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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

A COMPARISON OF RESULTS FROM THREE FIRE PROPAGATION TESTS

by

Alison M. Bisset

Summary

Several wallboards of British and Australian origin have been tested at both the Commonwealth Experimental Building Station and the Joint Fire Research Organization. The Australian ones were also tested at the National Bureau of Standards of the U.S.A. and this note correlates the results obtained.

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1. Introduction

Both the Commonwealth Experimental Building Station (C.E.B.S.) and the Joint Fire Research Organization (J.F.R.O.) have developed tests [1, 2] to measure the fire propagation hazard of wallboards and their treatments. In order to compare the classifications, specimens were interchanged between the two stations and this note gives the results of the tests by both organizations on their own and on each others materials. The materials supplied by the Commonwealth Experimental Building Station had previously been tested by the National Bureau of Standards (N.B.S.) in Washington [3], enabling a threefold comparison to be made.

2. The Fire Propagation Test [2]

2.1. Test method

The specimen under test forms one of the larger sides of a chamber of dimensions $7\frac{1}{2}$ in. x $7\frac{1}{2}$ in. x $3\frac{1}{2}$ in. Flames from a row of gas jets impinge on the lower part of the exposed surface. After the first three minutes of the test, the heating is increased by two electric elements.

The apparatus is shown in Fig. 1. Air enters through a rectangular orifice at the base of the chamber and the combustion products flow out through a chimney and cowl. Gas temperatures are measured by thermocouples located in the chimney. A standard temperature-time curve for purposes of classification is obtained by adding 50°C to the temperatures obtained throughout a test on an incombustible specimen with specified thermal properties.

2.2. Provisional Classification (Fig. 2)

Class A. Measured temperature-time curve crosses standard temperature-time curve after three minutes and remains above for less than three minutes.

Class B. Measured temperature-time curve crosses standard curve after five minutes but remains above for three minutes or more.

Class C. Measured temperature-time curve crosses standard curve after three minutes and before five minutes and remains above for three minutes or more.

Class D. Measured temperature-time curve crosses standard curve before or at three minutes.

3. Australian Tests

Three types of test were carried out by the Commonwealth Experimental Building Station. The first test gives a measure of the ignitability of the material, the second a measure of the rate of spread of flame, and the third a measure of the heat contribution of the material to the growth of fire. The tests are described elsewhere [1]. The indices from the three tests are combined to give an index of "early fire hazard" for each material. (Appendix I).

4. Results

The Australian materials are described in Table I together with a reference number [1]. The results obtained on the Fire Propagation Test, the National Bureau of Standards Index and the Commonwealth Experimental Building Station Early Fire Hazard Index are listed for each material in descending order of the Early Fire Hazard Index.

Table I

Description of Boards and Results

Description of Australian Boards and finishes	C.E.B.S. Specimen No.	C.E.B.S. Index of Early Fire Hazard	N.B.S. Index	J.F.R.O. Class	J.F.R.O. Time to Cross Standard Curve
3/16 in. Plywood, coachwood veneer filled. 2 coats copal varnish	6a	80	538	D	1.7
				D	2.2
				D	1.9
				Av.D	1.9
3/16 in. Australian hardboard No.2	1d	63	198	D	2.4
				D	1.8
				Av.D	2.1
3/16 in. Australian hardboard No.2* 1 coat heat intumescent ureaformaldehyde starch bound water paint. 2 coats high pigment ratio, short oil modified alkyd resin.	40	40	28	C	4.5
				C(top)	4.9
				D	2.6
				Av.C	4.0
½ in. Australian softboard No.1. 1 coat* heat intumescent ureaformaldehyde starch bound water paint. 2 coats casein bound water paint	9b	38	0.6	B	5.7
				B/C	5.0
				-	-
				Av.B	5.4
½ in. Australian softboard No. 1. 1 coat glue size, 2 coats alkyd resin casein bound water paint	31	38	5.1	B	6.0
				B	5.2
				B	5.3
				Av.B	5.5
½ in. Australian softboard No.1. 2 coats semi-gloss fire resisting paint	9a	33	25	C	4.3
				C	4.6
				C	4.5
				Av.C	4.5

*There is some evidence that these materials deteriorated between despatch and testing in the United Kingdom.

The British materials are described in Table II with the results and classifications of the Fire Propagation Test and the computed Early Fire Hazard Index in order of descending class on the Fire Propagation Test. The separate indices for each of the three Commonwealth Experimental Building Station tests are given in Appendix I for all the materials.

