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THE FLAMMABILITY AND FLASH POINT OF CELLULOSE ACETATE FILM CONTAINING VARIOUS AMOUNTS OF CELLULOSE NITRATE

by

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Summary

The effects on the flammability and flash point, of introducing different amounts of cellulose nitrate into a safety film base, have been investigated for a range of concentrations of cellulose nitrate from 3 per cent to 16 per cent.

Introduction

The work described in this paper was carried out at the request of a British Standards Institution Technical Committee on the 'Flammability of Safety Film'. The effect of introducing different amounts of cellulose nitrate on the flash point and flammability of safety film was investigated. A surface coating of cellulose nitrate is at present only occasionally used, but future developments in the film manufacturing industry might call for the wider use of surface coatings and even the inclusion of small amounts of cellulose nitrate in the body of the safety film base.

Specially prepared film containing amounts up to 16 per cent of cellulose nitrate, both in the base and as a surface coating, were tested.

Flammability tests

The apparatus used in the flammability test was that described in F.R. Note No. 7 (1), which consisted of two steel supports in the form of a 14 in. diameter semicircle, mounted on a base, with their adjacent edges 1 in. apart. A 21 in. length of film was held in position over the supports by two thin steel strips, and ignited at one end. The distance over which the film burnt was taken as a measure of its flammability. In previous work on the development of this flammability test (1) many different types of safety film as well as samples of paper, cotton, rayon and nitrate film were tested on the apparatus and a full report of the results appears elsewhere (1). These tests showed that none of the samples of safety film burnt over a distance greater than 16 in., whereas samples of nitrate film, some newsprints, cotton and rayon were still burning at 21 in.

In the present series of tests six samples of each type of film were tested on the apparatus and the results are shown in Table 1.

Fig. 1 shows the mean distance of spread of flame plotted as a function of the cellulose nitrate content. It would appear from this that a cellulose nitrate content of up to 4 per cent, either as a surface coating or as mixture with the base, does not increase the flammability of the film appreciably. Higher cellulose nitrate contents, up to concentrations of 16 per cent, in the body of the base cause little increase in its flammability. However, if higher cellulose nitrate contents are present as a surface coating then a marked increase in the flammability is observed.

With 14.5 per cent cellulose nitrate present as a surface coating, the film was still burning after a distance of 21 in., and was thus more flammable than any type of safety film. A probable explanation of the difference in behaviour of the film with the nitrate in the base and as a surface treatment may be that if the cellulose nitrate surface coating is thick enough, the film assumes the highly flammable characteristics of cellulose nitrate. However, within the limits of these tests the concentration is not high enough with the nitrate present in the body of the base to increase the flammability appreciably.

Flash point determinations

The flash point of a liquid or volatile solid is the temperature at which it gives off sufficient vapours to form an ignitable mixture with air near the surface of the material. The "flash point" of film is defined in this paper similarly, although the vapours given off by the film on heating are decomposition products. Materials in the neighbourhood of a fire are gradually heated and the spread of fire is often facilitated if these materials give off vapours which are ignitable. It was felt, therefore, that the "flash point" of the films was a better measure of the fire hazard than the ignition temperature.

To determine the flash point of the specimens of film under test a fixed weight of film (in this case 3.7 grams), in the form of punchings $\frac{1}{2}$ cm square, was placed in a Pyrex test-tube and one junction of a platinum—platinum-rhodium thermocouple placed in the centre of the specimen. The other junction of the thermocouple was placed in a Dewar flask. The test-tube was supported in a small electric furnace, the temperature of which was raised at about 4°C/min. The temperature of the furnace could be measured by a mercury in glass thermometer in the furnace wall. A small pilot flame was mounted over the top of the test-tube to ignite the vapours when they were given off in a sufficient quantity.

A representative selection of the films, containing different amounts of cellulose nitrate, were tested in this manner, as well as a normal safety film base and a sample of cartridge paper. The specimens of film which contained cellulose nitrate, either as a surface coating or in the base, behaved similarly, and a typical graph of specimen and furnace temperatures is shown in Fig. 2. In this case the flash point was 160°C, the vapours being first ignitable and the subsequent flame travelling down the test-tube at this temperature. Soon after this the temperature of the film increased rapidly, denoting an exothermic reaction, and on ignition the vapours burnt with a self-supporting flame. After some 4 or 5 minutes the flame died out, the vapours were no longer ignitable, and the temperature of the specimen fell to below the temperature of the furnace again. The tests showed that the severity of the exothermic reaction increased as the percentage of cellulose nitrate increased. As the temperature of the furnace was raised further the vapours became ignitable again at about 280°C, although in this case it was not accompanied by an exothermic reaction. Some 8 to 10 minutes after this second flash point the flames became self-supporting.

