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THE FIRE PROPAGATION TEST AS A MEASURE OF FIRE SPREAD. CORRELATION WITH FULL SCALE FIRES IN CORRIDORS

by

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INTRODUCTION

Corridors and other circulation areas in a building provide a means for the escape of people in case of a fire. It is important that materials used in their construction, particularly the exposed lining surfaces should not assist a fire to spread and hinder the evacuation of the occupants. For this reason the regulating authorities place great emphasis on the control of linings in these areas.

When the Building Regulations were being formulated an examination was made of the test methods available at that time which could be used for purposes of control. The two appropriate tests specified in B.S. 476[2] were those for Non-Combustibility and Surface Spread of Flame. Whilst maximum safety in the circulation areas could be provided by banning the use of combustible materials altogether there were grounds for avoiding such severe restrictions. An examination of results of the Surface Spread of Flame test however, showed that the best performance in this test, (Class 1) could be achieved by a wide variety of combustible materials capable of making differing contributions to the growth of a fire. This test alone therefore could not be regarded as suitable for assessing lining materials. In order to exclude materials at the lower end of the Class 1 range, a semi-functional specification had therefore been devised, which controlled either the combustible content or its availability to a fire. To meet this specification the material is required to be Class 1 standard in the 'Surface Spread of Flame' test and to consist of EITHER a non-combustible substrate with an exposed combustible finish not exceeding 0.8 mm in thickness; OR a combustible substrate covered on the exposed surface with a non-combustible skin of not less than 3 mm thickness. Materials meeting either of these specifications were designated Class 0 in England and Wales; (Class A in Scotland).

Whilst this presented a solution to the safety problem, it also produced anomalies by prohibiting the use of some otherwise acceptable products such as wood wool/cement slabs and mineral fibre boards, which failed to meet the specification part of the requirement but were known from experience to be as good in practice as some of the others qualifying as Class '0'.

Fire Propagation Test

In 1968 the Fire Propagation Test (B.S.476 : Part 6) was issued as a British Standard and on the evidence of its ability to discriminate amongst Class 1 products (F.R.Technical Paper No. 25)[3] it was considered that this test could be used to specify materials equivalent to Class 0 on the basis of their performance in the test above, and without the restriction of the physical specification. When the Ministry of Housing and Local Government (now part of the Department of the Environment) proposed the use of the test for this purpose, doubts were expressed as to its ability to deal with linings of all types. The basic work in the past which studied fire growth in buildings had been concerned with cellulosic products. The advent of plastics for use in buildings, particularly those of thermoplastic nature was considered to create situations which may not be truly assessed by this test. It was therefore felt that some further evidence was required to confirm the ability of the Fire Propagation Test to predict the growth of fire in buildings, more particularly in escape routes.

Corridor Tests

A series of tests was therefore carried out in a structure consisting of a room with an attached corridor constructed from aerated concrete slabs, the walls and ceilings of which were lined with selected materials whose performance on the Fire Propagation Test had been determined.

The test set-up consisted of a 2.8 x 3 m room having a 2.5 m high x 0.7 m wide opening in one wall connected to a 13 m long corridor (Fig.1). The corridor was 1.2 m wide x 2.5 m high and was closed at one end. The walls and the ceiling of the corridor were lined with the materials under test and the fire conditions were provided by a timber crib in the middle of the room, representing a fire load density of 15 kg/m^2. The crib was so designed that after about 4 or 5 minutes there was a rapid rise in the temperature of the hot gases emitted from the doorway onto the corridor, reaching a peak of nearly 900°C. During a preliminary run without linings after about 10 minutes the gas temperature close to the ceiling halfway down the corridor was about 500°C. After 15 minutes the fire intensity was considerably reduced and by 20 minutes the crib was virtually consumed.

Test Programme

In all, six tests were performed on four different types of linings, as listed in Table 1.

Table 1. Types of lining systems used in tests

System	Surfacing material	Thickness	Substrate	Adhesive	No. of tests
1	Plasterboard	9 mm	concrete*	-	1
2	Expanded Polystyrene Standard Grade	9 mm	asbestos/cement wall board (6 mm)	PVA based continuous adhesive film	2
3	Expanded Polystyrene Standard Grade	9 mm	asbestos/ cellulose board (3 mm)	latex based continuous adhesive film	1
4	Hardboard	3 mm	concrete*	-	2

*fixed directly to the corridor surfaces

The lining materials were selected to provide a range of performances in the Fire Propagation Test as shown in Table 2 below; at the safer end of the range a traditional (Class 0) material and a plastic lining system with a continuous adhesive film were included.

Table 2. Performance of linings in the Fire Propagation Test

Lining system	Sub-Index i_1	Index I
Plasterboard (9 mm)	5.7	9.7
Expanded Polystyrene (system 2 in Table 1)	5.5*	7.9*
Expanded Polystyrene (system 3 in Table 1)	10.3	19.4
Hardboard (3 mm)	15.6	35.6

*mean of two separate tests

Index I is the aggregate index, derived in accordance with the method specified in B.S. 476 : Part 6 and sub-index i_1 is the component obtained during the first 3 minutes of the test. The proposed specification for *Class 0 materials limits the value of the two indices* (*i.e.* I/i_1) *to* 12/6. It is seen from Table 2 that lining systems 1 and 2 would qualify for this purpose.

Test results and discussion

The test results are summarized in Table 3 and photographs taken during the course of the tests are shown in Plates 1 to 6.

Table 3. Performance of linings in corridor test

Lining Material	Timing of main development stages (min sec)			Additional observations
	Light smoke	Heavy black smoke	Flames into corridor	
Plasterboard (System 1)	1.30	5.00	10.45	Lining in vicinity of door damaged, small area fell from ceiling at 21 minutes and flamed for few seconds on the floor. No flame spread.
Expanded Polystyrene (System 2)	1.30	4.00	6.30	*No flame spread on lining.
Expanded Polystyrene (System 3)	1.30	4.00	6.00	Ignition of lining opposite doorway at 8 minutes followed by slow flame spread towards exit of corridor travelling about 6 m in the next 6 minutes.
Hardboard (System 4)	2.15	6.30	8.10	Within 1 minute of flames emerging from the doorway the flames had spread the full length of the corridor, the corridor being filled with flames from floor to ceiling.

*Slight flaming near door, ceiling lining completely damaged, wall lining only partially damaged.

The design of the experiment was such that smoke emitted from the crib fire stratified in the corridor forming a 1.5 m thick layer at the fire chamber end and thinning to less than 1.0 m at the exit end. The appearance of flames from the room opening varied from about 6 - 10 minutes in various tests and whilst the ceiling linings had been exposed to high gas temperatures prior to this time, the wall temperatures were low below about mid-height.