Table II
British Materials
Commonwealth Experimental Building Station Early Flame Spread Index

Description of British Material and Finish	J.F.R.O. No.	Early Fire Hazard Index (C.E.B.S.)	Joint Fire Research Organization Class	Mean time to Cross Standard Curve Min.	Sec.
Woodwool	1	0	A	Never	
Fibre insulating board + 1.05 oz/ft^2 intumescent paint	2	5	B	13	35
Fibre insulating board + 0.52oz/ft^2 intumescent paint	3	33	B/C	5	0
Fibre insulating board + silicate paint (one coat)	4	45	C	4	0
Hardboard	5	73	D	2	48
Fibre insulating board + distemper	6	78	D	0	48

The relation between the Joint Fire Research Organization, Commonwealth Experimental Building Station and National Bureau of Standards classifications is shown schematically in Table III.

5. Correlation between tests

By plotting the Commonwealth Experimental Building Station Index against the time at which the standard curve of the Joint Fire Research Organization test is crossed in (fig. 3), a tentative relation between the classifications given by the two tests is obtained. This is shown in Table IV.

TABLE IV

Tentative Relation between Tests

C.E.B.S. Index	J.F.R.O. Class
Less than 5	A
Between more than 5 and about 35	B
Between about 35 and about 55	C
Greater than about 55	D

However, all the materials tested were classified on the Fire Propagation Test only by the time at which the standard curve was crossed and the time spent above it was not relevant to their classification. No material classified by the second method was included in the exchange and this may be the reason why the "heat evolved" index does not appear to play a critical role in the present correlation. This may be seen from the data given for the separate indices. Omitting the "heat evolved" index makes no difference to the order in which the materials are placed.

A second limitation to this relation is that all the materials tested were cellulosic in origin and the general pattern of their behaviour when exposed to flames or heat is likely to be the same. The resulting classification of materials made of foamed plastics or even of cellulose materials with reflecting surfaces (4) might be different. However, the results obtained so far suggest that it is possible to obtain a good correlation between Fire Propagation Classification and the Commonwealth Experimental Building Station Index and an adequate correlation between the National Bureau of Standards Index and the Commonwealth Experimental Building Section Index.

References

1. Ferris, J.E. Fire hazards of combustible wallboards. S.R. No. 18. Commonwealth Experimental Building Station, Australia, October 1955.

2. Hird, D., and Karas, G. C. A method for classifying the fire hazard of internal linings and their treatments. Joint Fire Research Organization F.R. Note No. 166/1955.

3. Robertson, A.F., Gross, D. and Loftus, J. A method for measuring surface flammability of materials using a radiant energy source. Proc. A.S.T.M. Vol. 56 p.p. 1437 - 1453. 1956.

4. Bigmore, R.H., Karas, G.C., and Roberts, Valerie E. Fire Propagation tests on some wallboards supplied by the National Bureau of Standards. Joint Fire Research Organization, F.R. Note 337/1957.

Acknowledgments

Thanks are due to Miss Valerie E. Roberts and Miss Constance J. Cook for carrying out the tests.

APPENDIX I

C.E.B.S. Early Fire Hazard Index

The index is $2\frac{1}{2}$ times the sum of three separate indices, it may range in value from 0 - 100, the degree of hazard increasing as the value of the index increases.

(a) Ignition time index. An integer, to the nearest minute, equal to the difference between 20 and the ignition time at a given intensity of radiation.

(b) Spread of flame index. Index numbers are related to the time for flames to spread to the top of a 9 ft. wall. They are four thirds the time taken for a radiometer to register an increase of 0.14 w/cm^2 over its original value.

Index No.	1.33 x Time for Radiation Intensity to increase by 0.14 w/cm^2 (t min)
0	$t > 4\frac{1}{2}$
1	$4\frac{1}{2} > t > 4$
2	$4 > t > 3\frac{1}{2}$
3	$3\frac{1}{2} > t > 3$
4	$3 > t > 2\frac{1}{2}$
5	$2\frac{1}{2} > t > 2$
6	$2 > t > 1\frac{1}{2}$
7	$1\frac{1}{2} > t > 1$
8	$1 > t > \frac{1}{2}$
9	$\frac{1}{2} > t >$ 10s
10	10s $> t$

(c) Heat evolved index. The index in (b) does not give sufficient weight to the hazard represented by the amount of heat evolved by the board. The third index relates to the mean of the intensities of radiation on a thermopile at one minute and two minutes after ignition.

