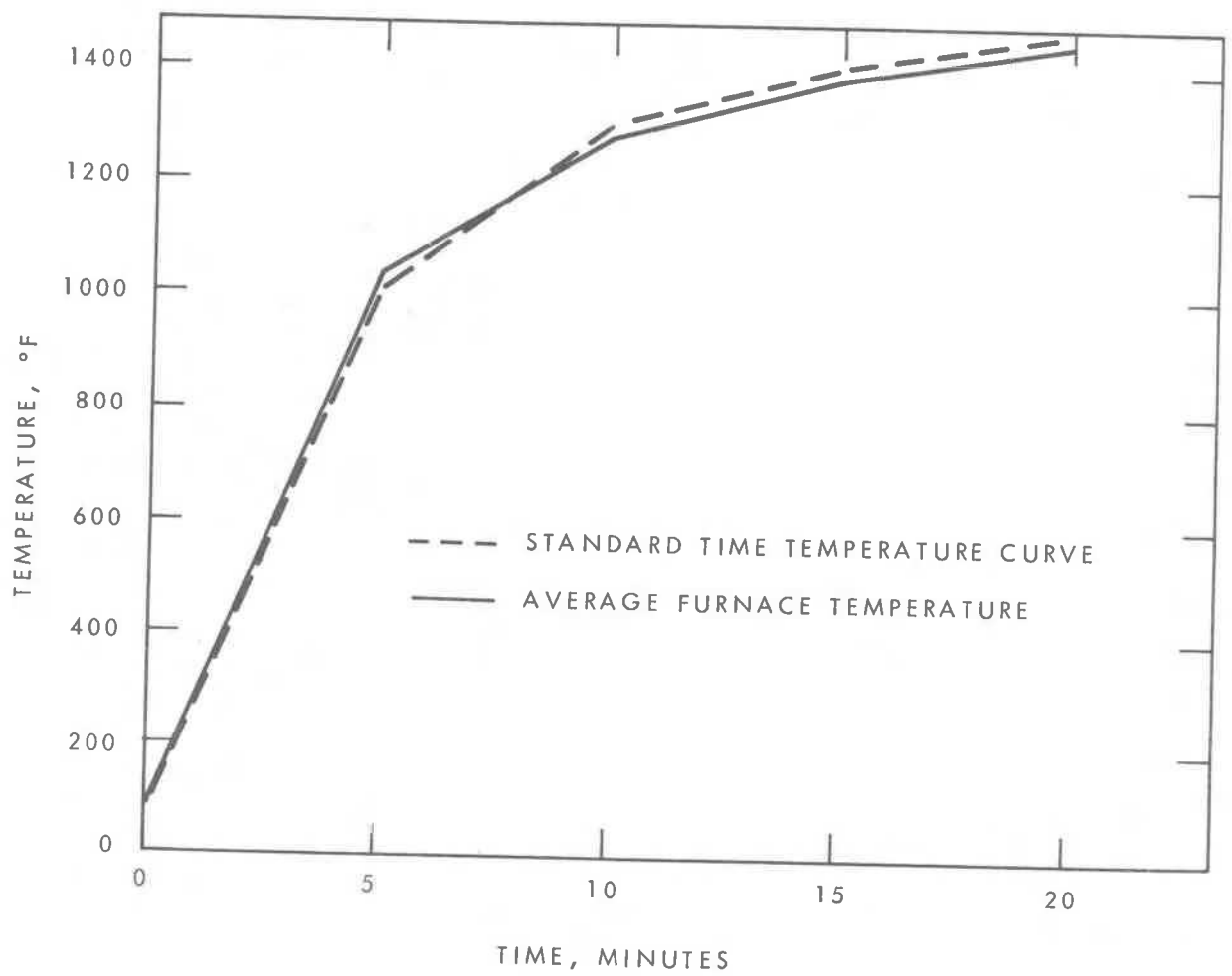


FIGURE A63  
DOOR TEST NO. 10 FURNACE TEMPERATURES

BR 5319-26

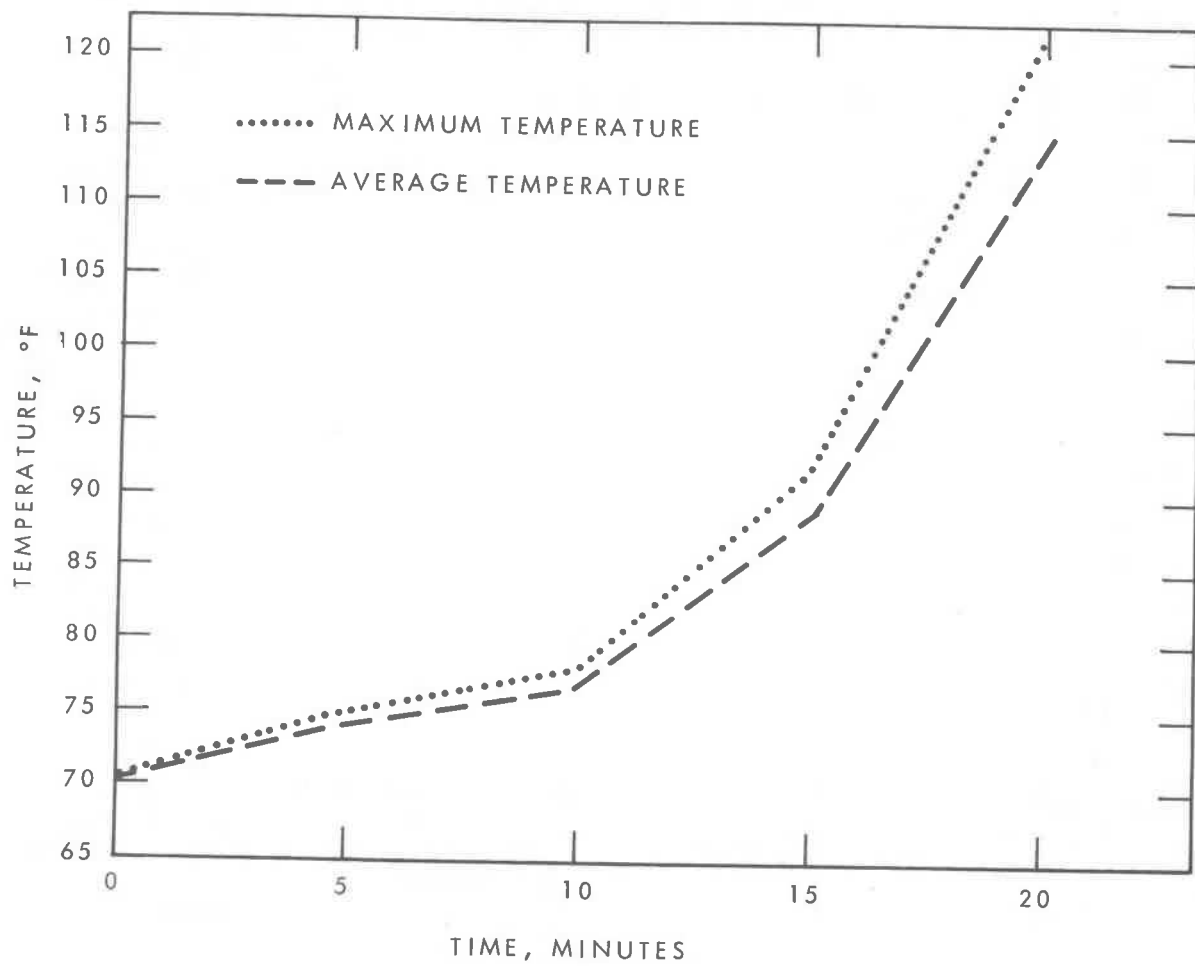


FIGURE A64

DOOR TEST NO. 10 UNEXPOSED SURFACE TEMPERATURE DOOR A

BR 5319-27

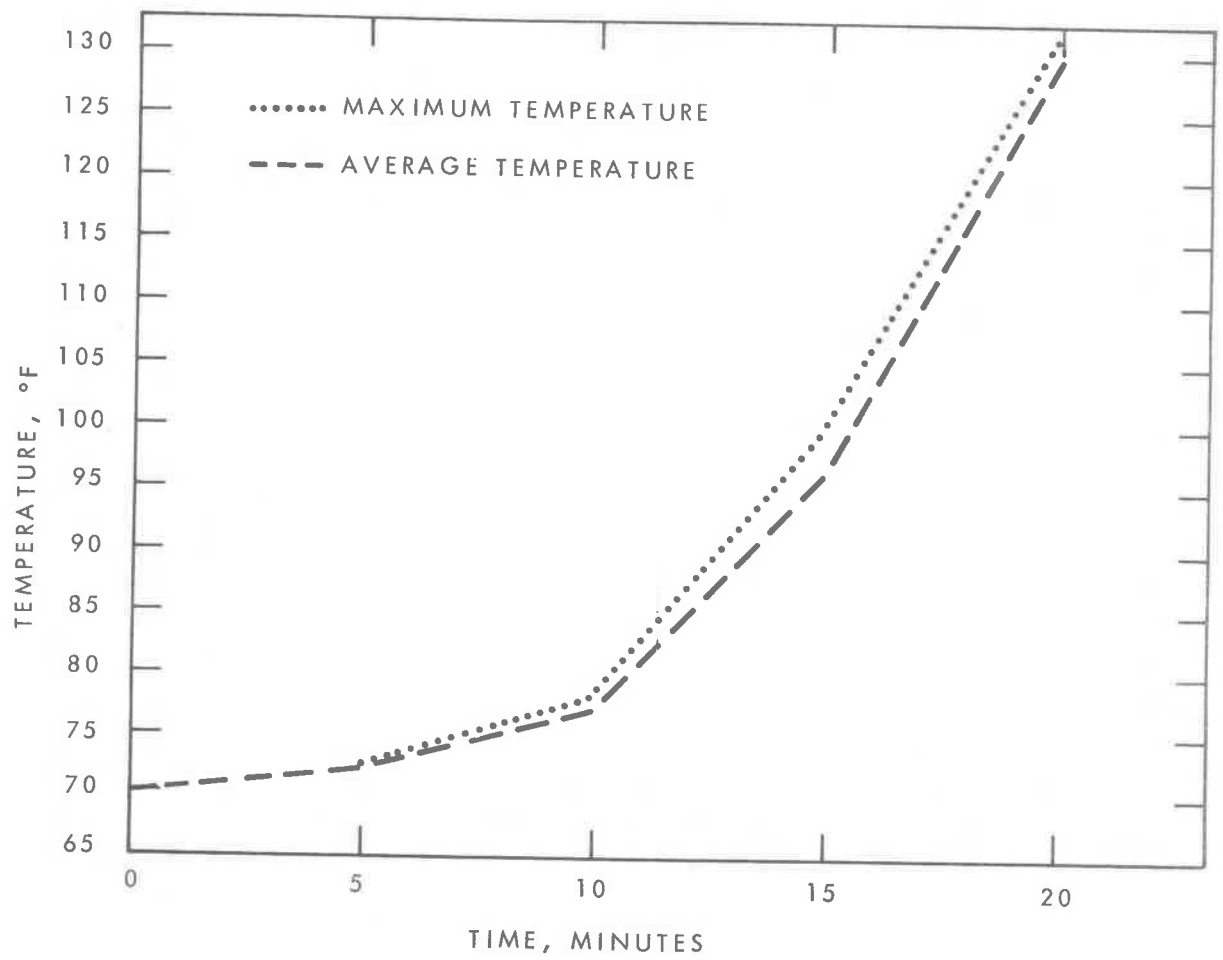


FIGURE A65

DOOR TEST NO. 10 UNEXPOSED SURFACE TEMPERATURE DOOR B

BR 5319-28



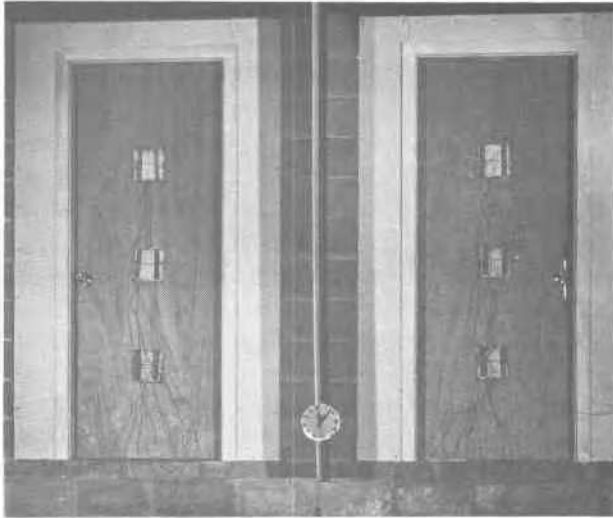


Figure A66. Door Test No. 11.  
Unexposed face at 7 min.

Figure A67. Door Test No. 11.  
Unexposed face at 14 min.

