CONFIDENTIAL F.R. Note No. 7/51

April, 1952.

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

A TEST TO MEASURE THE FLAMMABILITY OF CINEMATOGRAPH SAFETY FILM

by

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Summary

A test has been developed which compares the flammability of cinematograph safety film with other cellulosic materials. The results indicate that safety film, both 35 mm and 16 mm, is less flammable than cotton, newsprint and similar materials.

1. Introduction

The work described in this note was carried out at the request of British Standards Institution Technical Committee CME/6. Its purpose was to investigate the relative fire hazard of various types of safety film marketed to-day with other comparable cellulosic materials in common use.

2. Development of Apparatus

Some preliminary work was carried out to compare the fire hazard of safety film with the known hazard of nitrate film. To do this, a length of 35 mm safety film was mounted vertically and its lower end ignited. It was found that the flame spread upwards over most types of safety film. However, if the upper end of the specimen were ignited, in no experiment did the flame spread downwards. Nitrate film subjected to the same test permitted the spread of flame in either direction.

In the light of these results it was considered that if a specimen of safety film were mounted in a semicircular form, and ignited at one end, it would continue to burn to a point which would be characteristic of the particular type of film. This may be explained by considering the heat transfer between the flame and the film. The flame front continues to advance provided the film directly in front of the flame is heated to its ignition temperature. Initially, when the flaming is taking place on the section of film which is vertical or nearly vertical, the film directly in front of the flame is heated by convection and radiation from the flame. As the flame front advances towards the horizontal section of the film the contribution of heat from the flame decreases since the angle between the plane of the flame and the film increases. A point may therefore be reached at which the heating received by the film from the flame is insufficient for burning to continue. This point is determined by the nature of the film under test.

Tests carried out on 35 mm film showed that nitrate film would continue to burn over 21 in. of the perimeter of a 14 in. diameter semicircle, whereas safety film burnt up to a length of 16 in. on the perimeter. The relative flammability of safety film and other materials in the same form could be assessed from the length to which each material continued to burn.

The distance of flame spread for any one specimen in these preliminary tests was generally greater when the emulsion was upwards and so in all subsequent tests the film specimens were mounted in this way.

3. Apparatus and experimental procedure for 35 mm film tests

The apparatus on which the tests on 35 mm film were carried out is shown in Fig I and Plate I. Two steel supports in the form of a 14 in. diameter semicircle were mounted on a steel base, with their adjacent edges 1 in. apart. One support was graduated at inch and half inch intervals over a length of 21 in. A copper cup 1 cm x 2 cm x 0·3 cm was mounted on an insulating base between the two supports at one end of the semicircle. A 21 in. length of film was held in position over the supports by means of two thin steel strips.

The test was carried out as follows, 0·3 cc of absolute alcohol were introduced into the copper cup and ignited. The distance over which the film burnt was noted.

Six specimens of each type of film were tested in this way and the results are shown in Table I.

4. Experimental procedure for 16 mm film

Because 16 mm cinematograph safety film is widely used, a test to cover this size of film is also necessary. Preliminary tests were carried out using an apparatus similar to that shown in Fig I and Plate I but with the adjacent edges of the two semicircular steel supports 12 mm apart. Some specimens of film which had been tested on the 35 mm apparatus were cut down to 16 mm. The results showed that these specimens burnt to a length less than that on the 35 mm apparatus. This result was to be expected since the flame was much smaller and the heating by convection and radiation was therefore considerably reduced. When the flame died out the angle of the film (to the vertical), at that point, was noted and the second apparatus was altered so that this angle was obtained at a distance equal to the distance of spread on the 35 mm test. In this way it was found that the diameter of the semicircle should be 18 in. for the 16 mm film test. It was felt desirable to obtain this result for the sake of uniformity between the two tests.

The apparatus which was used for testing specimens of 16 mm film is shown in Fig II and Plate II. It is essentially the same as that used for testing the 35 mm film. The two semicircular supports, of 18 in. diameter, were mounted with their inside edges 12 mm apart. A copper cup 1 cm x 1 cm x 0·3 cm was mounted on an insulating base between the two steel supports at one end of the semicircle. The film was held in position by two steel strips passing over the semicircular supports.

The method of testing was identical with that already described for the 35 mm film. 0·3 cc of alcohol were used as the igniting source and the distance the film burnt was noted.

Six specimens of each type of film were tested, the results are given in Table III.