Fig. 3 shows the temperature graphs for the triacetate base used in the film samples containing cellulose nitrate, and Fig. 4 those for cartridge paper. The flash points which were determined are shown in Table 2.

Table 2

Flash point measurements

Specimen	Flash point °C
1. Containing 3% cellulose nitrate in the base.	220
2. Containing 6.5% cellulose nitrate in the base.	206
3. Containing 16% cellulose nitrate in the base.	210
4. Containing 4% cellulose nitrate as a surface coating.	186
5. Containing 9% cellulose nitrate as a surface coating.	182
6. Containing 14.5% cellulose nitrate as a surface coating.	162
7. Triacetate safety base.	305
8. Cartridge paper.	288

In those films containing any cellulose nitrate, the nitrate decomposed at a lower temperature than the rest of the base giving ignitable vapours at temperatures between 160°C and 220°C. The second flash point of these films was due to the decomposition of the base, at temperatures in the range 270°C to 300°C.

Conclusions

Within the limits of concentration used in these tests, the inclusion of cellulose nitrate in the body of the safety film base did not appreciably increase the flammability. With the cellulose nitrate present as a surface coating, however, the flammability increased as the percentage of nitrate present increased.

The presence of cellulose nitrate in either form leads to a considerable reduction in the flash point. Thus under certain conditions, for instance in a closed or poorly ventilated space, an inflammable mixture of gases would be obtained at a lower temperature than with film containing no cellulose nitrate.

Acknowledgements

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Table 1

Flammability tests

Specimen	Distance of spread (in.)	Thickness (in.)
3% cellulose nitrate as a mixture with cellulose acetate base.	3.5 4 3 4.5 4 4.5	.0057
Mean	3.9	
6.5% cellulose nitrate as mixture with cellulose acetate base.	3 3.5 4 4 4 4	.0055
Mean	3.8	
12% cellulose nitrate as mixture with cellulose acetate base.	4 6 3 6 5.5 4	.0050
Mean	4.8	
16% cellulose nitrate as mixture with cellulose acetate base.	2.5 7.5 8.5 6 6.5 7	.0040
Mean	6.3	
4% cellulose nitrate as surface coating on both sides of triacetate base.	4 3 4 4.5 4 4.5	.0058
Mean	4.0	

Table 1 (contd.)

Flammability tests

Specimen	Distance of spread (in.)	Thickness (in.)
9% cellulose nitrate as surface coating on both sides of triacetate base.	15.5 7 6.5 6 7.5 17.5	.0065
Mean	10.0	
14.5% cellulose nitrate as surface coating on both sides of triacetate base.	21 21 13.5 21 20.5 14.5	.0067
Mean	19.6	

References

1. Pickard, R.W. and Hird, D. A test to measure the flammability of cinematograph safety film. Department of Scientific and Industrial Research and Fire Offcies' Committee Joint Fire Research Organization. F.R. Note No.7/51.

