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STORAGE OF EKTACHROME INFRA-RED FILM. (U)
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(6) STORAGE OF EKTACHROME INFRA-RED FILM.

by

(10) D. M. Fox, BA

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ADDENDA

Aerochrome, Ektachrome, Estar, Kodak Versamat and Wratten are the registered trade marks of Kodak Limited.

errata: P.5 Para 3, line 1; Fig 1 should read Fig 2.

ROYAL AIRCRAFT ESTABLISHMENT

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STORAGE OF EKTACHROME INFRA-RED FILM

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SUMMARY

Experiments to establish the effects of storage less ideal than that recommended by the manufacturer - *ie* that it is kept in a freezer at -18 to -20°C, have shown that even after one year's storage at 4°C, the infra-red layer retains sufficient sensitivity for use in emergencies.

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1 INTRODUCTION

Photographic film specially sensitized to record near infra-red radiation (700 to 900 nm) has been used for many years in agricultural and forest surveys to detect disease and to monitor crop yields. It also has application for military purposes, in aerial reconnaissance of troop disposition, etc, since normal camouflage although effective within the visual spectral range may not reflect in the near infra-red. It will thus appear as an anomaly among normal vegetation, which has high infra-red reflectivity due to the spectral reflectivity characteristics of active chlorophyll in the leaves. With black and white infra-red film the anomaly will appear as a local change in density and will not necessarily be readily identified.

To overcome this problem a 'false' colour film (eg Kodak Ektachrome infra-red) can be used. Green, red and infra-red radiation is recorded by separate layers in the emulsion, which after processing display the images recorded in these spectral bands by blue, green and red colours in the reversal transparency. This means that a green camouflage paint and dead or diseased foliage with little or no infra-red reflectance, will record as a blue image among predominantly red vegetation, making identification particularly easy.

Several limited experiments were conducted to establish the effects of storage less ideal than that recommended by the manufacturer[1], ie that the film is kept at -18 to 23°C until required.

1.1 Ektachrome IR film

Kodak Ektachrome Infra-red film is available for aerial reconnaissance cameras (Kodak Aerochrome Infra-red type 2443) and in film cassettes for 35 mm still cameras. It is an integral tripack reversal colour film coated on a 0.10 mm polyethylene terephthalate (Estar) base, and was designed for the Kodak E4 or EA5 processing chemistry.

The three emulsion layers are chemically sensitized to their respective spectral bands (Fig 1) but the inherent sensitivity of the silver halide to higher energy photons (wavelength <500 nm) is not attenuated, chemically or by inter-emulsion filter layers. It will be noted in Fig 1 that the sensitivity of the infra-red layer at 400 nm is nearly eight times greater than at 800 nm. To prevent ultra-violet and blue radiation exposing all three layers, a sharp cut filter, with transition wavelength at about 500 nm, must be used. Kodak recommend the use of a Wratten 12 filter and its transmission characteristics are included in Fig 1.

The infra-red sensitizing dye loses activity rapidly at moderate temperatures, and Kodak recommend that to obtain optimum results the film is stored in a freezer at -18 to -23°C until required. Under these conditions the film should remain essentially unchanged sensitometrically for up to 12 months from date of delivery. It is also stated[2] that the film may be kept at temperatures not exceeding 2°C for up to 14 days without adversely affecting results.

1.2 Storage tests

Several batches of film were used in experiments during July and August 1977, to establish what changes in sensitometric characteristics may occur after varying conditions of storage.

Film 'A': was fresh stock, batch number 2236-137, with expiry date July 1978. It had been stored at -20°C since delivery by Kodak on 20 June 1977.

Film 'B': batch number 2236-133 with expiry date August 1977 had been stored at 4°C for about one year.

Film 'C': batch number 2236-133 with expiry date September 1977 had been stored in a different refrigerator from film 'B' at 4°C for just under one year.

In the first experiment, one sample of each film, taken from its respective storage immediately before exposure, was used as a control being kept at -20°C after exposure until all of the other films were ready for processing. The second sample was subjected to a temperature of 30°C for 2 days before exposure, and the final sample was subjected to a temperature of 30°C for 2 days before and 2 days after exposure.