5. Tests on other cellulosic materials

In order to compare the hazard of safety film with other cellulosic materials in the same form, specimens of nitrate film, newsprint, cartridge paper, cotton and rayon were subjected to the same test in both 35 mm and 16 mm widths. Six specimens of each material were tested and the results are shown in Tables II and IV.

6. Discussion of results

Rayon appears to be more hazardous than safety film, yet both consist essentially of the same material, cellulose acetate. This is probably due to the fact that rayon material has a larger specific surface than safety film.

The calorific values of three types of safety film were determined and the results are given in the table below.

Specimen	Calorific value B.Th.U./lb.
A Processed	8580
F Base	8820
G Base	9050

These values are slightly higher than the value for wood which is about 8,000 B.Th.U./lb.

7. Conclusions

Whilst the tests described do not give an absolute measurement of the fire hazards of the materials tested, they do indicate that the hazard of those safety films which have been examined is less than that of nitrate film, newsprint, cartridge paper, cotton and rayon. This conclusion is based on the final distance of flame spread for each type of material.

Acknowledgements

The authors wish to express their indebtedness to Mr. D. I. Lawson for suggestions which led to the design of the apparatus. Thanks are also due to Mr. P. S. Tonkin who carried out the calorific value determinations and Miss J. E. L. Walters for her assistance in some of the experimental work.

TABLE I

Distance of spread of flame on 35 mm safety film

Specimen	Thickness in. x 10^3	Distance of flame spread in.
A Base	5·3	1·5 2·5 2·5 2 2·5 2
A Emulsion coated	5·9	13 14 13 11 12 8·5
A Processed	5·8	3 2·5 2·5 2·5 3 3
B Base	5·7	3 3 3·5 6·5 10 4
B Emulsion coated	5·9	12 10 10·5 11·5 10·5 11·5
B Processed	5·8	13 11 10 11 11·5 11·5
C Base	5·3	11·5 11 12 12 11 8

TABLE I (continued)

Specimen	Thickness in. x 10^3	Distance of flame spread in.
C Emulsion coated	5·7	11·5 13 14·5 13 12 13
C Processed	5·7	13 13·5 13·5 12 12·5 12
D Base	5·4	3 2·5 2·5 2·5 3 3·5
D Emulsion coated	5·9	2·5 2·5 2·5 2·5 2·5 3
D Processed	5·9	2·5 2·5 2·5 2·5 3 7·5
E Base	5·3	3 3 5·5 6·5 2·5 10·5
E Emulsion coated	5·5	12 13·5 13 12·5 14 15·5

TABLE I (continued)

Specimen	Thickness in. x 10^3	Distance of flame spread in.
F Base	5·7	13 15 13 13·5 14 13
F Processed	5·8	13 13 14 13·5 13·5 11·5
G Base	5·6	2·5 2 2 2·5 2·5 2·5
G Processed	5·5	2·5 2·5 3 5 5·5 4·5
H Base	5·0	2·5 2 2 2·5 2 2·5
H Processed	6·1	2·5 2·5 2·5 3·5 4 4
I Base	5·8	12 11·5 11·5 11 12 11·5

TABLE I (continued)

Specimen	Thickness in. x 10^3	Distance of flame spread in.
I Processed	6·0	10·5 11 11·5 11·5 11·5 11·5
J Base	5·8	2·5 2 2 2·5 2·5 2
J Processed	6·0	3 2·5 3 3·5 2·5 3·5
Acetate base with cellulose nitrate surface coating	5·7	3 2·5 2·5 2·5 2 2·5
Negative film on acetate base with cellulose nitrate surface coating	6·2	10·5 10·5 10·5 11·5 10·5 12
Safety positive no silver image	6·1	4 4 4 4 4·5 5
Safety positive developed black	6·1	4·5 6 4 4 6 11

TABLE I (continued)

Specimen	Thickness in. x 10^3	Distance of flame spread in.
K Processed - not hardened	5·8	10·5 11 12 10·5 12 11·5
K Processed - hardened	5·8	10·5 11·5 11 11 10·5 11
L Processed - not hardened	5·0	13·5 12·5 12·5 12 13 12
L Processed - hardened	6·0	11·5 11 11 11 11 11
M Processed - not hardened	5·8	12 11·5 10·5 11·5 10·5 12·5
M Processed - hardened	5·7	11 12 11·5 11·5 11·5 12