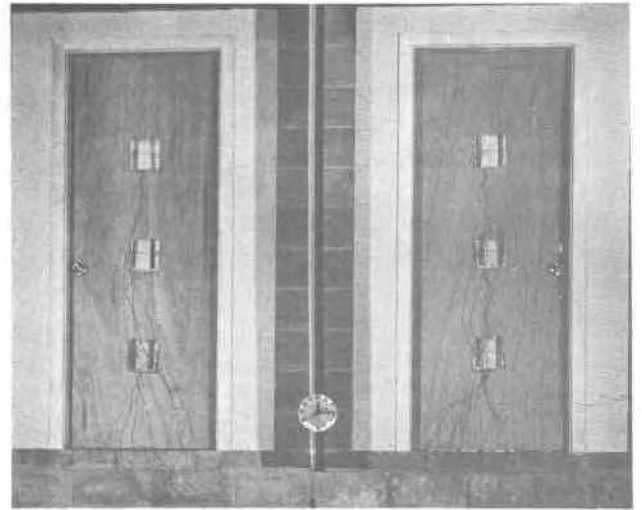


Figure A68. Door Test No. 11.  
Unexposed face at 19 min.

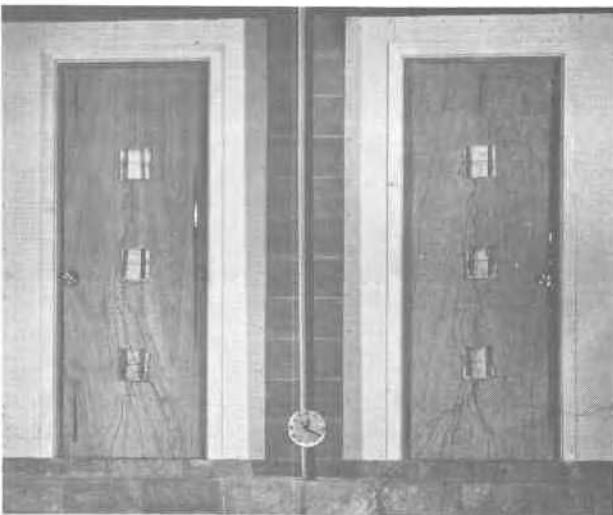
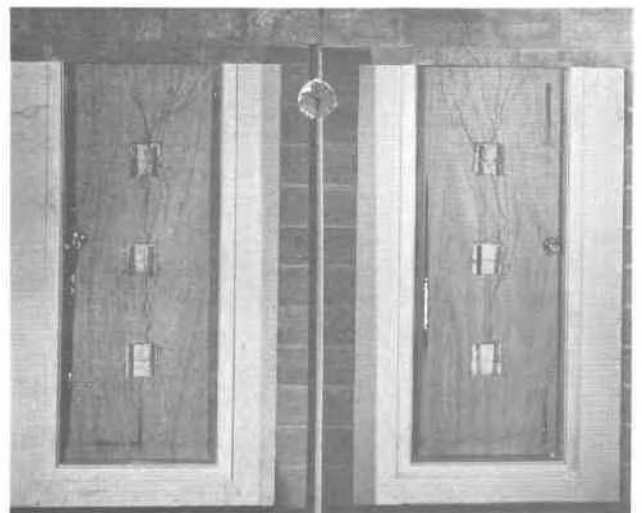


Figure A69. Door Test No. 11.  
Unexposed face at 21 min.



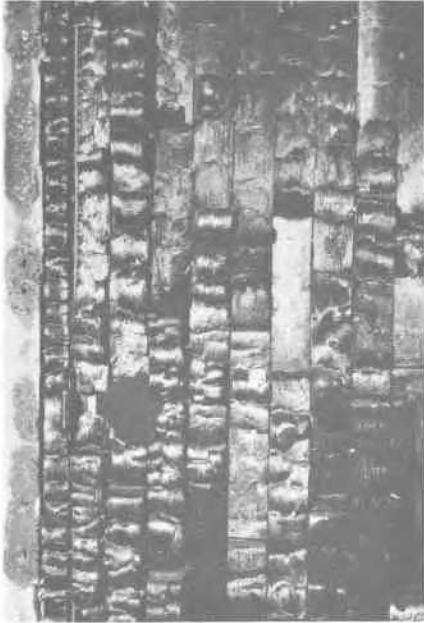


Figure A70. Door Test No. 11.  
Exposed face of Door A at latch  
set after test.

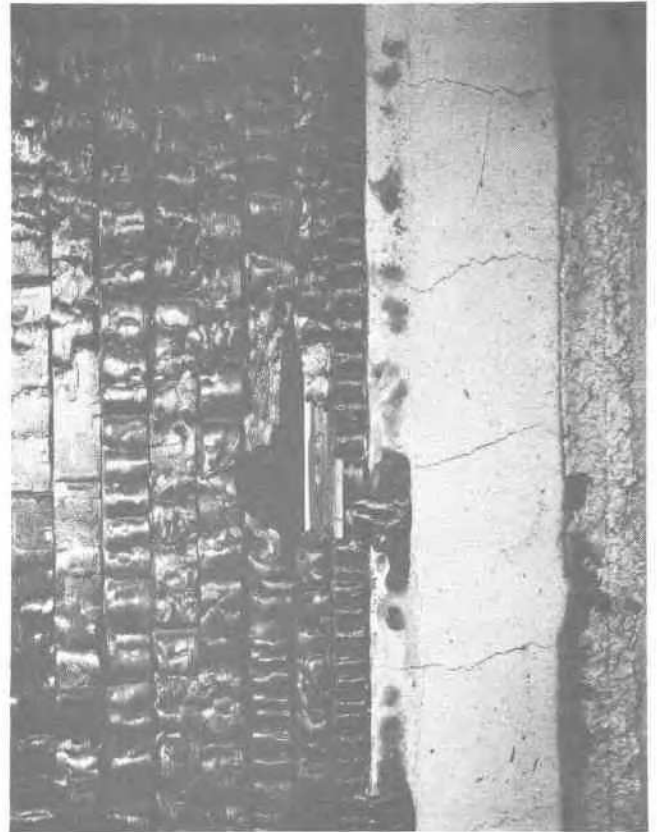


Figure A71. Door Test No. 11.  
Exposed face of Door B at latch  
set after test.