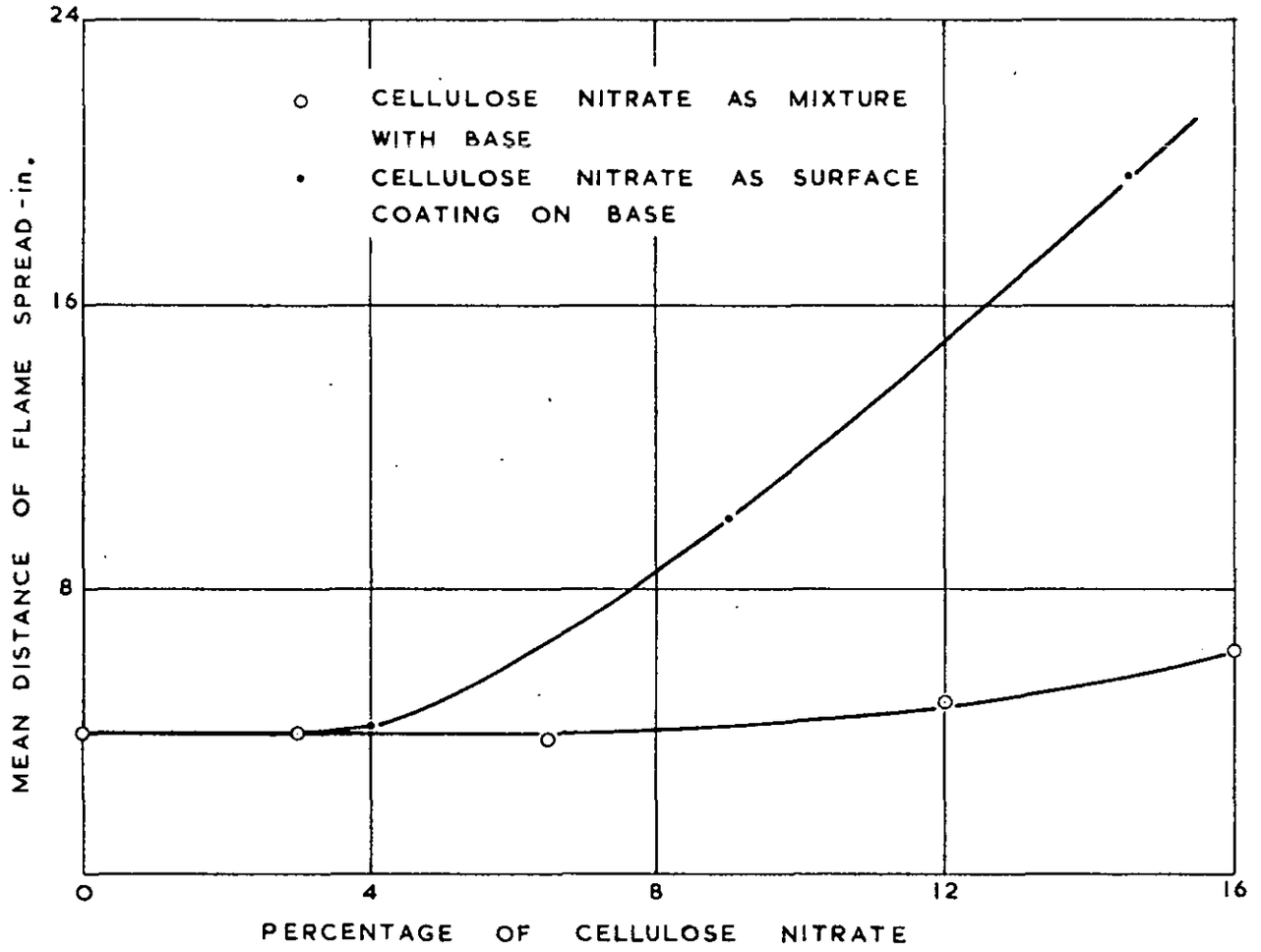
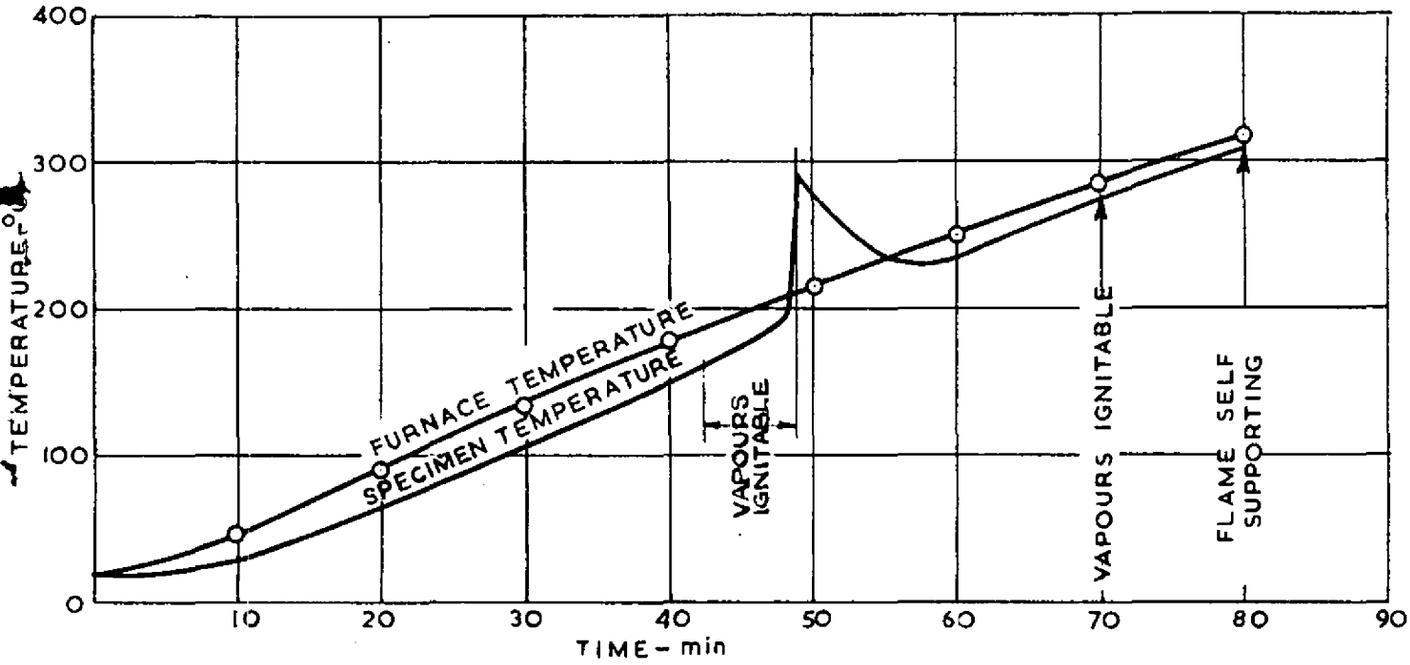