TABLE II

Distance of spread of flame on cellulosic materials 35 mm in width

Specimen	Thickness in. x 10^3	Distance of flame spread in.
Nitrate film - emulsion coated	5·9	21 21 21 21 21 21
Newsprint - I ($1·15 \times 10^{-3}$ oz/in^2)	2·9	17 17 18 17 17 17·5
Newsprint - II ($1·21 \times 10^{-3}$ oz/in^2)	3·5	21 21 21 21 21 21
Cartridge paper ($3·32 \times 10^{-3}$ oz/in^2)	7·6	21 20 21 12·5 21 21
Cotton print ($2·77 \times 10^{-3}$ oz/in^2)	8·6	21 21 21 21 21 21
Rayon ($3·86 \times 10^{-3}$ oz/in^2)	5·0	21 21 19 21 21 21

TABLE III

Distance of spread of flame on 16 mm safety film

Specimen	Thickness in. x 10^3	Distance of flame spread in.
K Processed - not hardened	5·6	12 12 13·5 12·5 13 12
K Processed - hardened	5·7	11·5 3·5 4·5 12 4·5 3
L Processed - not hardened	5·8	12 13 13 12 12·5 12·5
L Processed - hardened	5·8	6 7 4 3 12 3·5
M Processed - not hardened	5·3	10·5 11 12 12·5 12 12·5
M Processed - hardened	5·3	11 3·5 5 5 11·5 4·5
N Base	5·7	2 2 2·5 2 2 2

TABLE III (continued)

Specimen	Thickness in. x 10^3	Distance of flame spread in.
N Processed	6.3	2·5 2·5 3 2·5 2 3
O Base	5·7	3·5 3 4 2·5 12·5 4·5
O Processed	5·9	5 4·5 5·5 5·5 7 7

TABLE IV

Distance of spread of flame on cellulosic materials 16 mm in width

Specimen	Thickness in. x 10^3	Distance of flame spread in.
Nitrate film - emulsion coated	5·9	27 27 27 27 27 27
Newsprint I ($1·15 \times 10^{-3}$ oz/in^2)	2·9	22·5 12·5 20·5 20 18 20
Newsprint II ($1·21 \times 10^{-3}$ oz/in^2)	3·5	27 27 27 27 27 27
Cartridge paper ($3·32 \times 10^{-3}$ oz/in^2)	7·6	19 21 20 21 13 21·5
Cotton print ($2·77 \times 10^{-3}$ oz/in^2)	8·6	27 25·5 27 27 27 27
Rayon ($3·86 \times 10^{-3}$ oz/in^2)	5·0	20 15·5 27 16·5 20 23·5