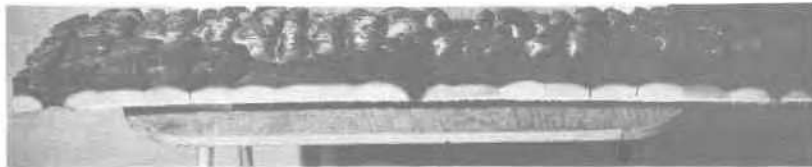


Figure A72. Door Test No. 11.  
Section of Door A after test.

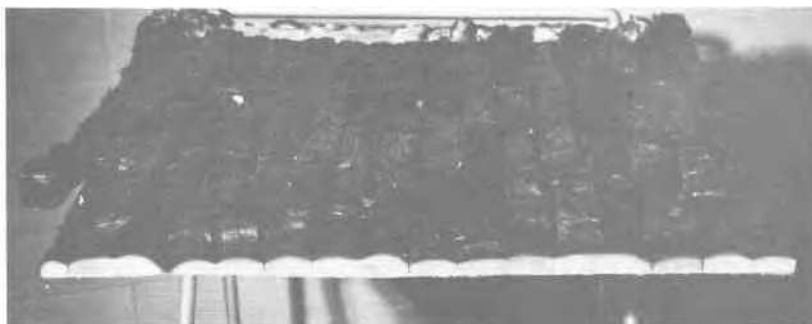


Figure A73. Door Test No. 11.  
Section of Door B after test.