For the second experiment samples of films 'A' and 'C' were subjected to a temperature of 30°C for 4, 8 and 14 days before exposures: again one sample of each was kept at a control, and after exposure all of the films were kept at -20°C until they were sent for processing.

In both tests, a standard scene was photographed at various exposure levels so that qualitative assessment could be made of any changes resulting from the various storage conditions. The scene contained objects of spectrally pure green and red colouring, and a healthy geranium plant as an infra-red reflecting subject. A sensitometric wedge was exposed on each film, with a sensitometer conforming to BS:1380:1974. A Wratten 12 filter was added to the optical path of the sensitometer, and to the camera lens, to absorb radiation below 500 nm.

The films were processed in a Kodak Versamat Processor, and the densities of the sensitometric wedges were measured with a MacBeth Quantalog TD 102 transmission densitometer. The green, red and infra-red sensitive layers of the film produce positive complementary images of yellow, magenta and cyan dyes respectively, and the optical densities were measured through blue, green and red filters (Wratten 94, 93 and 92). In the graphs (Figs 2 and 3) the emulsion layers are referred to by the colour of the analysing filter in the densitometer.

The speed of each emulsion layer was determined by the method described in BS:1380:Part 2:1974, and the speed criteria plotted as a function of time stored at 30°C. The equivalent arithmetric speed can be obtained from the BS formula:-

$$\text{speed} = \frac{\text{constant}}{E_m}$$

where the constant = 10, and E_m is the speed criterion expressed in lux seconds.

The results of the first experiment (Fig 1) with all three films indicate that a slight loss of speed occurred in the infra-red sensitive layer when the films were kept for 2 days at 30°C before exposure, but that further storage for 2 days at 30°C after exposure caused no significant changes. The control wedge for film 'B' was unfortunately slightly fogged, and the points plotted for the 0 day condition are of doubtful accuracy. It is thought that they should be similar to the values obtained with film 'C' for the same condition. The graphs show an apparent increase in the speed of the green sensitive layer (labelled B) of films 'B' and 'C' relative to film 'A'. It is probable that this merely reflects the batch to batch variation of the manufacturing process, and since the dye used to sensitize the green layer is least affected by storage conditions it provides a useful reference for evaluating the speeds of the other layers. The manufacturer endeavours to maintain consistency in overall film speed for successive batches, but the first priority is to match the speeds of the three emulsions so that the colour balance is within tolerance. If one assumes that film 'A', being fresh stock, is typical of the relative speeds of the three layers, then for film 'C' the infra-red layer (R) has lost nearly 0.1 log E units in speed for the control wedge, and 0.15 log E units after 2 days storage at 30°C. In Fig 3 the results of films 'B' and 'C' have been normalized to the 'B' (blue) speed of film 'A'.

The results of the second experiment are shown in Fig 4: the disparity in relative speeds of the three emulsion layers between the two experiments is almost certainly due to processing variations. Before the films from the second experiment were processed, the developing machine was given routine servicing and new processing solutions were prepared. This serves to demonstrate the importance of consistent processing if variations in effective emulsion speed are to be avoided. Storage for 14 days at 30°C particularly affected the infra-red sensitive layer of both films 'A' and 'C', with a speed loss of 0.1 log E units (one third of a stop) for 'A', and 0.13 log E units (nearly half a stop) for 'C'. If the results for 'C' are normalized to the green sensitive layer speed of 'A' (see Fig 5) the infra-red sensitive layer of film 'C' has lost 0.23 log E units (over two thirds of a stop) compared to its speed when new.

The transparencies of the standard reflected the sensitometric results - the red image being slightly under exposed relative to the green and blue images, in films 'B' and 'C' and in those films which had been stored for 14 days at 30°C. In all cases, analysis was perfectly feasible, and it was only comparison with results on fresh stock that revealed how the infra-red sensitivity had deteriorated.

2 CONCLUSIONS

Limited tests with Ektachrome IR film have shown that for optimum performance it should be stored at about -20°C until required, and it should be used before its expiry date. However, film kept at 4°C for up to one year may retain sufficient sensitivity in the infra-red sensitive layer for qualitative investigations of infra-red reflectance and could be used in emergencies, but it is suggested that the exposure should be increased by a half stop to compensate for loss of speed.