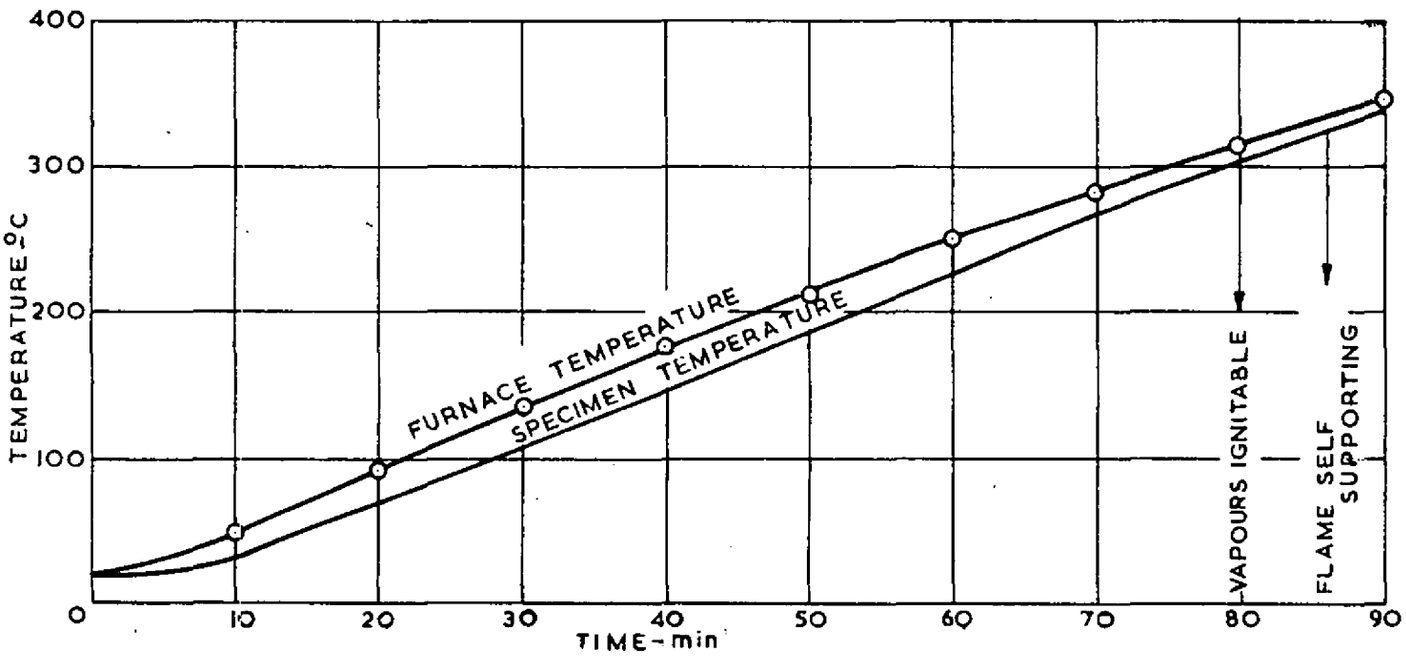