The plasterboard lining (system 1) and the expanded polystyrene lining attached to asbestos/cement wall board (system 2) ignited only locally near the door opening after the emission of flames, and the flaming did not spread either along the ceiling or the walls. In the case of the expanded polystyrene tiles attached to a sbestos/cellulose board (system 3), after the emission of flames, wall surfaces adjacent to the opening and facing it were ignited, flame spread occurring along the top portion of the walls. The spread of flame was slow (approximately 1 m/min) and the ignited tiles were soon consumed, resulting in a narrow flame front travelling towards the open corridor end, rather than the whole wall surface flaming at the same time. At the end of this test it was observed that the lower parts of the wall were relatively undamaged, melted and burnt material forming a triangular wedge having its maximum depth adjacent to the doorway.

The untreated hardboard lining ignited soon after 8 min 10 sec in the first test when the flames were emitted from the room, flaming spread very quickly (in about 45 sec) to the end of the corridor involving the whole of the exposed surface. In the second test similar behaviour was observed, the rapid flame spread occurring a little later. The intensity of flaming was high ahd the ignited lining was quenched with a water hose to prevent damage to the corridor.

CONCLUSION

The purpose of the limited series of tests described in this report was to demonstrate the ability of the Fire Propagation Test to grade different materials in their correct order of performance in an actual fire situation, and to show that a fire propagation index of 12/6 or under corresponds in general to the safety standards associated with the current Class 0 specification. This correlation was successfully established.

The tests WERE NOT designed to show the superiority or otherwise of plastics over cellulosic products, the materials used being chosen solely on the grounds of their fire propagation index. NOR do the tests permit the inference that linings of expanded polystyrene systems will be acceptable for use on escape routes. It has been shown elsewhere[4] that the behaviour of expanded polystyrene depends markedly on the method of fixing and decoration, which cannot easily be controlled in practice. Moreover, materials need to be examined for their smoke-producing properties when intended for use on escape routes.

REFERENCES

1. British Standard 476 : Part 6 : 1968

2. British Standard 476 : Part 1 : 1953

3. The Fire Propagation Test, its development and application - Fire Research Technical Paper No. 25

4. MORRIS, W.A., HOPKINSON, J.S and MALHOTRA, H.L. Fire Hazards of Expanded Polystyrene Linings. Fire Research Note No. 827.