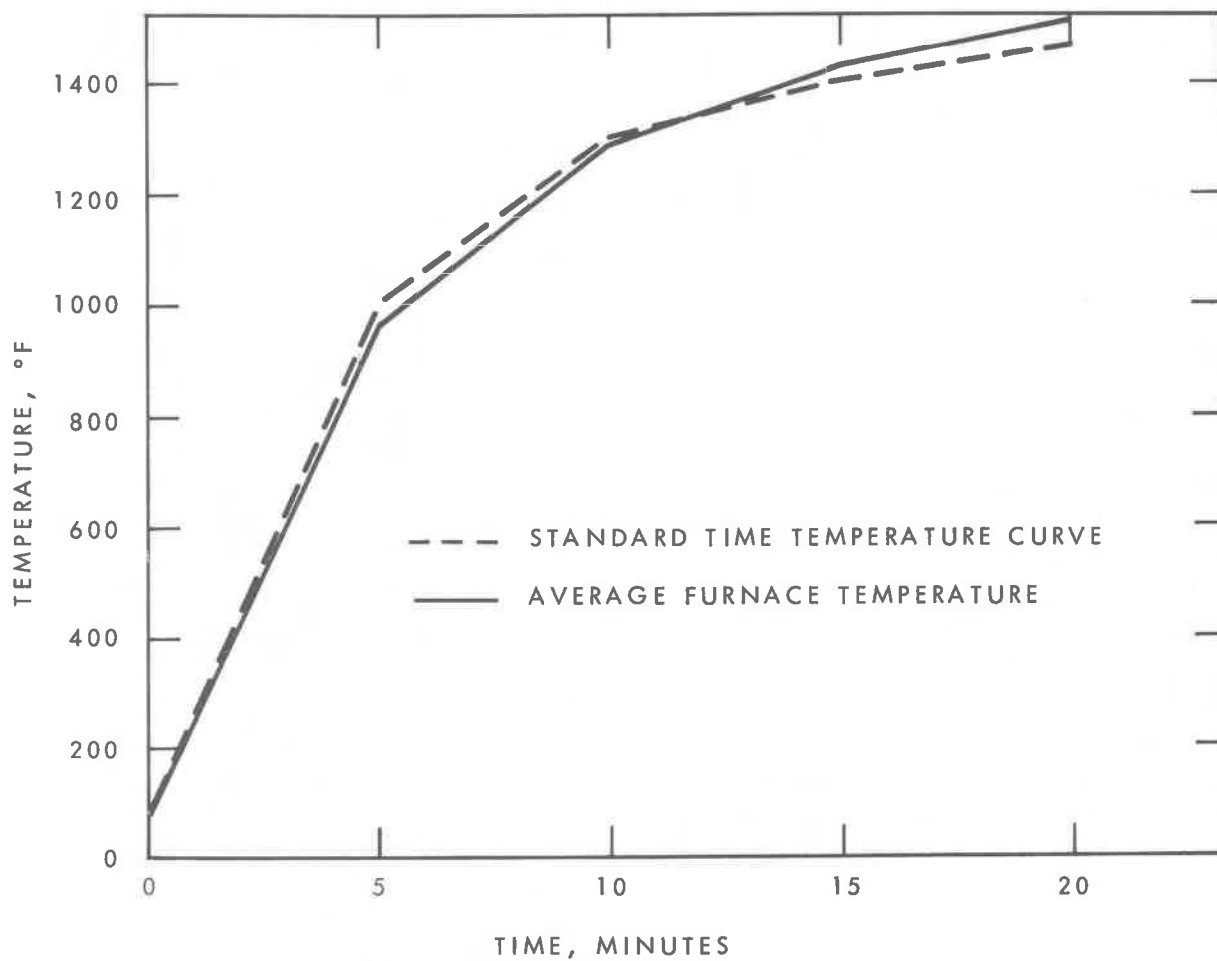


FIGURE A74

DOOR TEST NO. 11 FURNACE TEMPERATURES

BR 5319-29

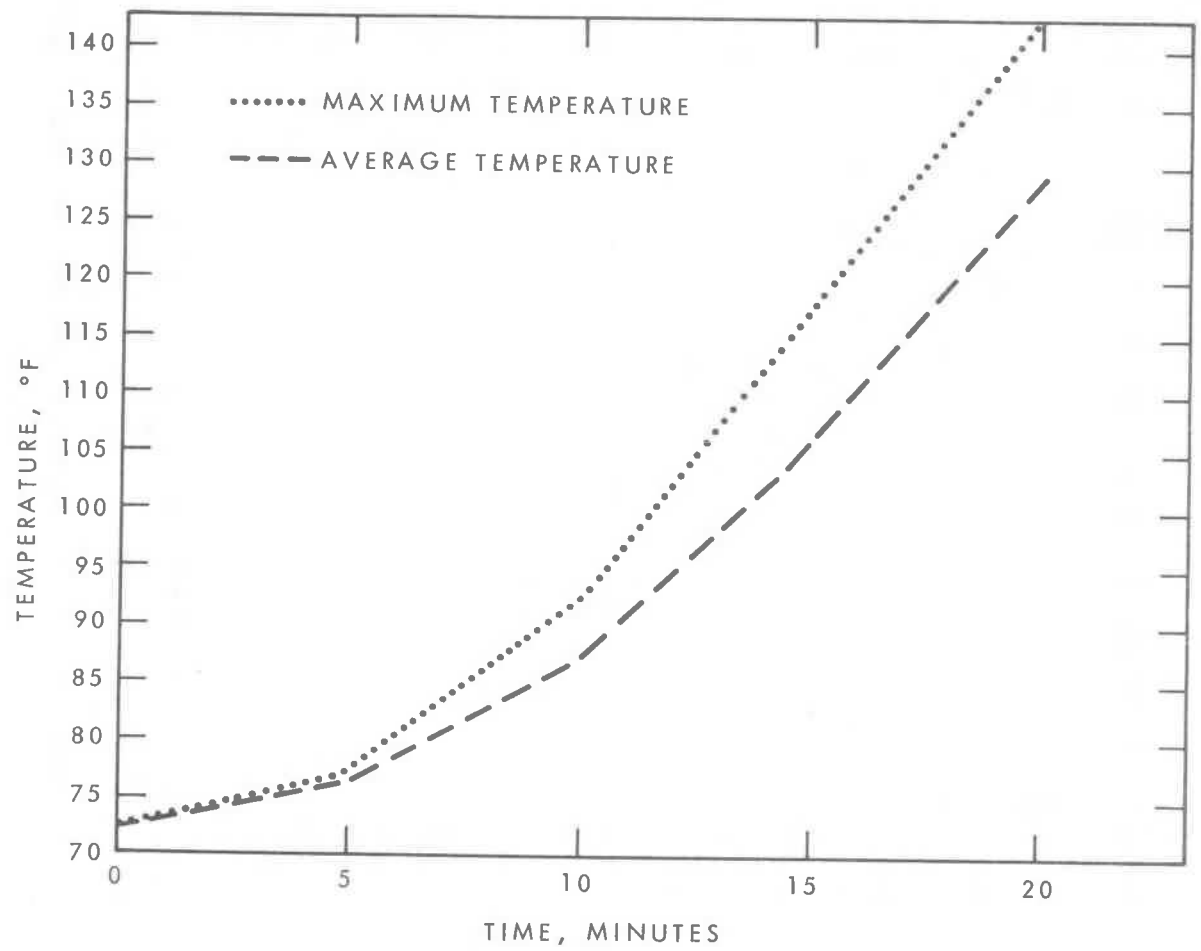


FIGURE A75  
DOOR TEST NO. 11 UNEXPOSED SURFACE TEMPERATURES DOOR A

BR 5319-30

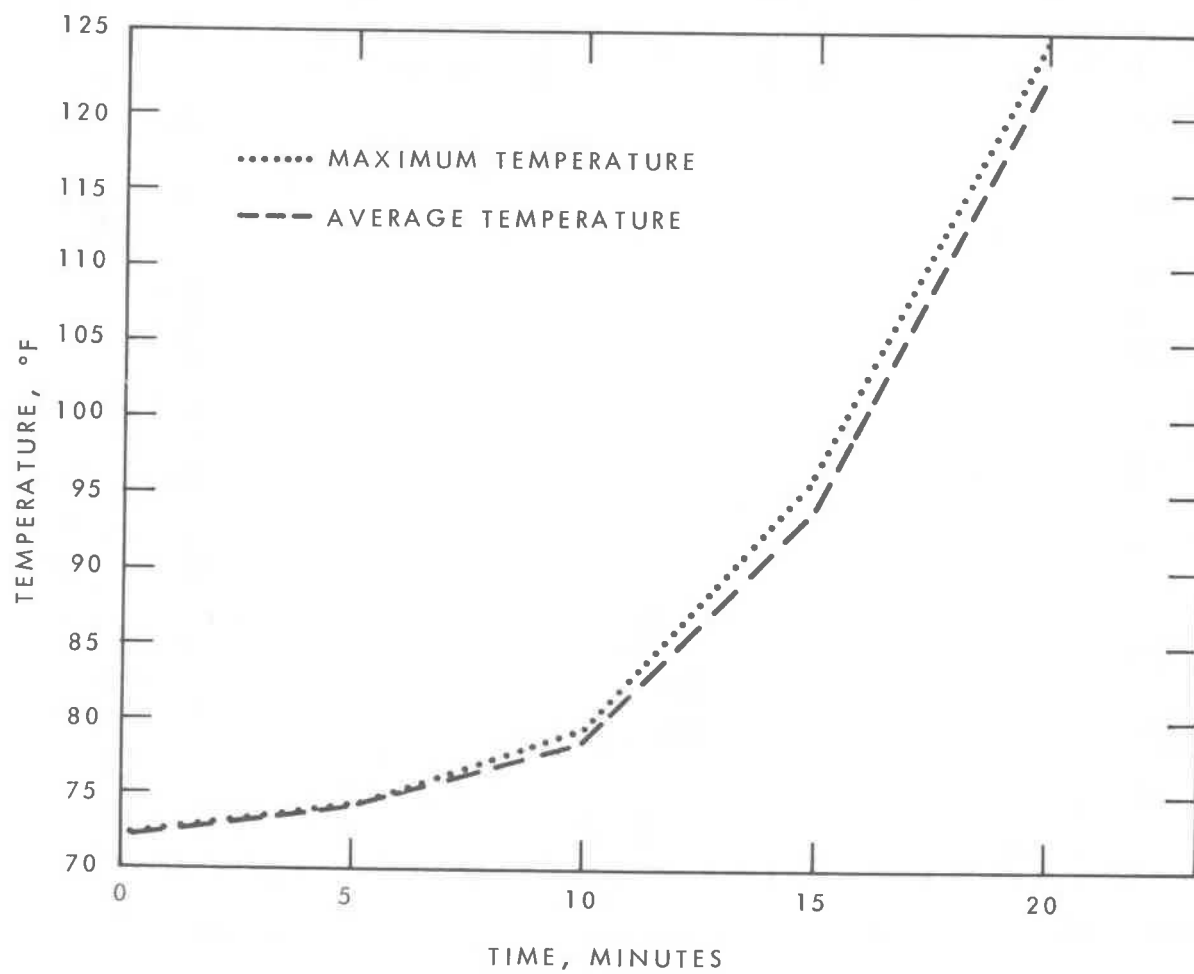
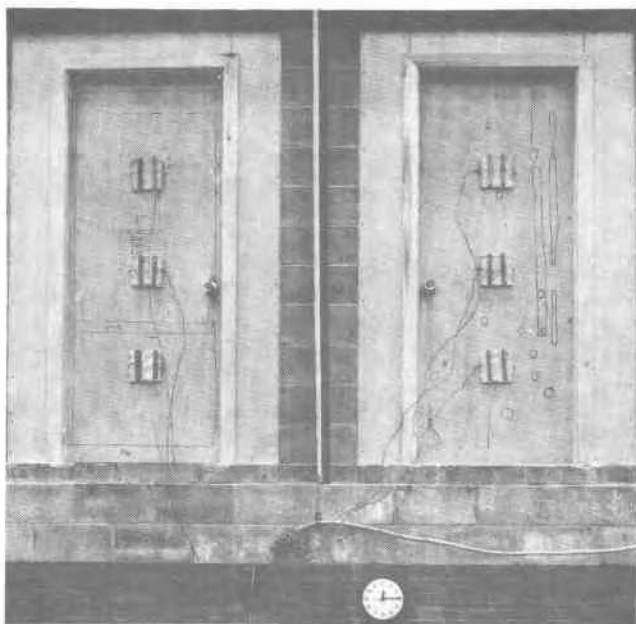


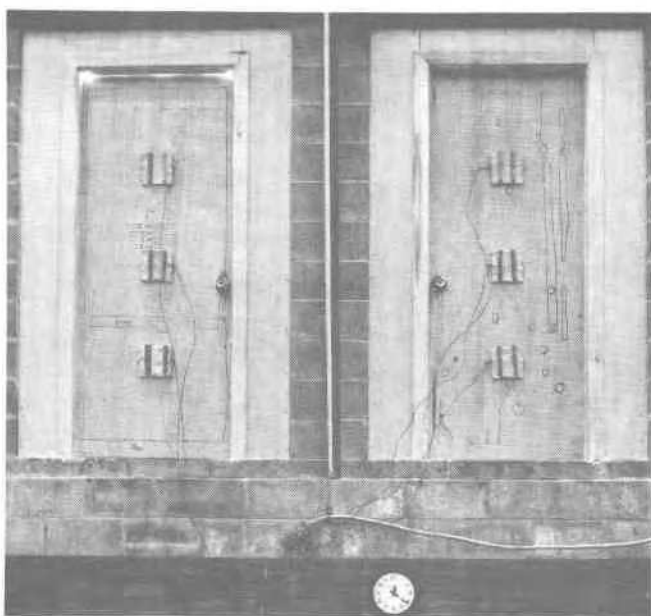
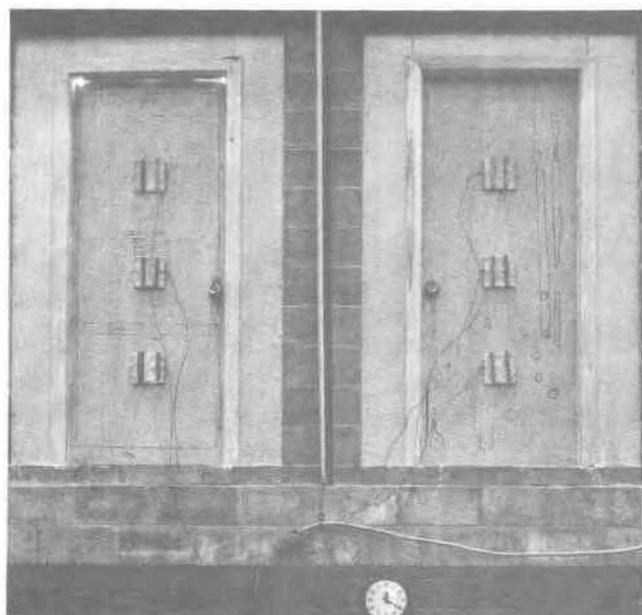
FIGURE A76

DOOR TEST NO. 11 UNEXPOSED SURFACE TEMPERATURES DOOR B



**Figure A77. Door Test No. 12.  
Unexposed face at 15 min.**

**Figure A78. Door Test No. 12.  
Unexposed face at 20 min.**



**Figure A79. Door Test No. 12.  
Unexposed face at 21 min.**

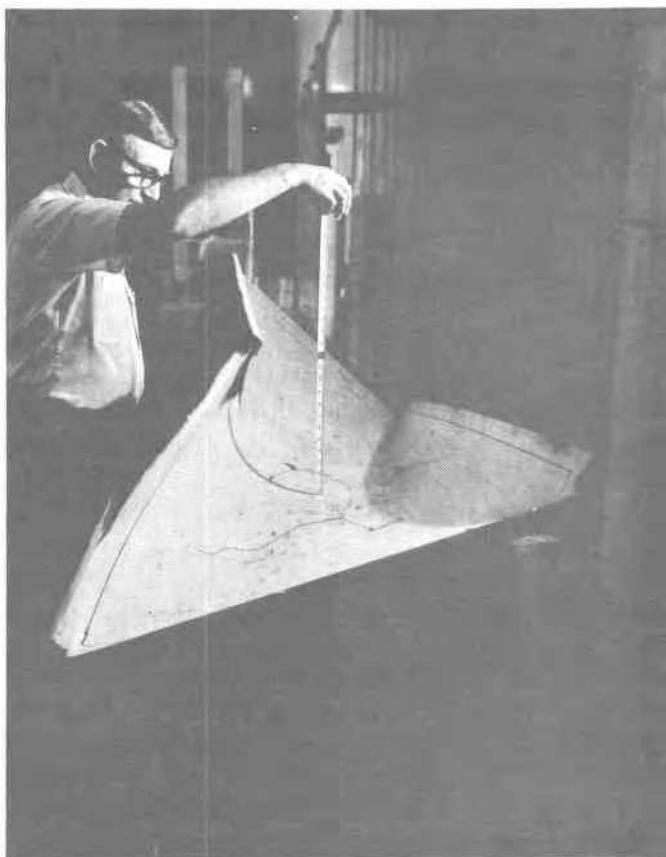


Figure A80. Door Test No. 12.  
Door B following fire exposure  
and hose stream.