Index No.	Mean of radiant intensities (w/cm^2) at 1 and 2 mins.
0	< 0.025
1	$0.05 > I > 0.025$
2	$0.075 > I > 0.05$
3	$0.1 > I > 0.075$
4	$0.125 > I > 0.1$
5	$0.15 > I > 0.125$
6	$0.175 > I > 0.15$
7	$0.2 > I > 0.175$
8	$0.2257 > I > 0.2$
9	$0.25 > I > 0.225$
10	$I > 0.25$

The Commonwealth Experimental Building Station index for their own and the Joint Fire Research Organization materials is made up as follows.

British Materials

Commonwealth Experimental Building Station Materials

Index SR18

C.E.B.S.	Indices (a)	(b)	(c)	Early Fire Hazard Index
6a	15	9	8	80
1d	14	6	5	63
40*	14	0	2	40*
9b*	13	0	2	38*
31	13	0	2	38
9a	13	0	0	33

Joint Fire Research Organization Materials

Code No.	Index (a)	(b)	(c)	Early Fire Hazard Index
1	0	0	0	0
2	2	0	0	5
3	12	0	1	33
4	16	0	2	45
5	15	7	7	73
6	16	9	6	78

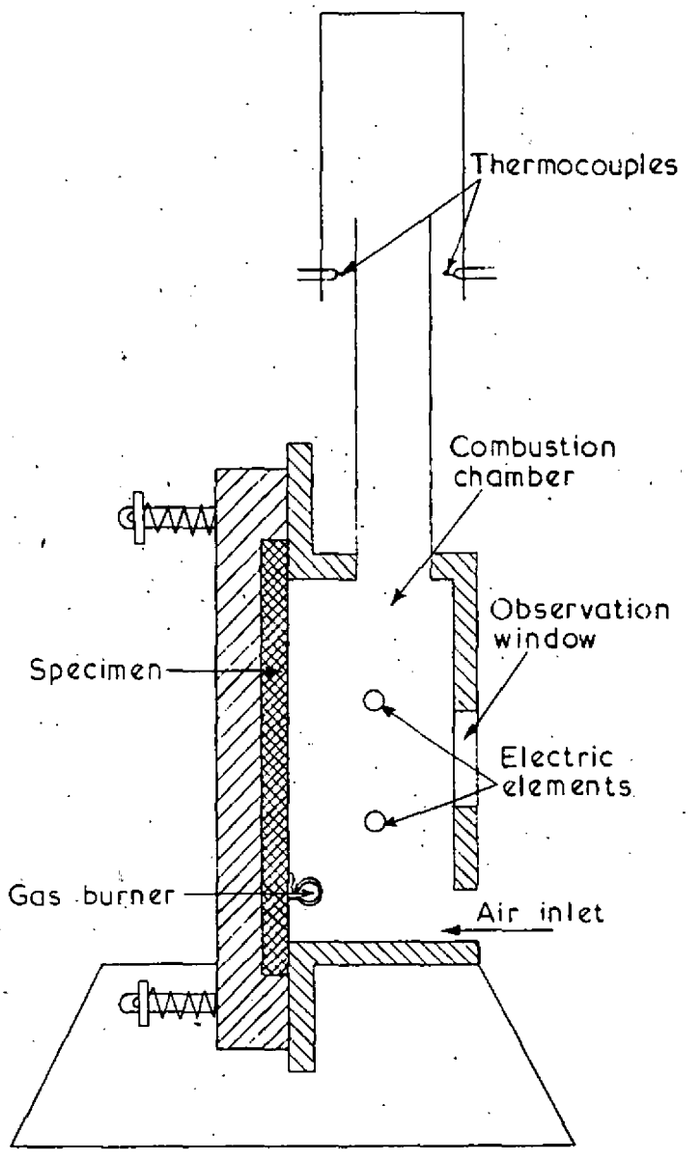

FIG.1. FIRE PROPAGATION TEST APPARATUS

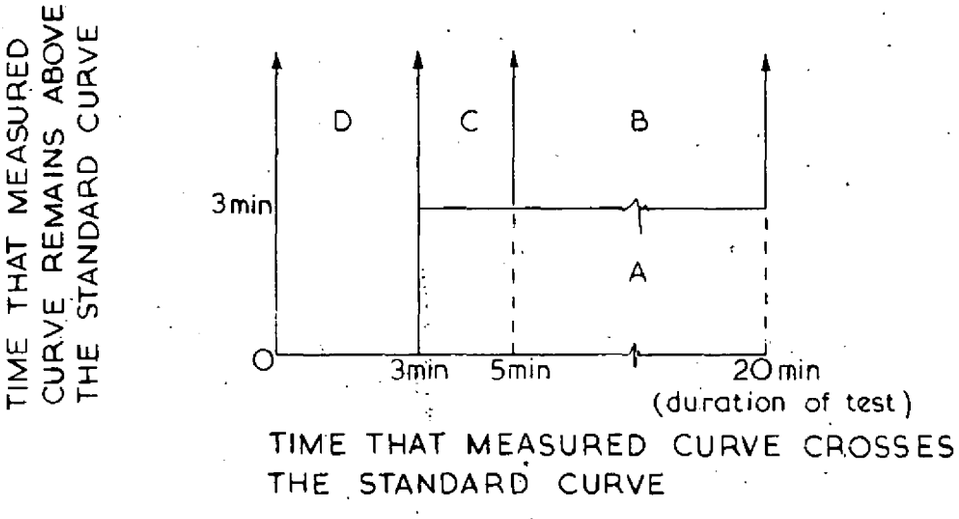

FIG. 2. PROVISIONAL CLASSIFICATION

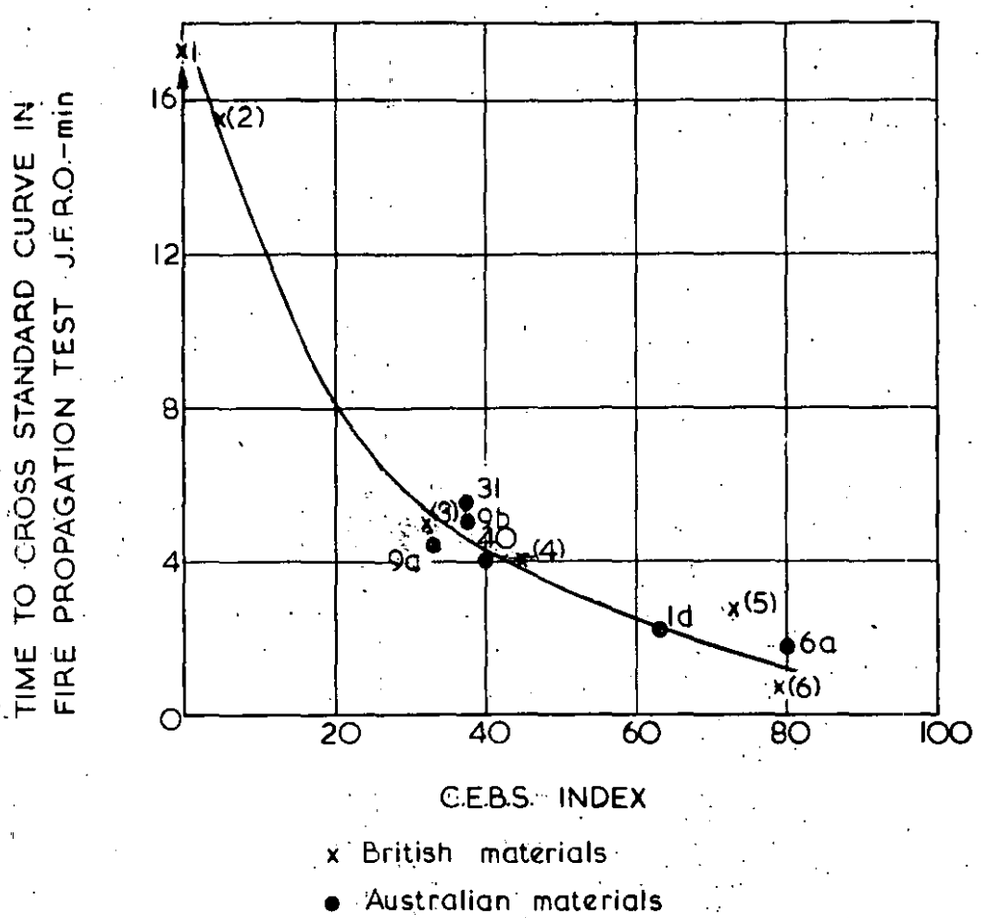

FIG. 3. CORRELATION BETWEEN TESTS OF C.E.B.S. & J.F.R.O.

TABLE II

TEST	BRITISH Fire Propagation Test / CLASS A	B	C	D	AUSTRALIAN Commonwealth Experimental Building Station Index 0 20 40 60 80 100
AUSTRALIAN C.E.B.S. Index	0 20 40 60 80 100				
U.S.A. National Bureau of Standards Flame Spread Index	100 200 300 400 500				