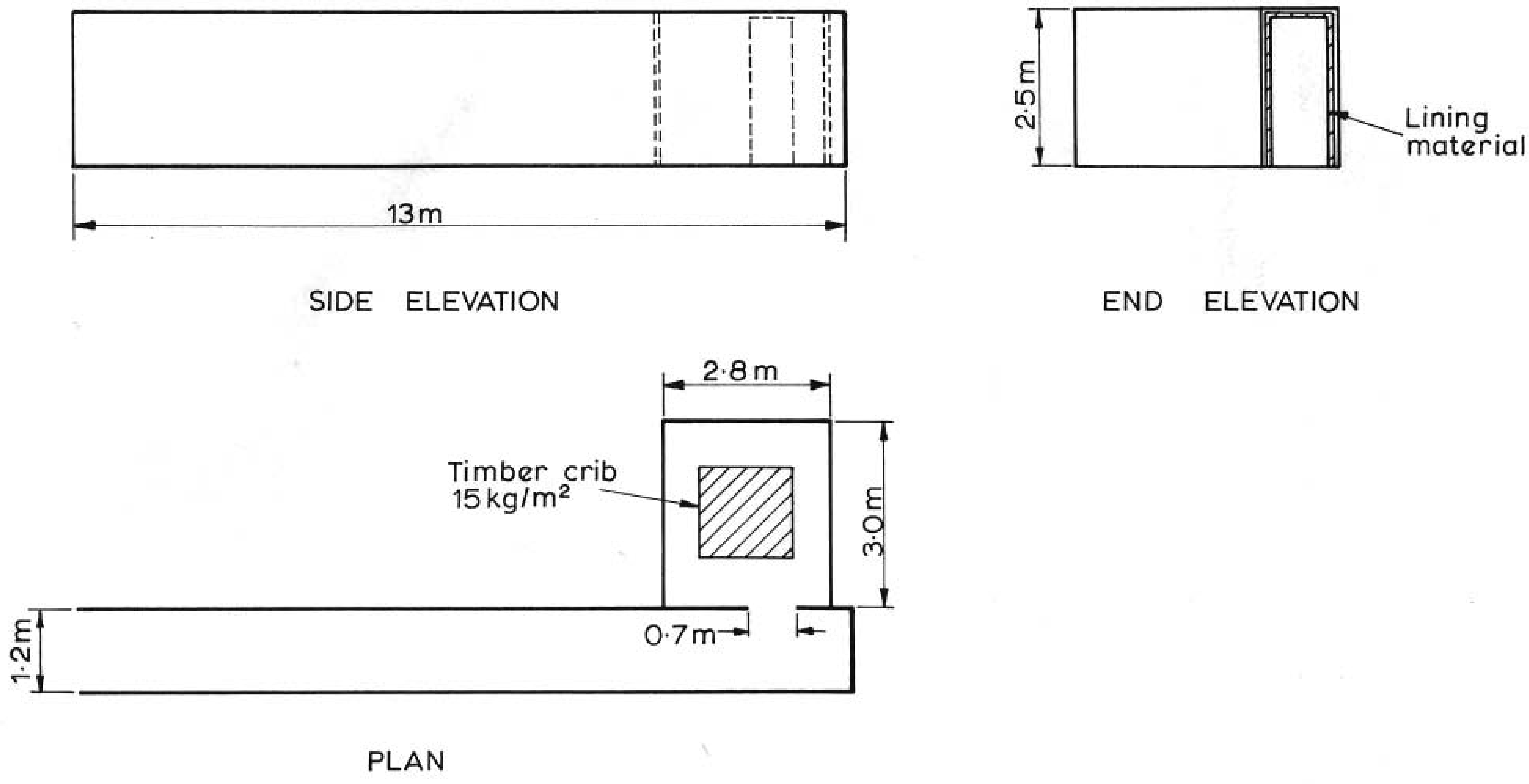
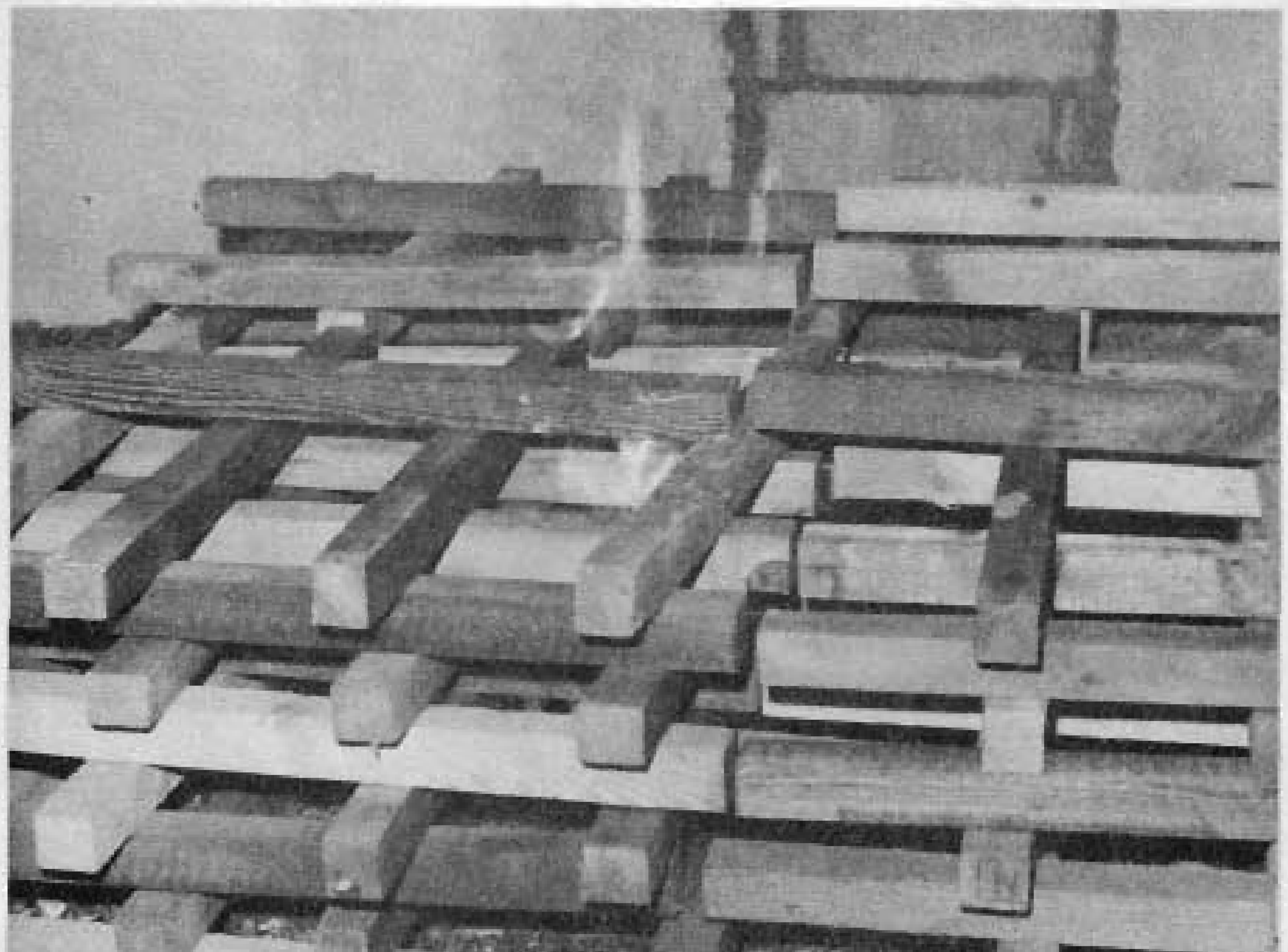
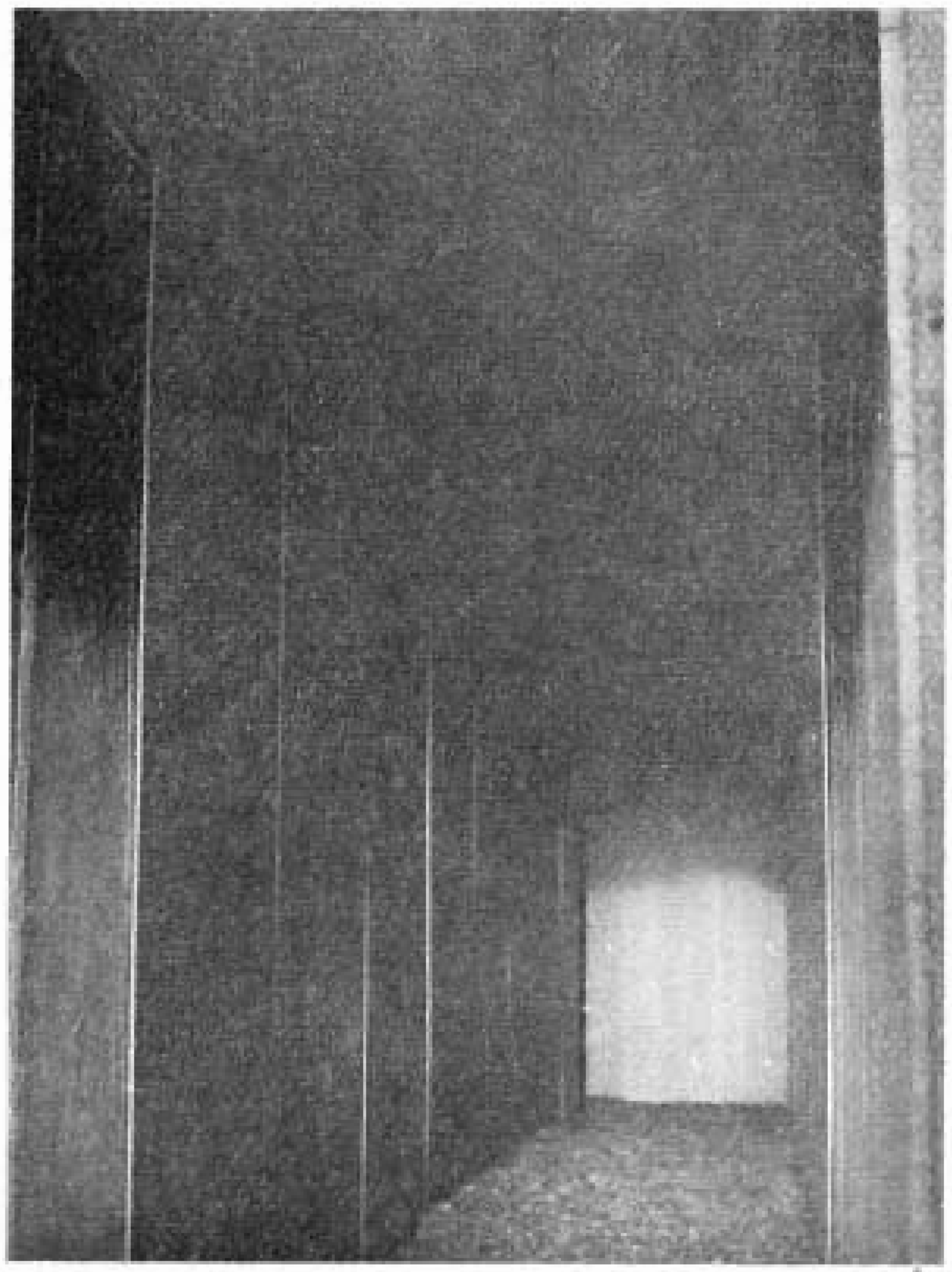