Figure A81. Door Test No. 12.  
Section through Door A following  
fire test.

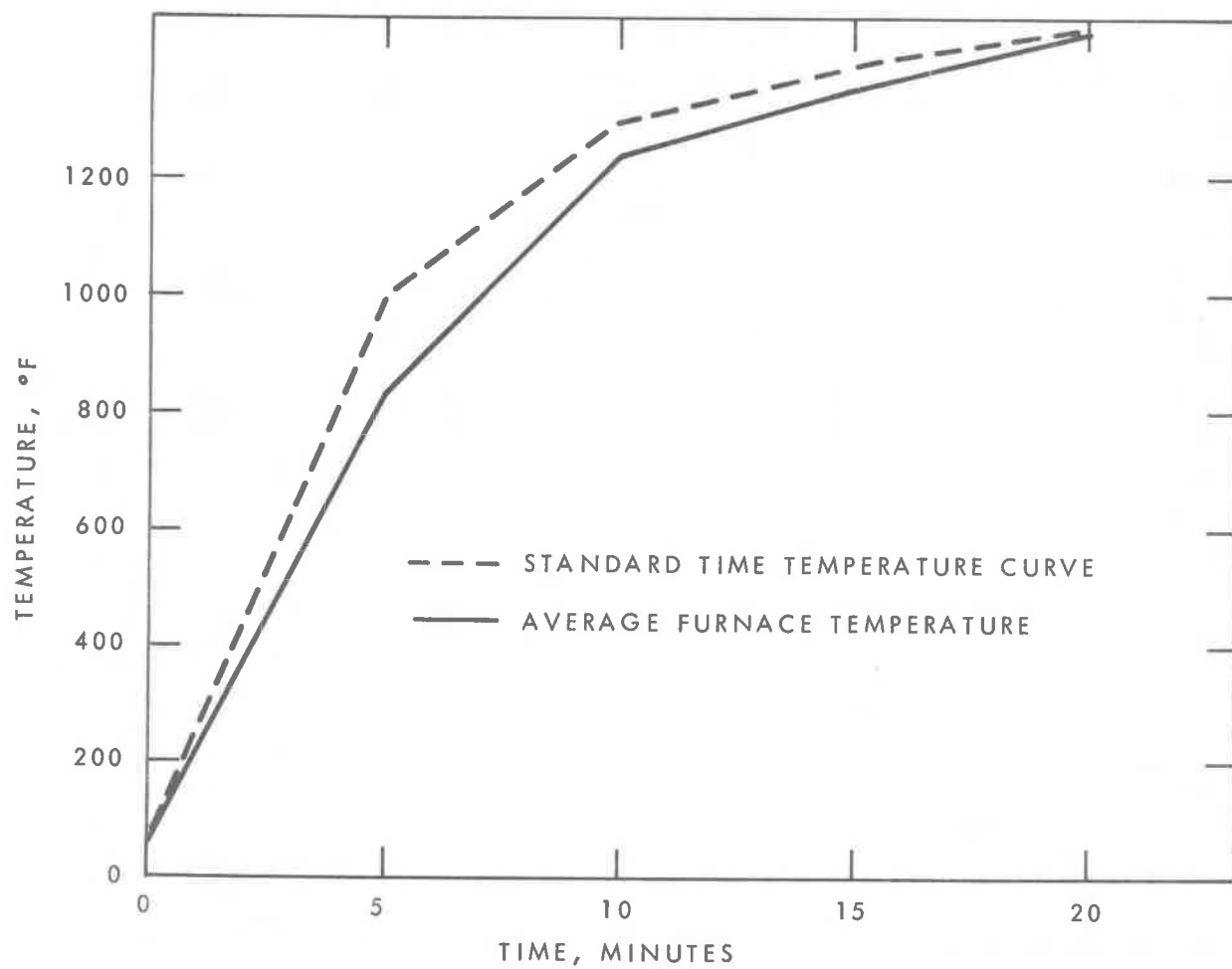


FIGURE A82

DOOR TEST NO. 12 FURNACE TEMPERATURES



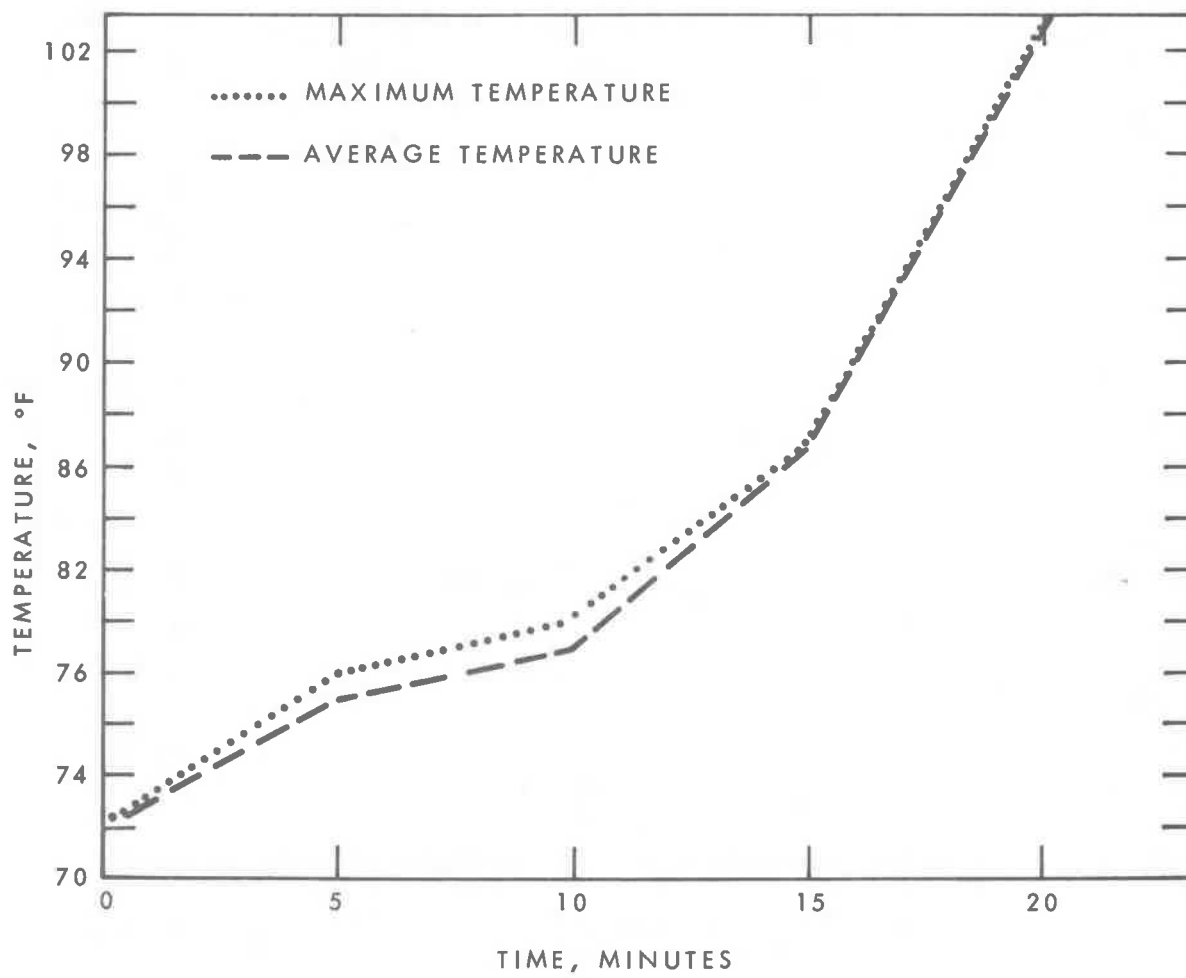


FIGURE A83  
DOOR TEST NO. 12 UNEXPOSED SURFACE TEMPERATURES DOOR A

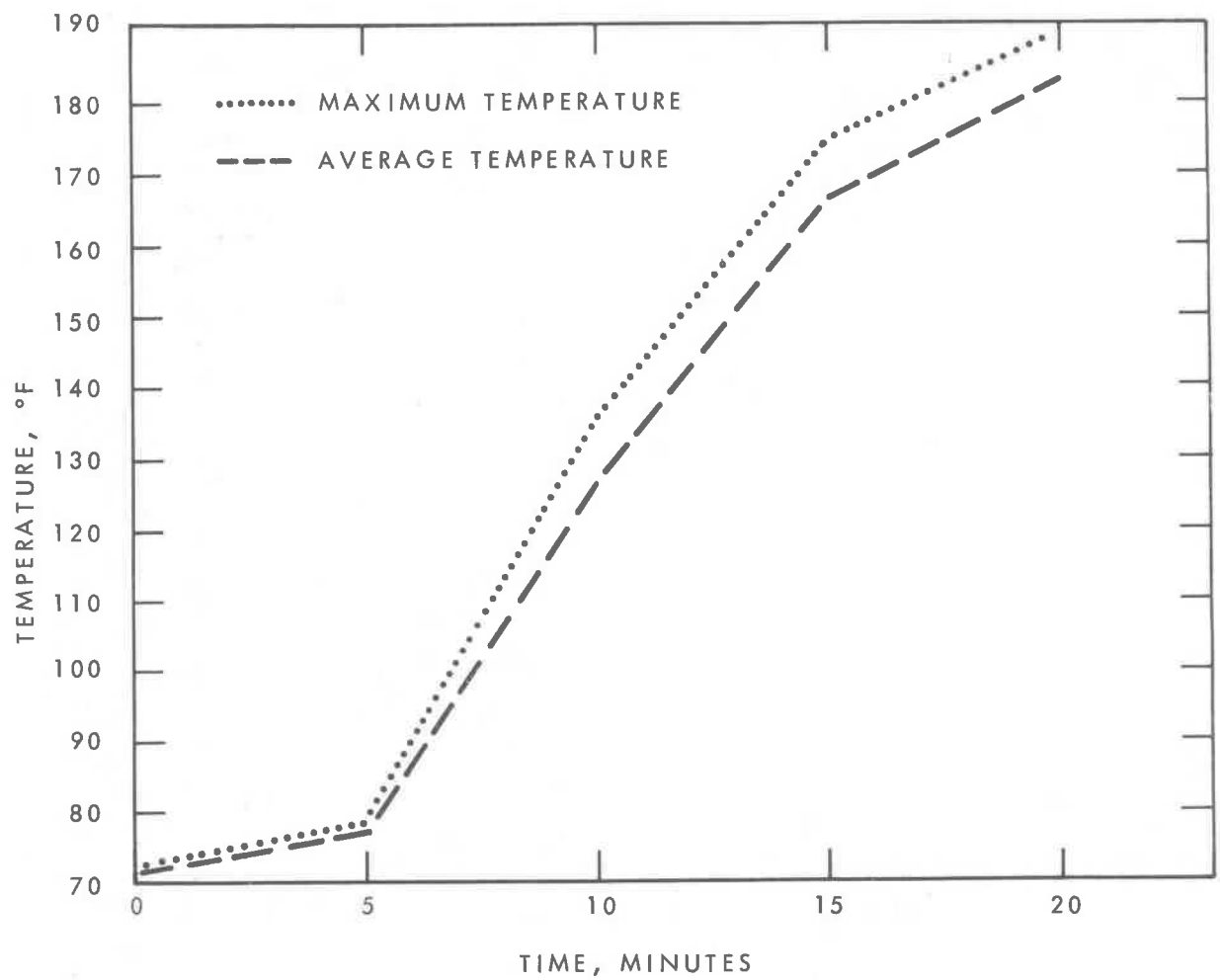


FIGURE A84  