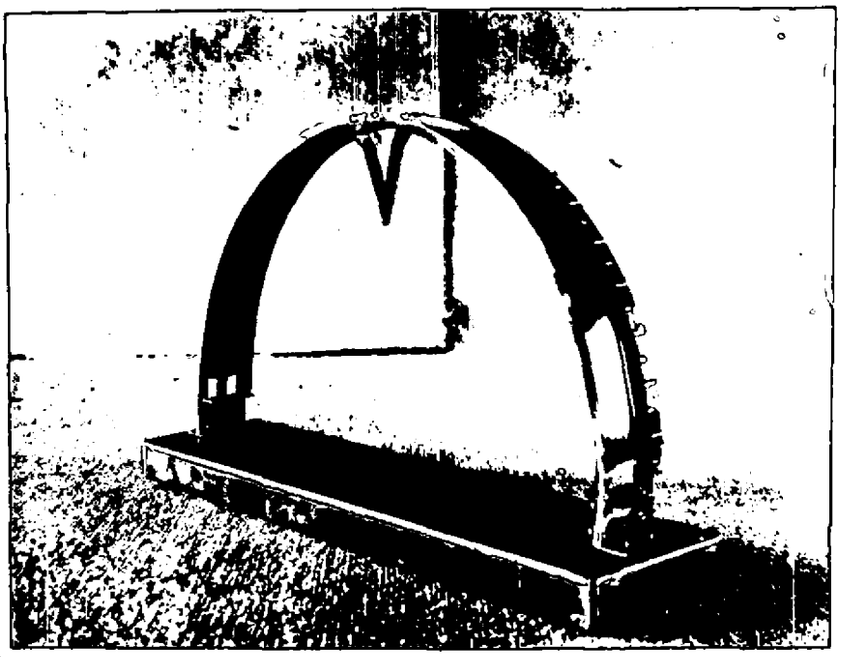

PLATE 1 APPARATUS FOR TESTS ON 35 mm FILM

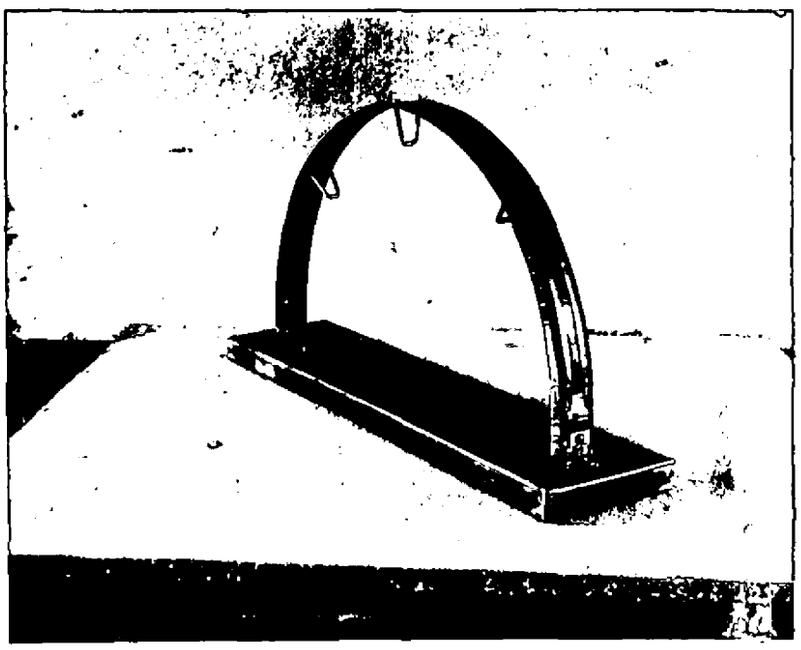

PLATE 2 APPARATUS FOR TESTS ON 16 mm FILM