FIG. 1. TEST CORRIDOR LAYOUT

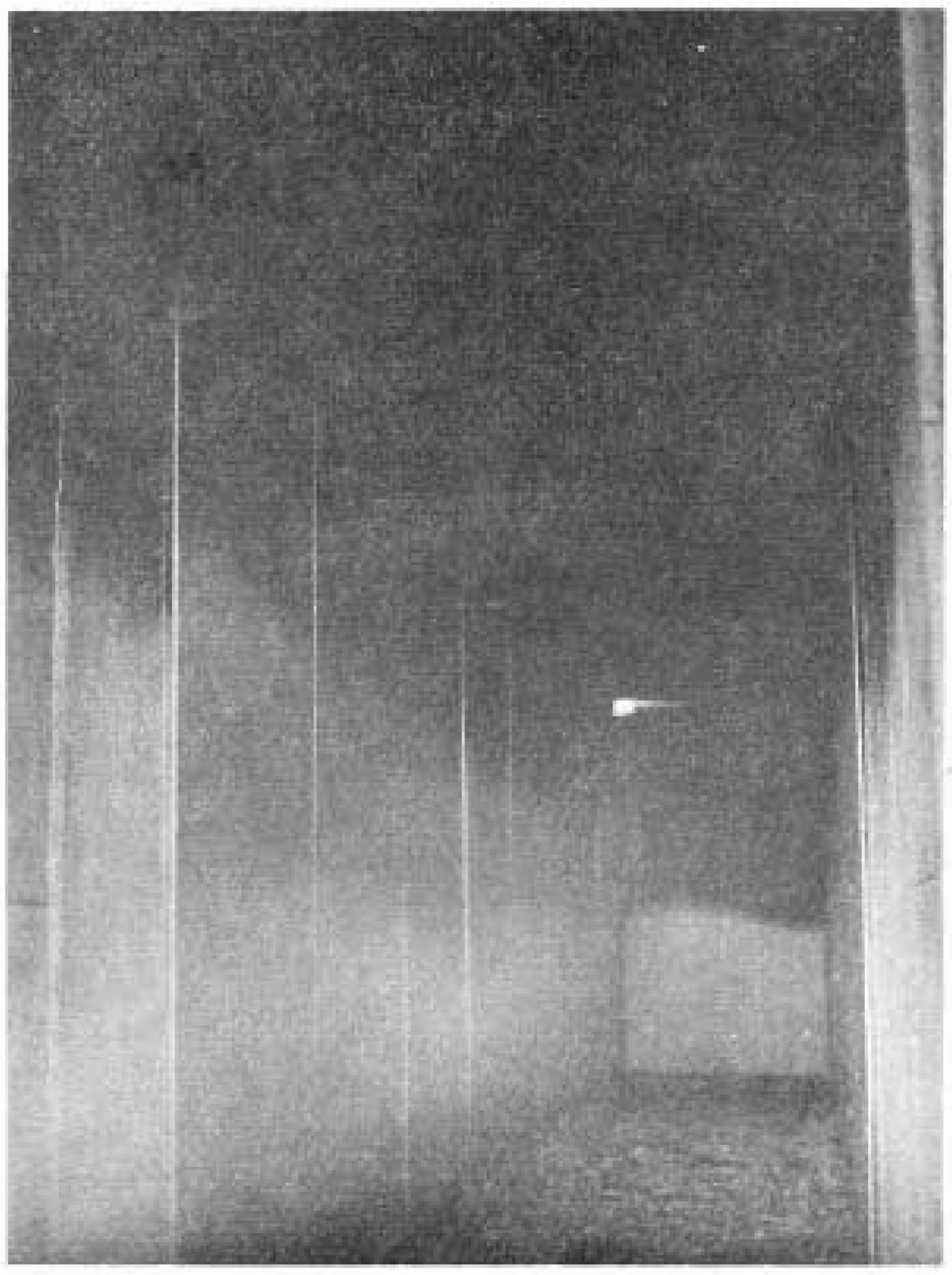
GENERAL VIEW OF TEST CORRIDOR
PLATE 1



TIMBER CRIB SHORTLY AFTER IGNITION
PLATE 2