DOOR TEST NO. 12 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-34

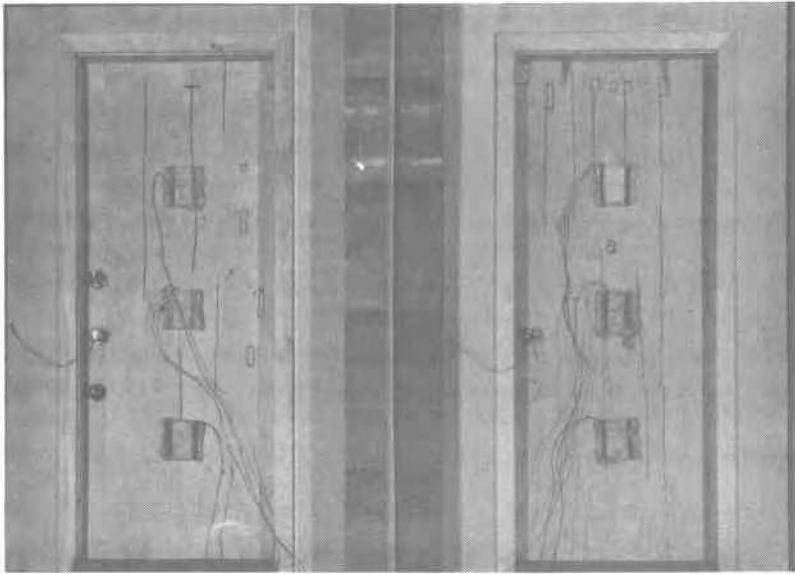


Figure A85. Door Test No. 13.  
Unexposed side at 16 min.

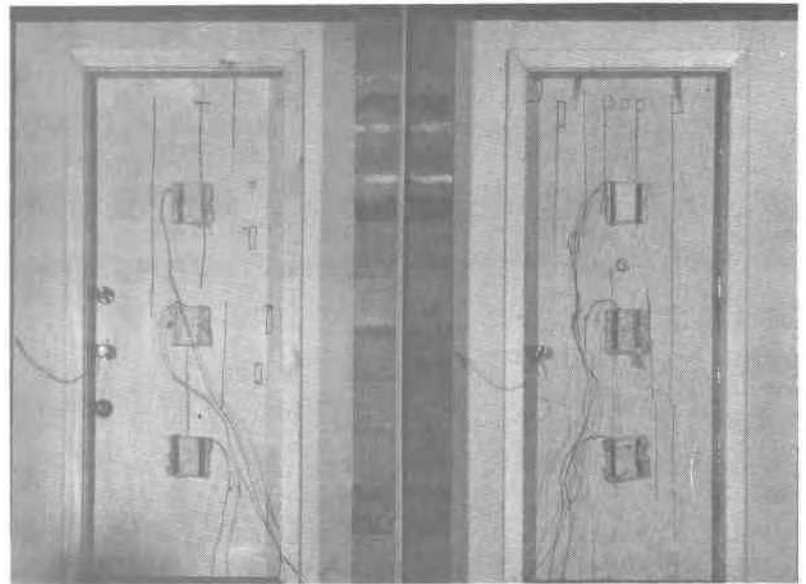


Figure A86. Door Test No. 13.  
Unexposed side at 18 min.

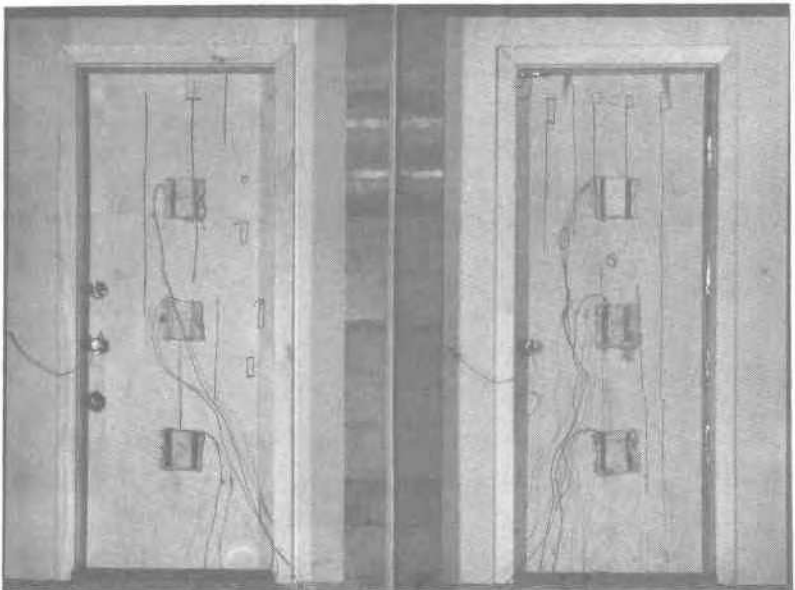
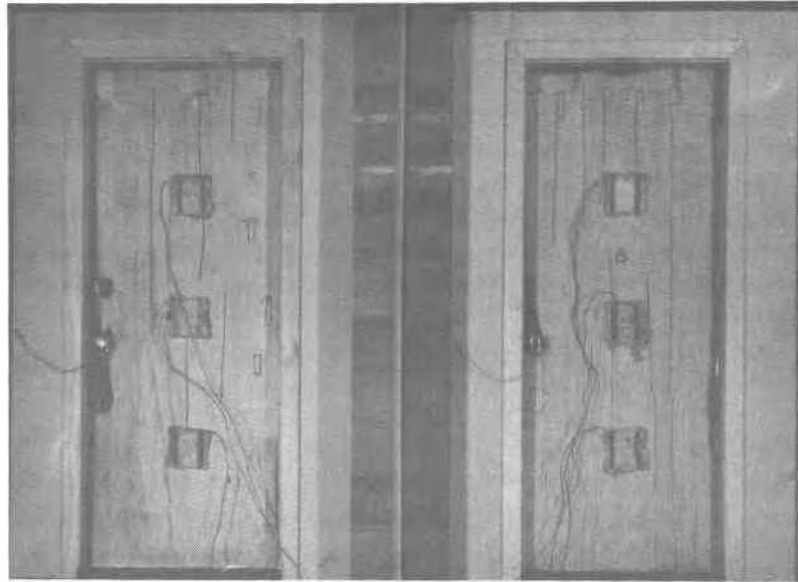
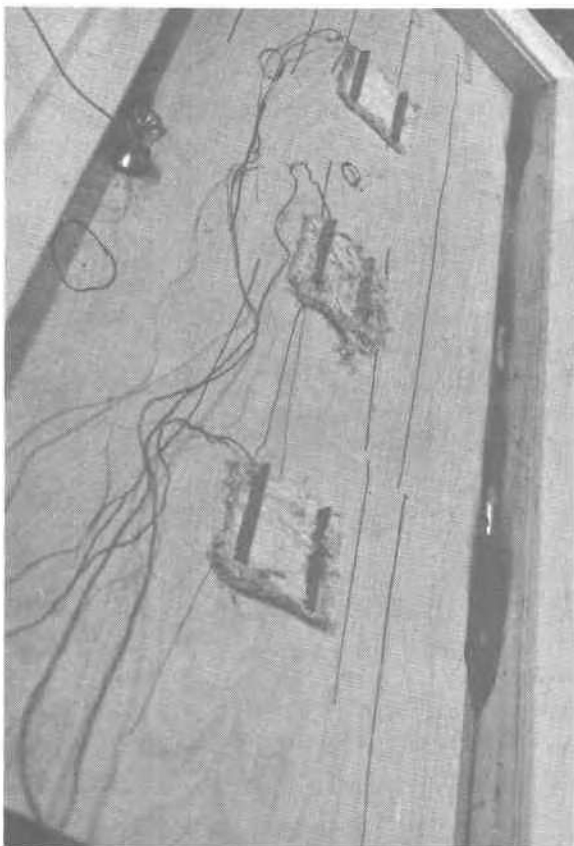