FIG. 1. DISTANCE OF SPREAD OF FLAME AS A FUNCTION OF THE CELLULOSE NITRATE CONTENT



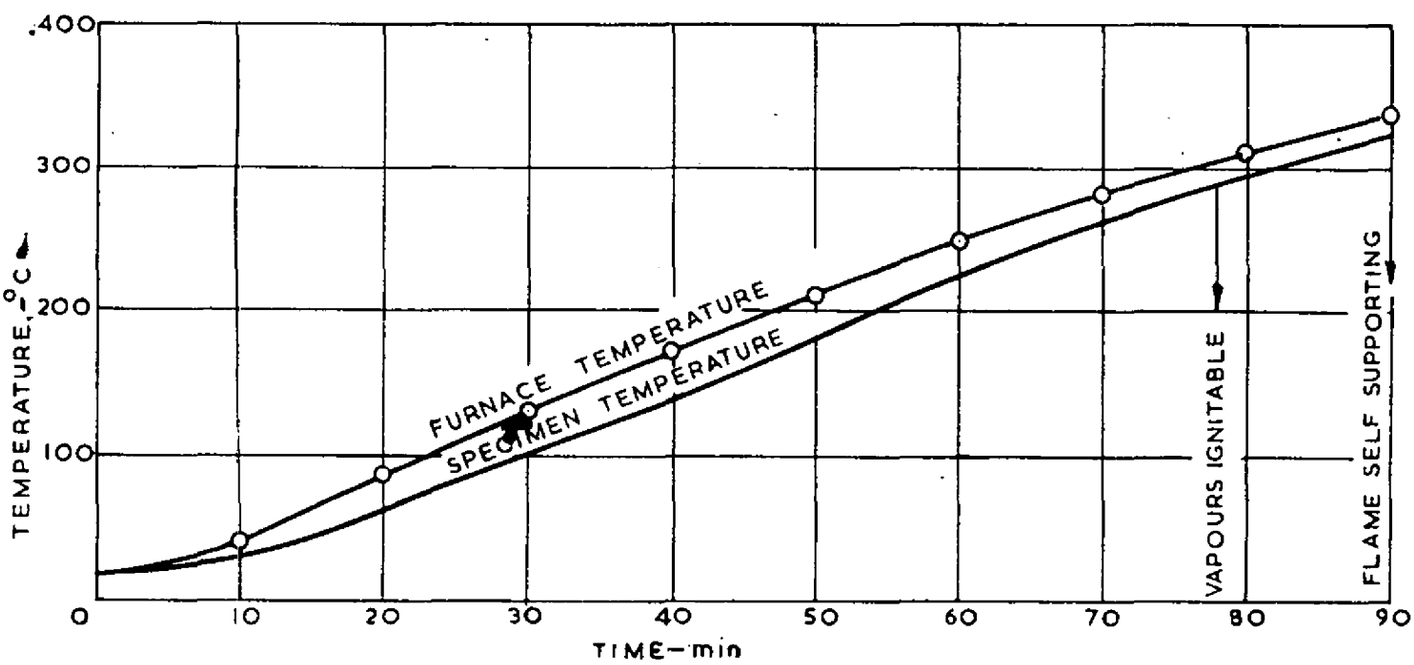
SPECIMEN – TRIACETATE BASE WITH 14·5% CELLULOSE NITRATE AS SURFACE COATING

FIG. 2. TIME / TEMPERATURE CURVES



SPECIMEN – TRIACETATE SAFETY BASE

FIG. 3. TIME / TEMPERATURE CURVES



SPECIMEN – CARTRIDGE PAPER

FIG. 4. TIME / TEMPERATURE CURVES