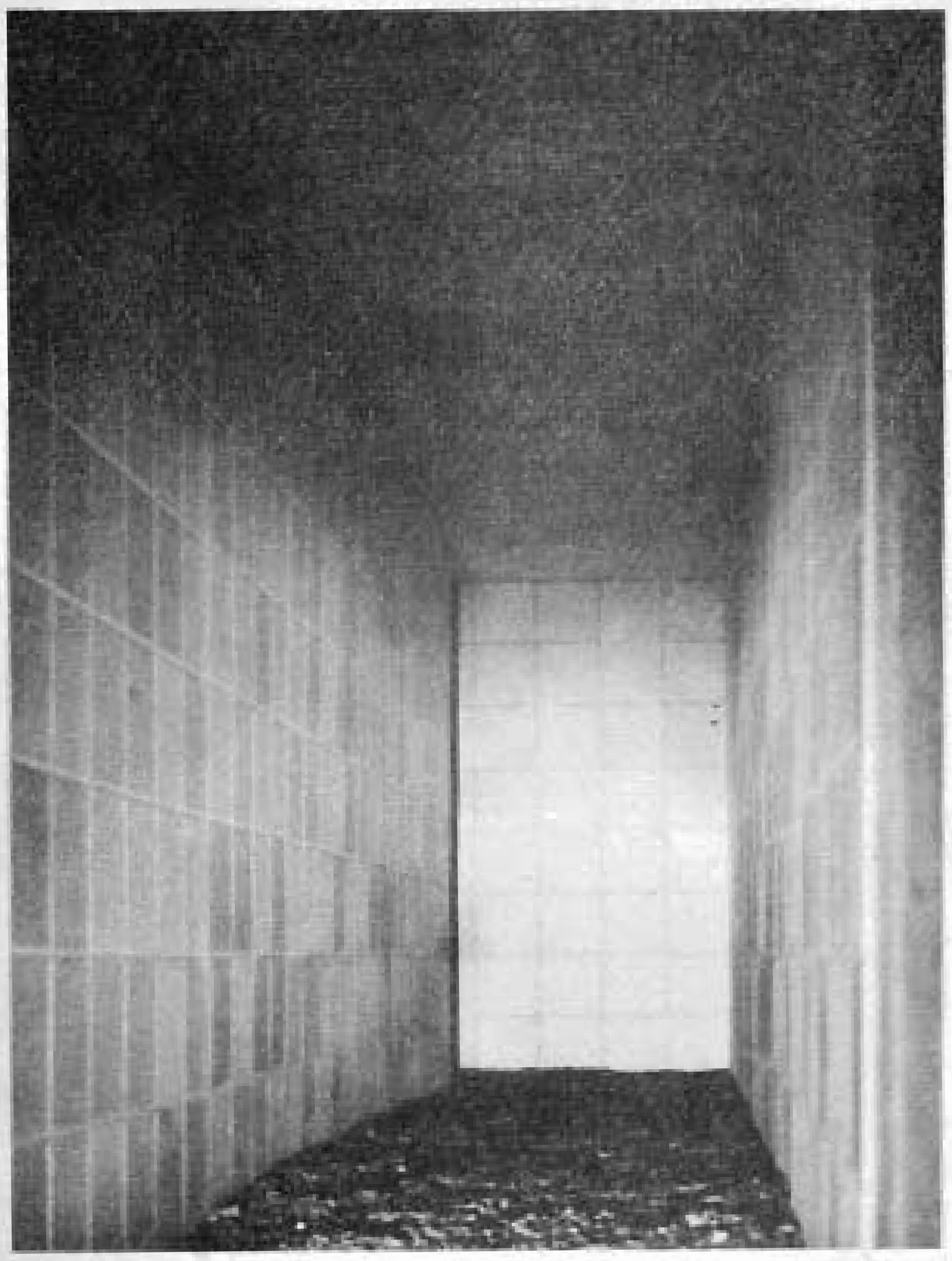
a) 3 min



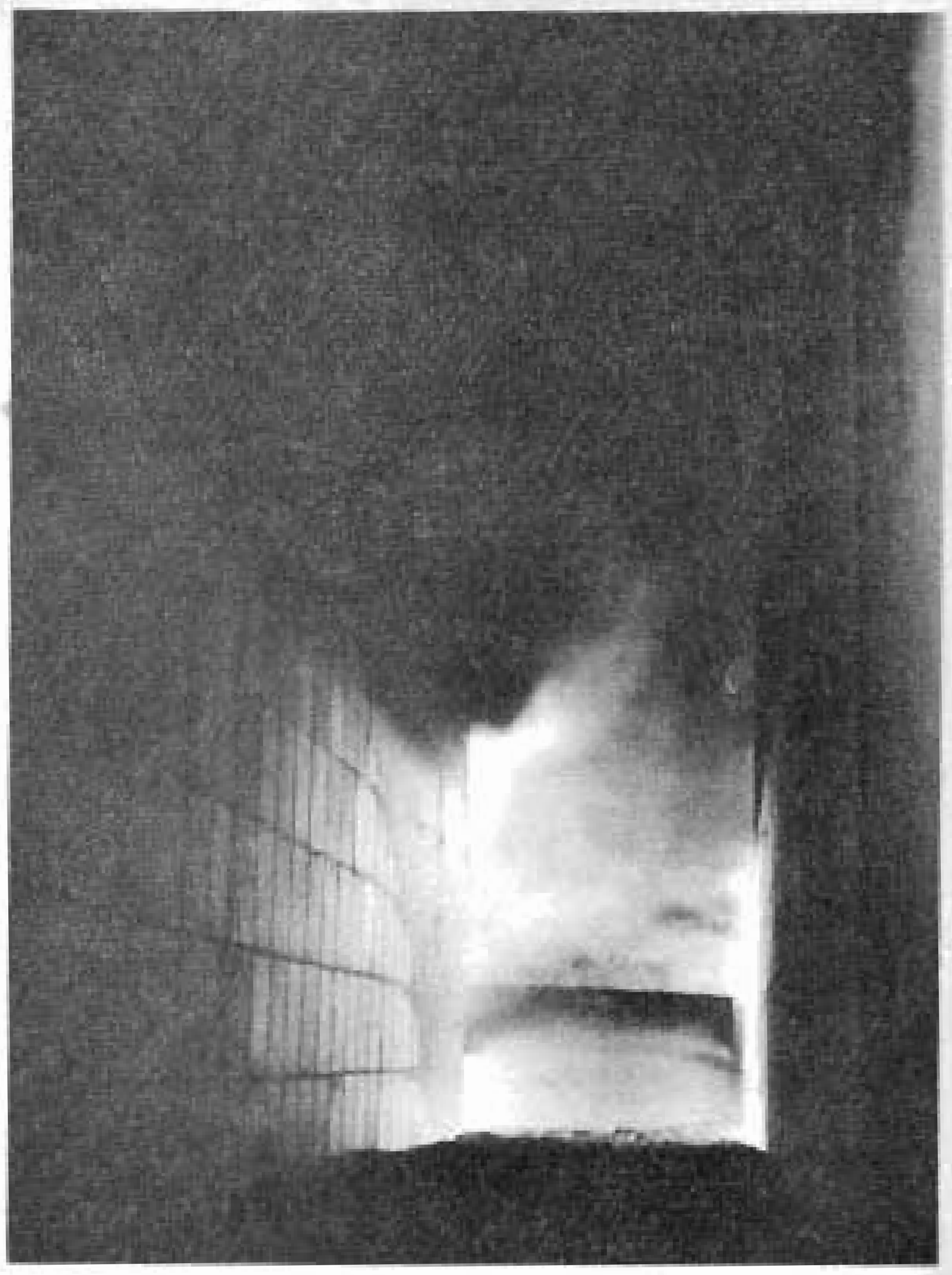
b) 12 min

c) at end of test

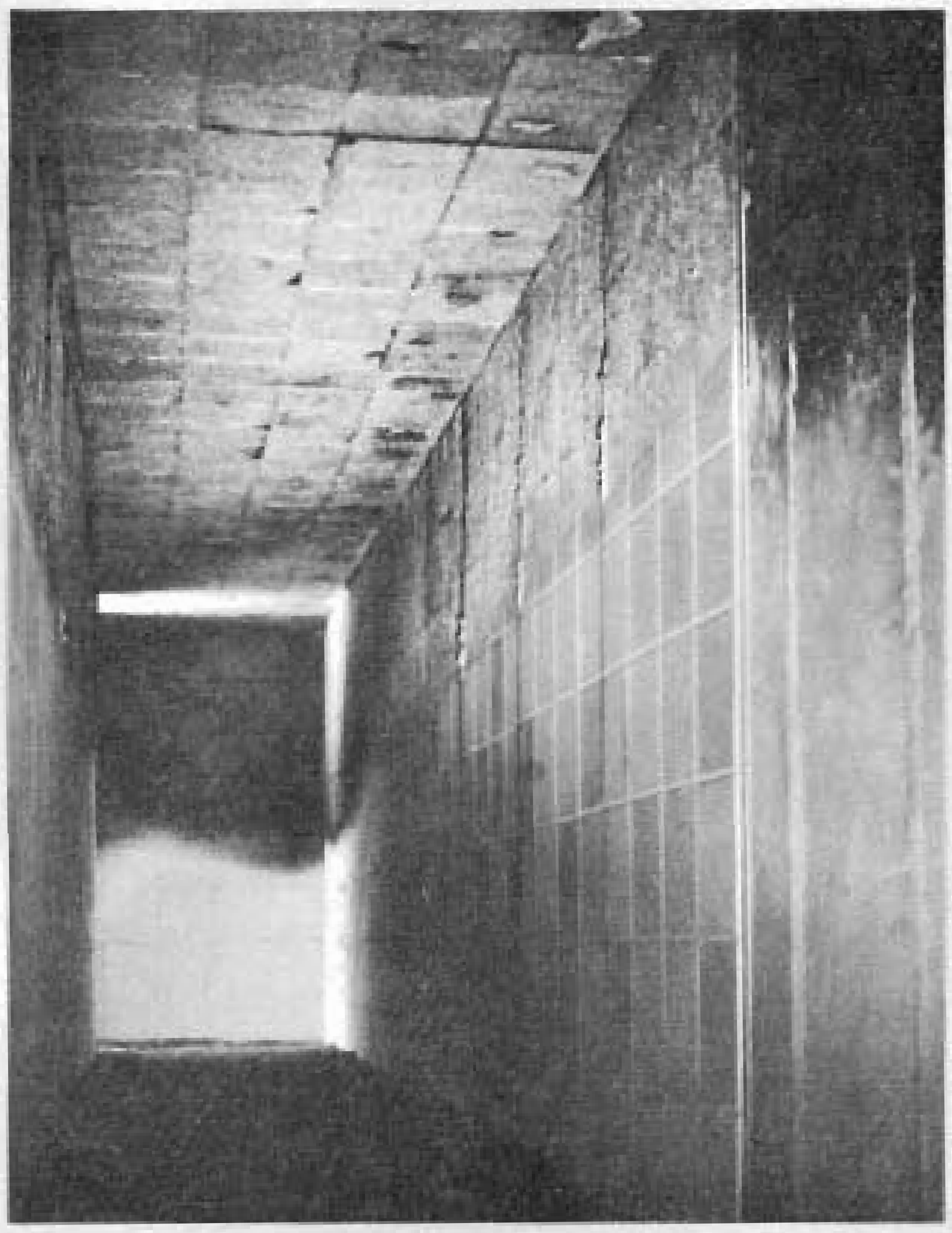