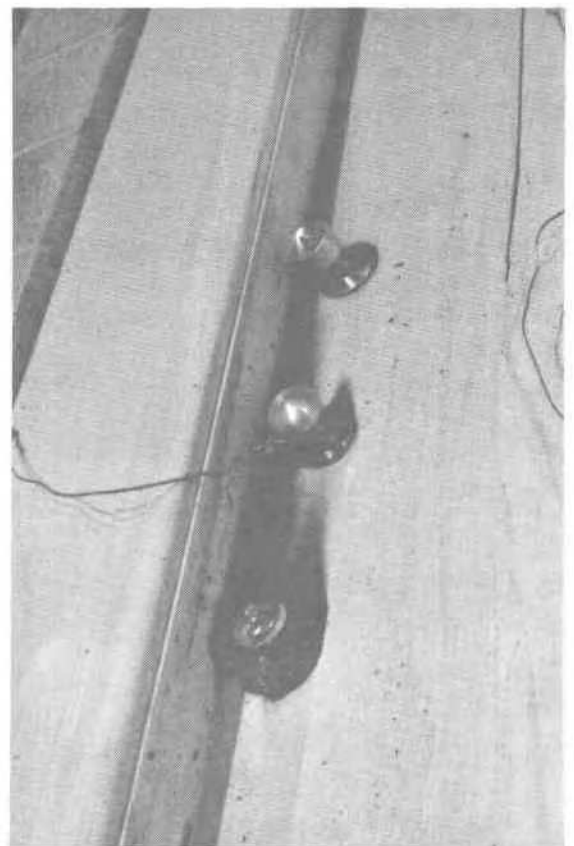
Figure A87. Door Test No. 13.  
Unexposed side at 20 min.



**Figure A88. Door Test No. 13.  
Unexposed side following fire  
exposure.**



**Figure A89. Door Test No. 13.  
Holes through Door A viewed  
diagonally.**



**Figure A90. Door Test No. 13.  
Knobs on Door B following test.**

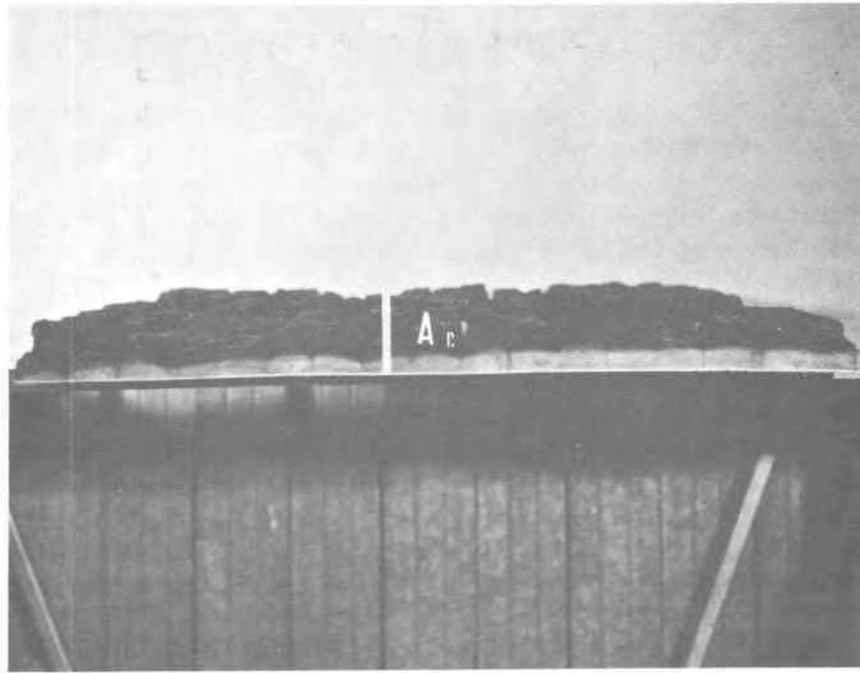


Figure A91. Door Test No. 13.  
Cross section of Door A following  
fire test.

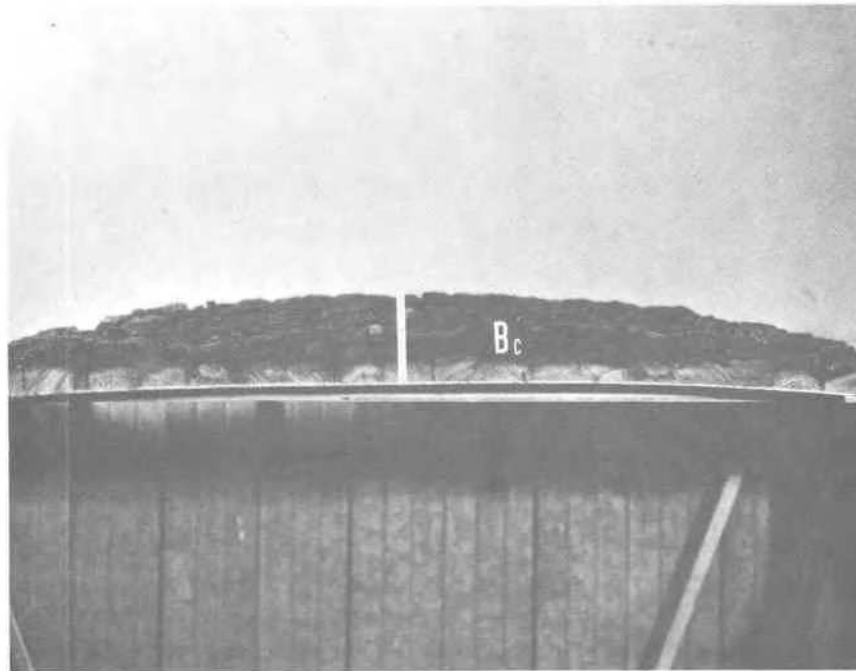


Figure A92. Door Test No. 13.  
Cross section of Door B following  
fire test.