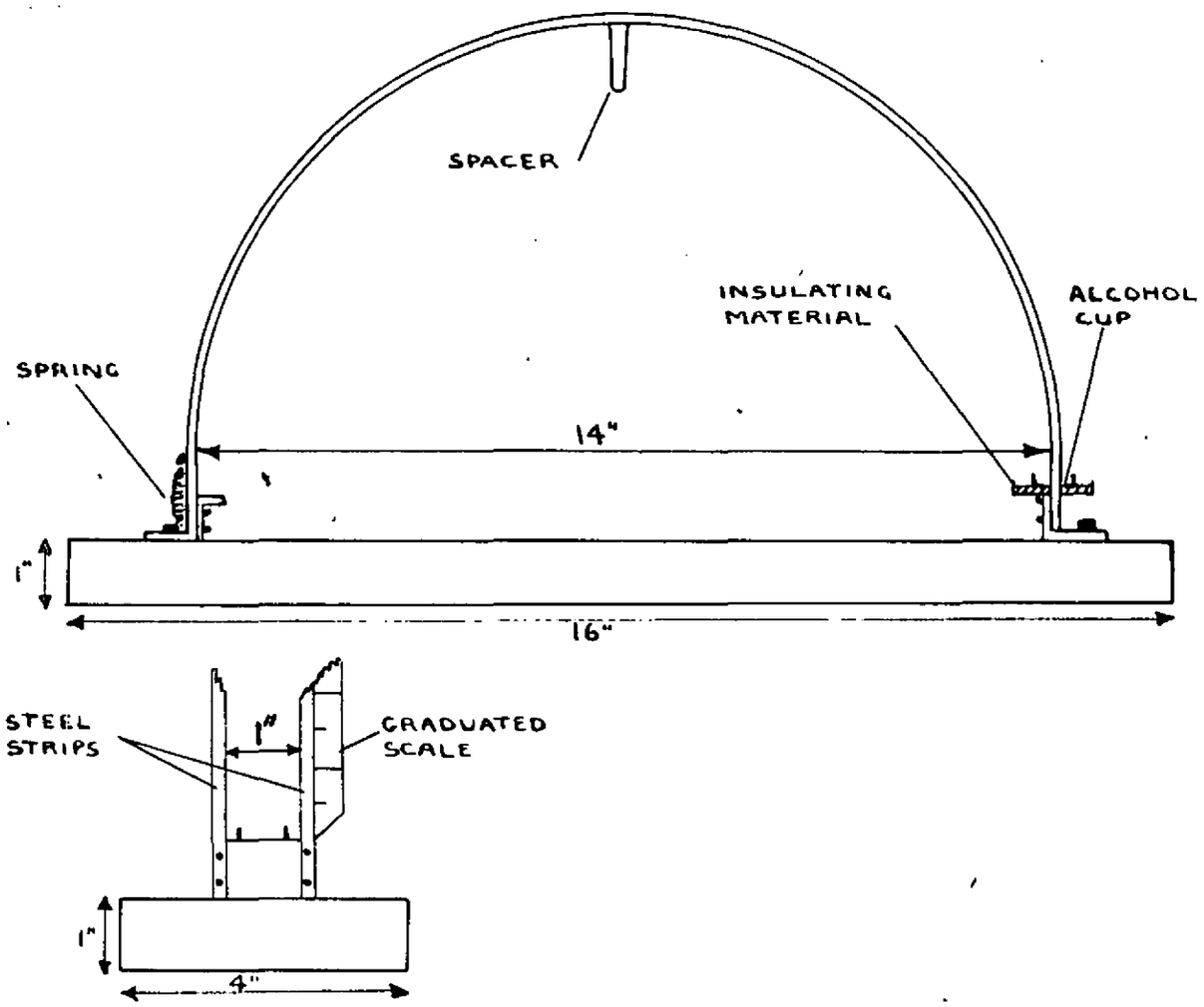

FIG. 1. APPARATUS FOR TESTS ON 35 MM FILM

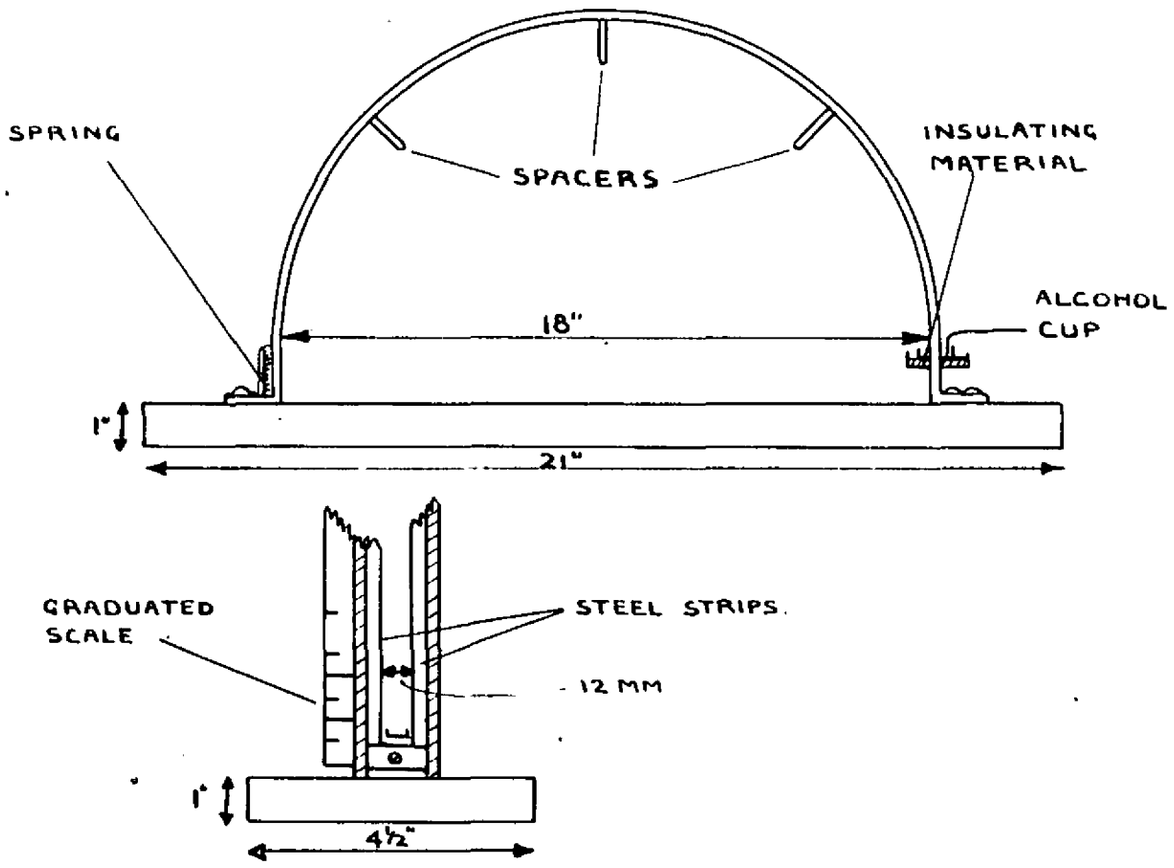

FIG. 2. APPARATUS FOR TESTS ON 16 MM FILM