PLASTER BOARD LINING (SYSTEM 1)
PLATE 3



a) 3 min



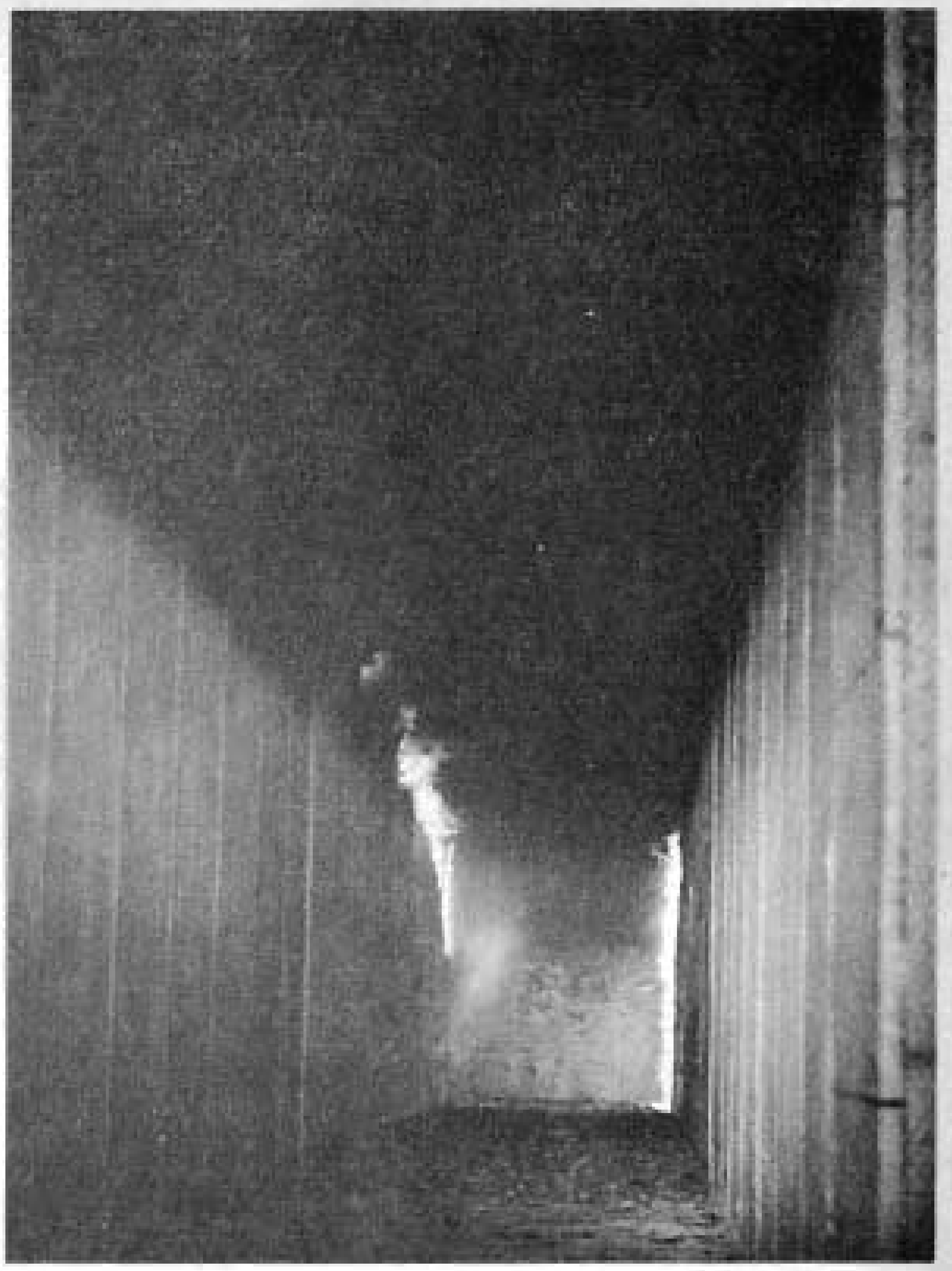
b) 12 min



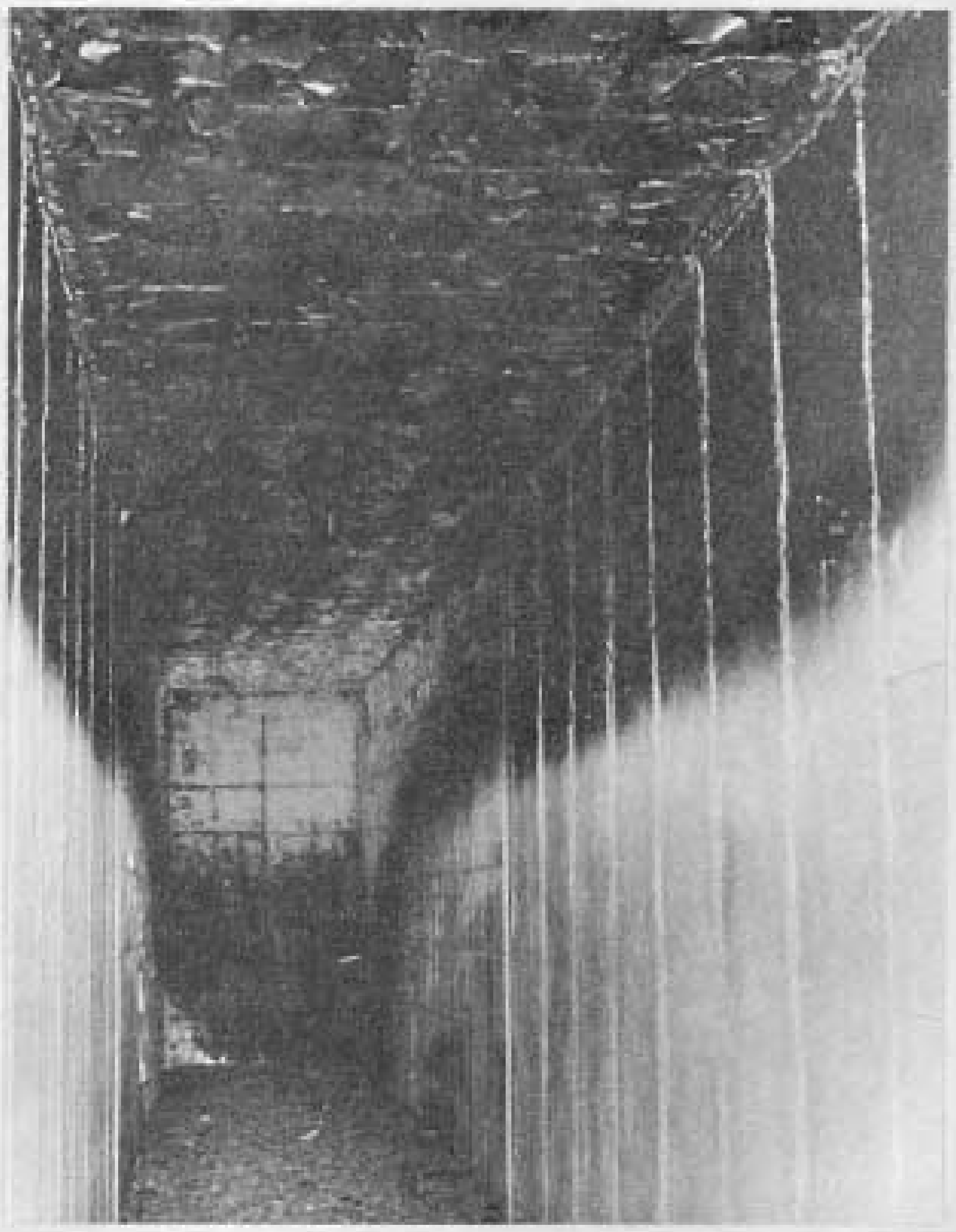
c)at end of test