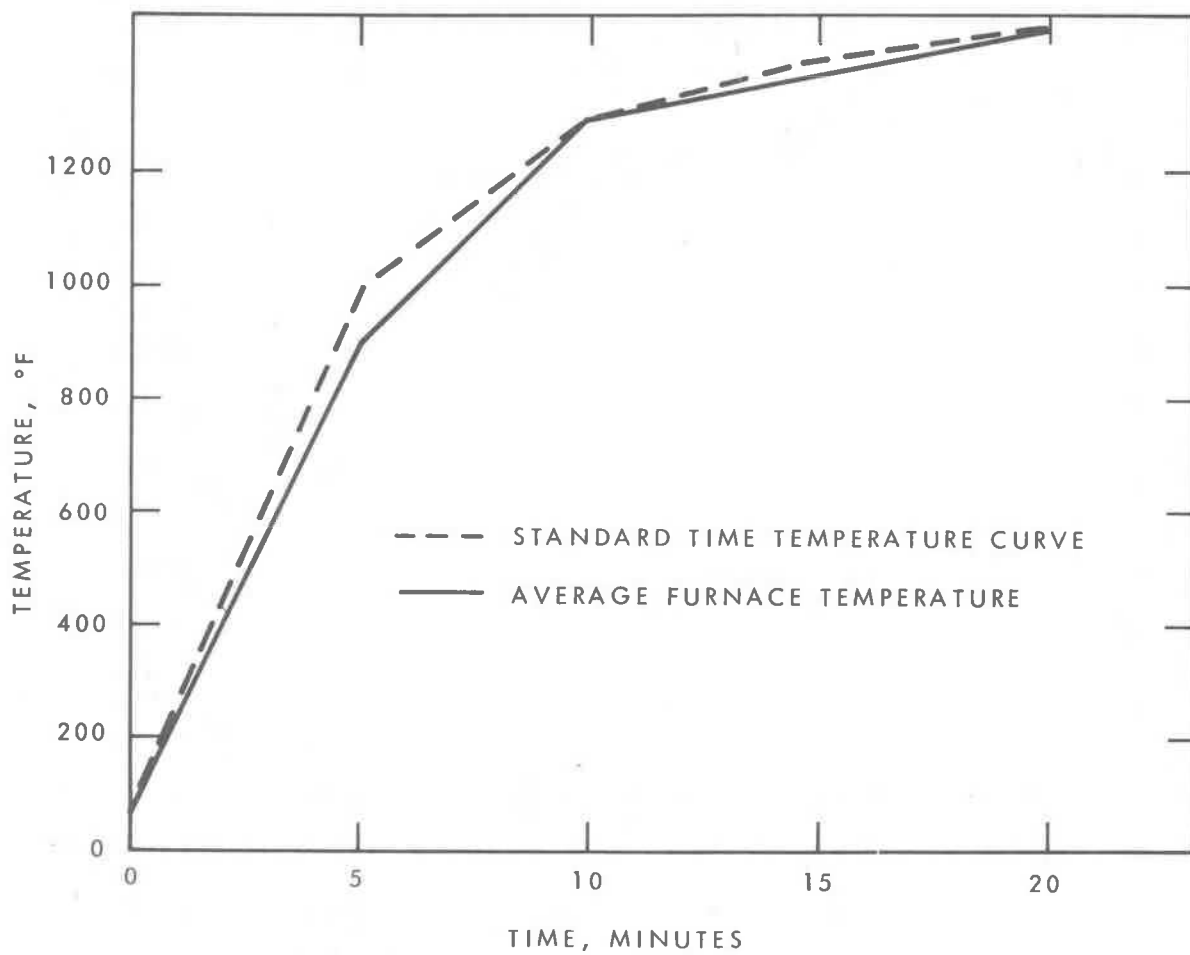


FIGURE A93  
DOOR TEST NO. 13 FURNACE TEMPERATURES

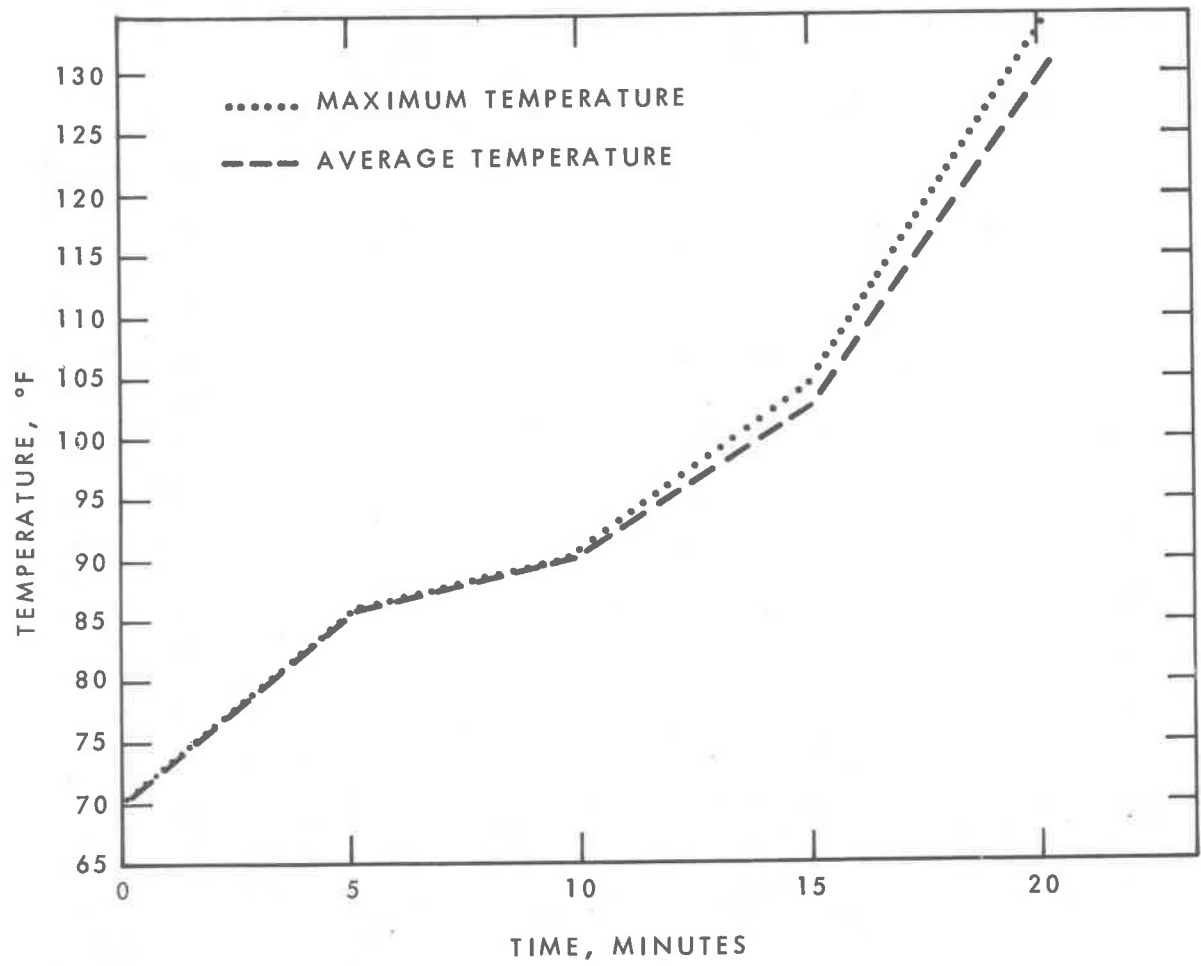


FIGURE A94

DOOR TEST NO. 13 UNEXPOSED SURFACE TEMPERATURE DOOR A

BR 5319-36

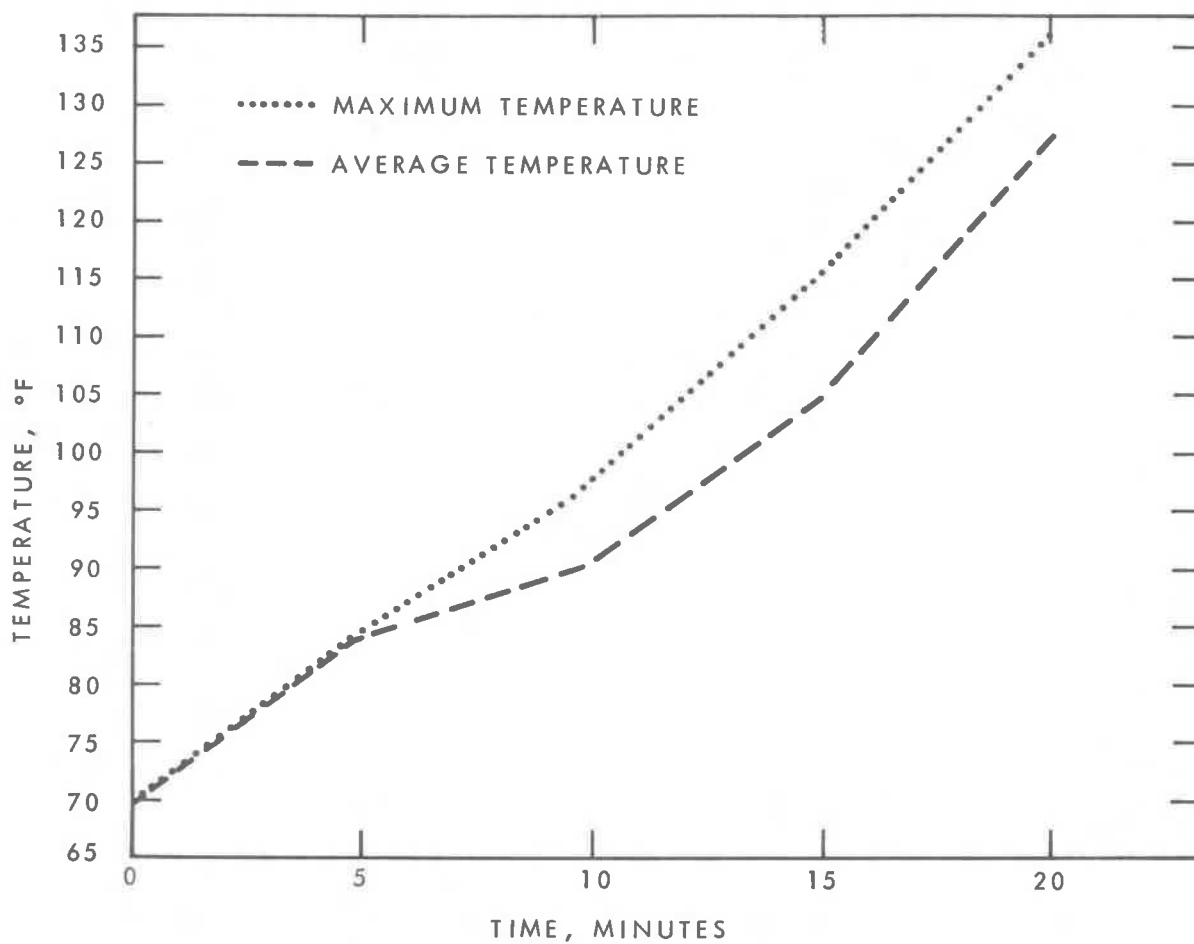


FIGURE A95  
DOOR TEST NO. 13 UNEXPOSED SURFACE TEMPERATURES DOOR B

BR 5319-37