EXPANDED POLYSTYRENE LINING (SYSTEM 2)
PLATE 4

a) 3 min



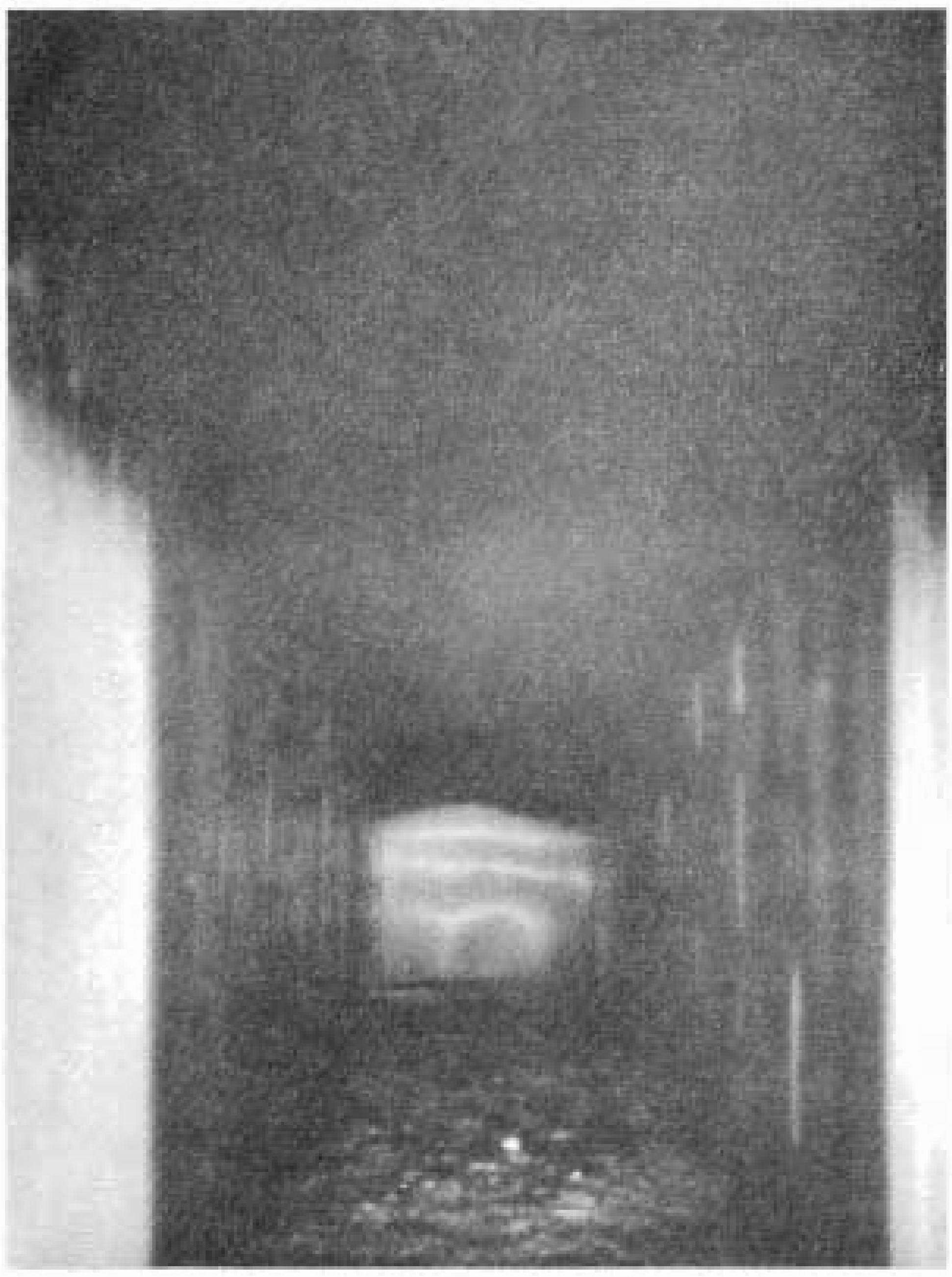
b) 12 min



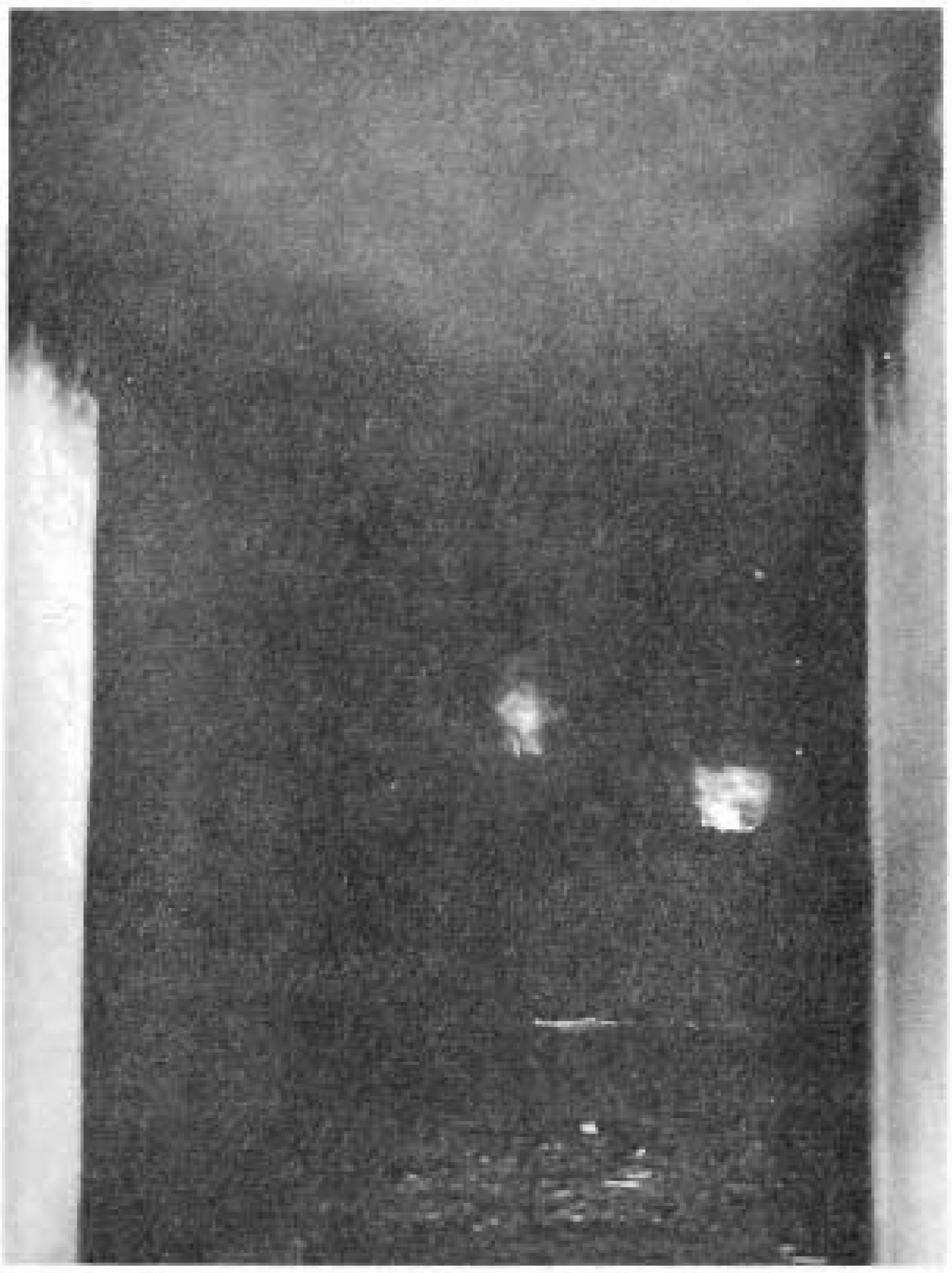
c) at end of test

EXPANDED POLYSTYRENE LINING (SYSTEM 3)

PLATE 5

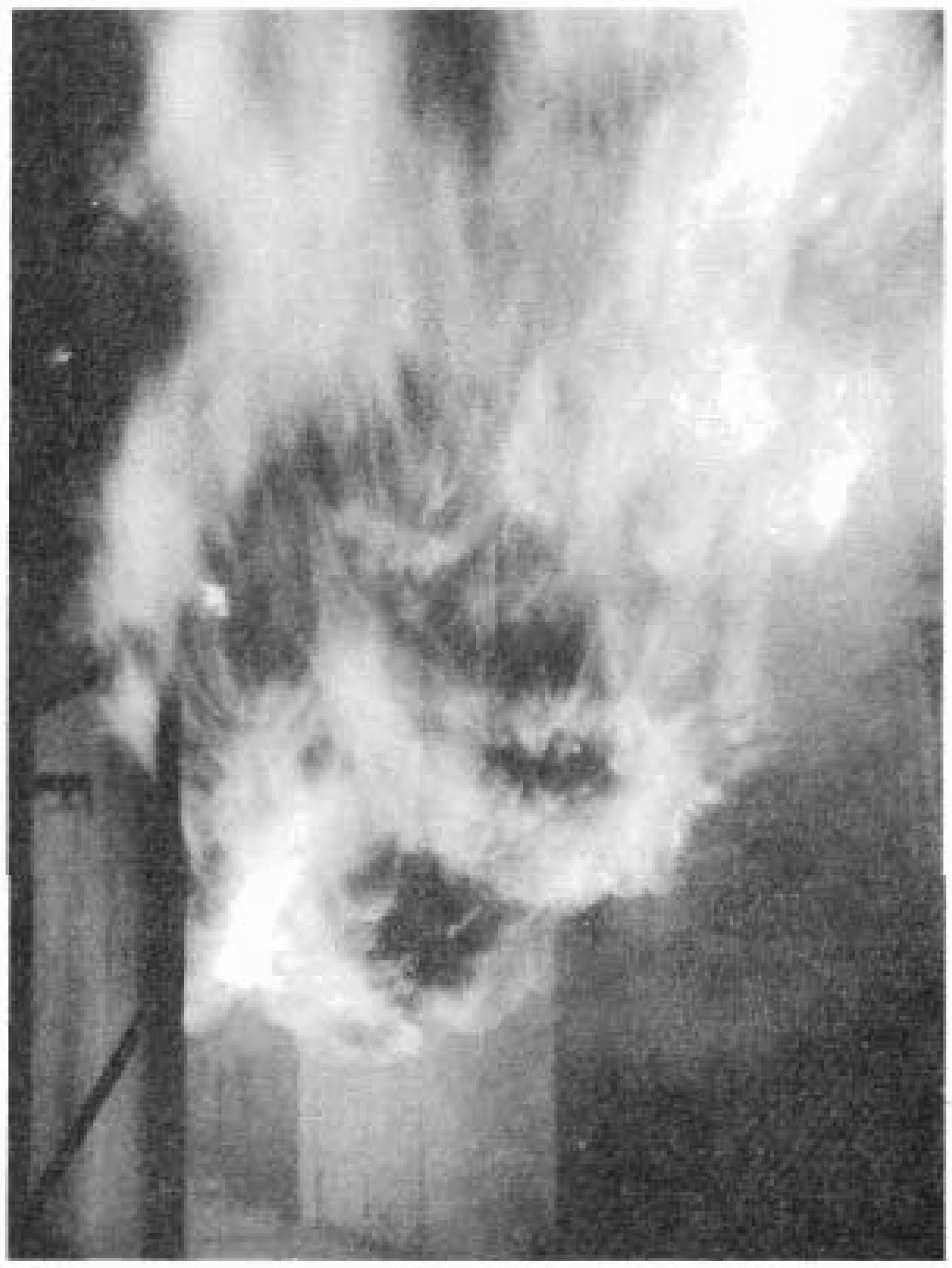


a) 5 min



b) 7 min

c) 7 min 30 sec



b) 8 min

HARDBOARD LINING

PLATE 6