Considerable variations in results may occur with different emulsion batches and with faulty processing chemistry or techniques, and it is recommended that film from the same batch is used throughout any experiment, and that control wedges are processed with each film to monitor processing chemistry.

REFERENCES

No	Author	Title, etc
1	Eastman Kodak Co	Kodak Ektachrome Infra-red film leaflet number KP62870d, 1-76
2	Eastman Kodak Co	Kodak Aerochrome Infra-red film 2443 Aerial data. Kodak publication M-69

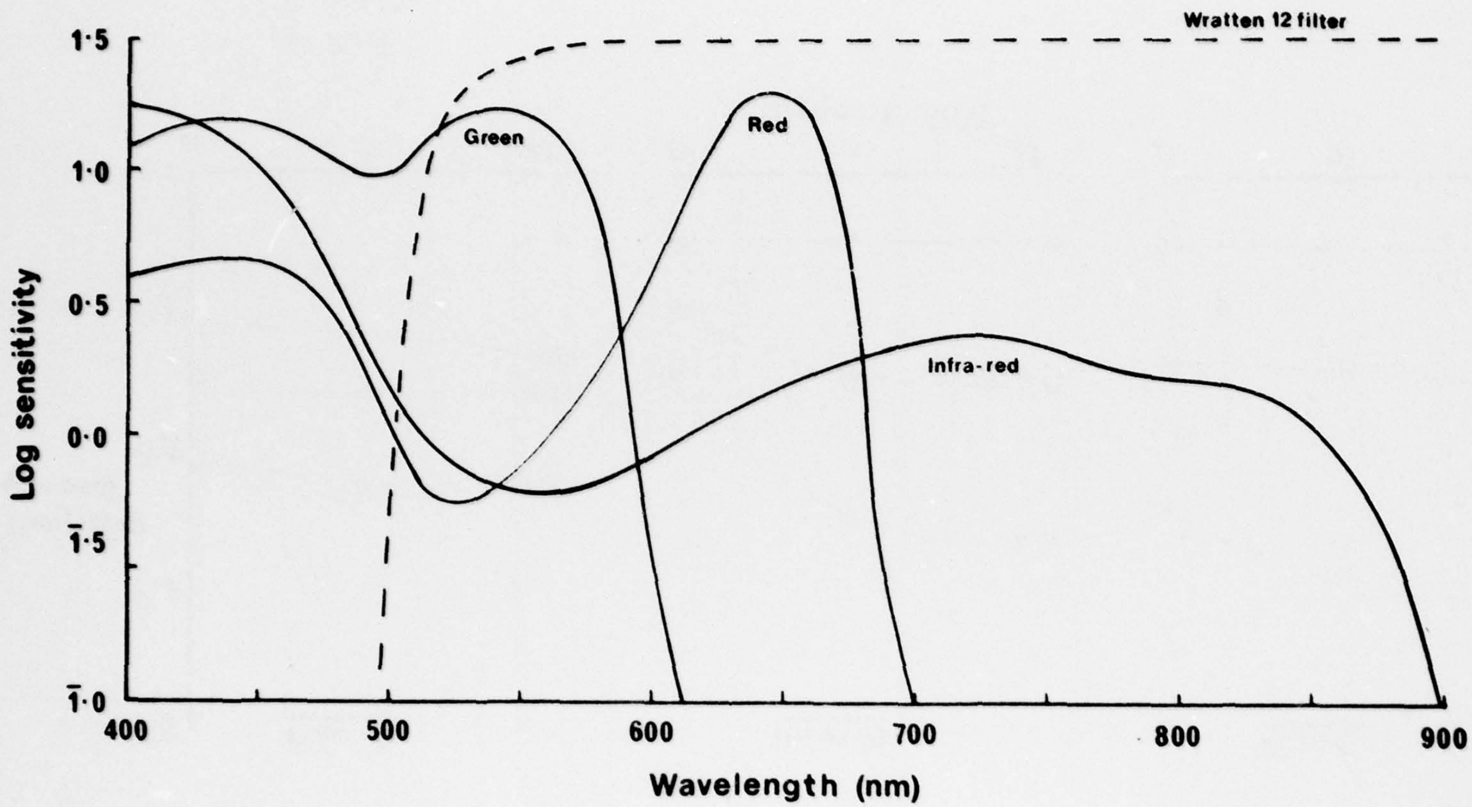


Fig 1 Spectral sensitivity curve for Ektachrome IR film

Fig 2

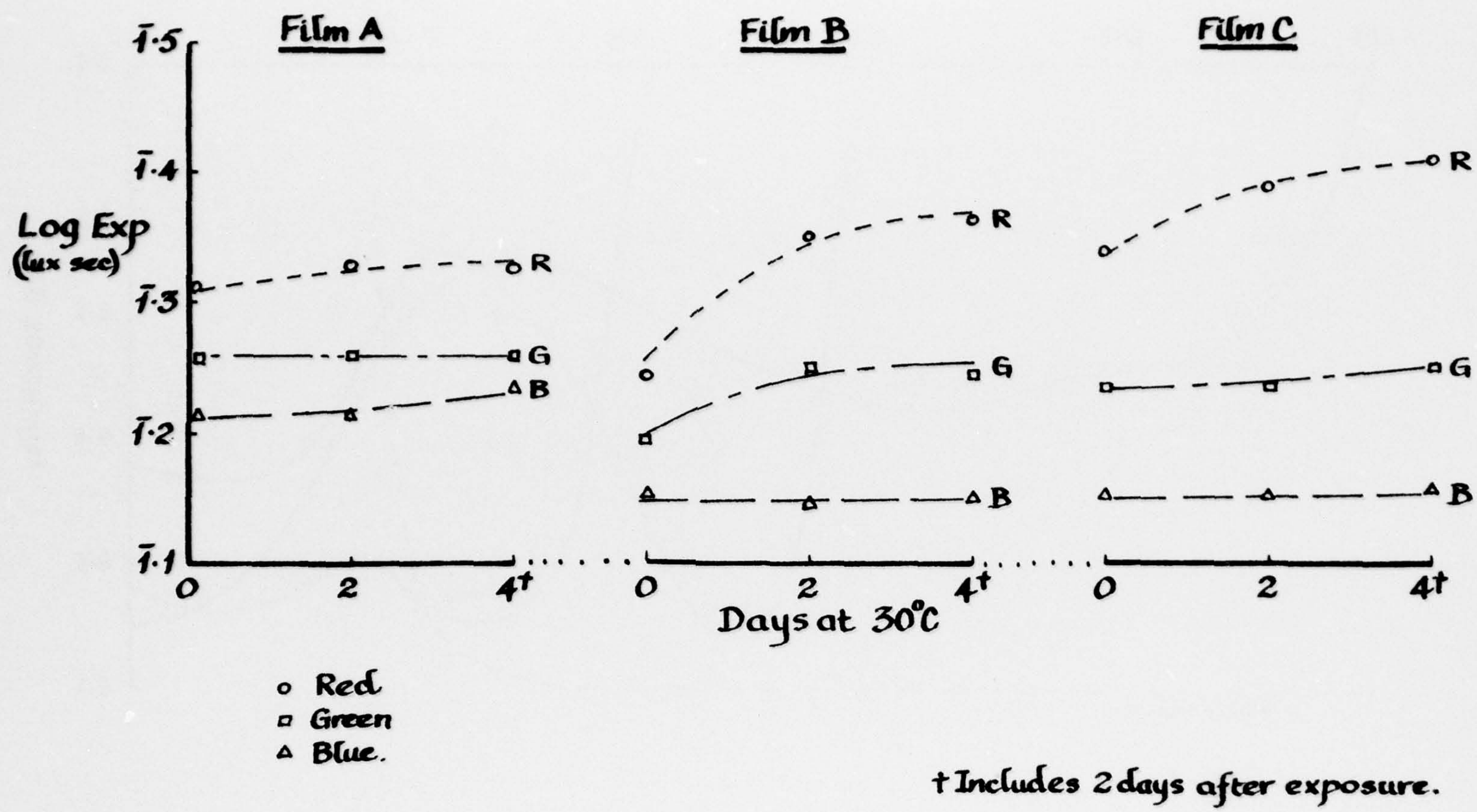


Fig 2 Test 1. Graph of speed/time stored at 30°C

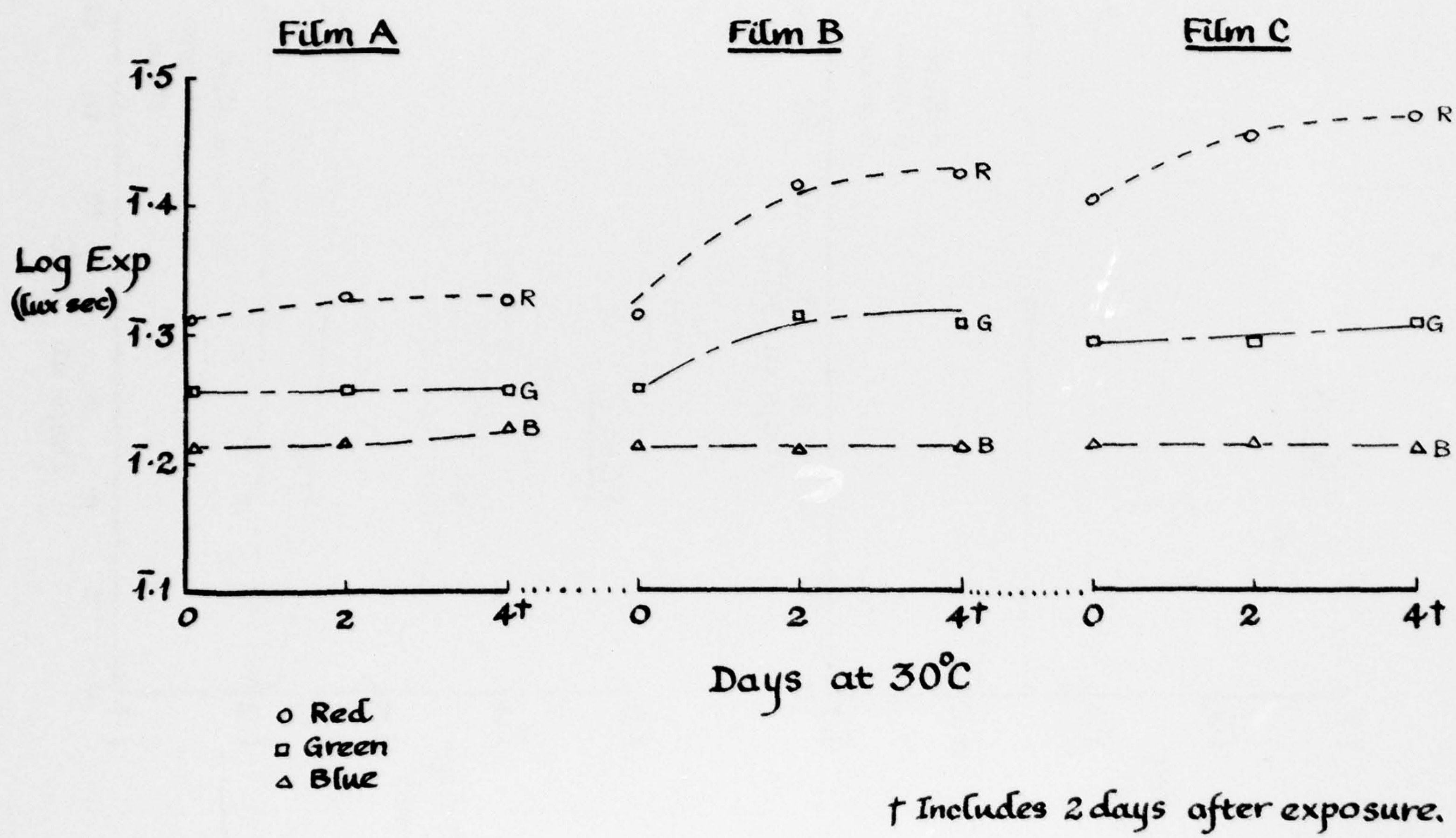
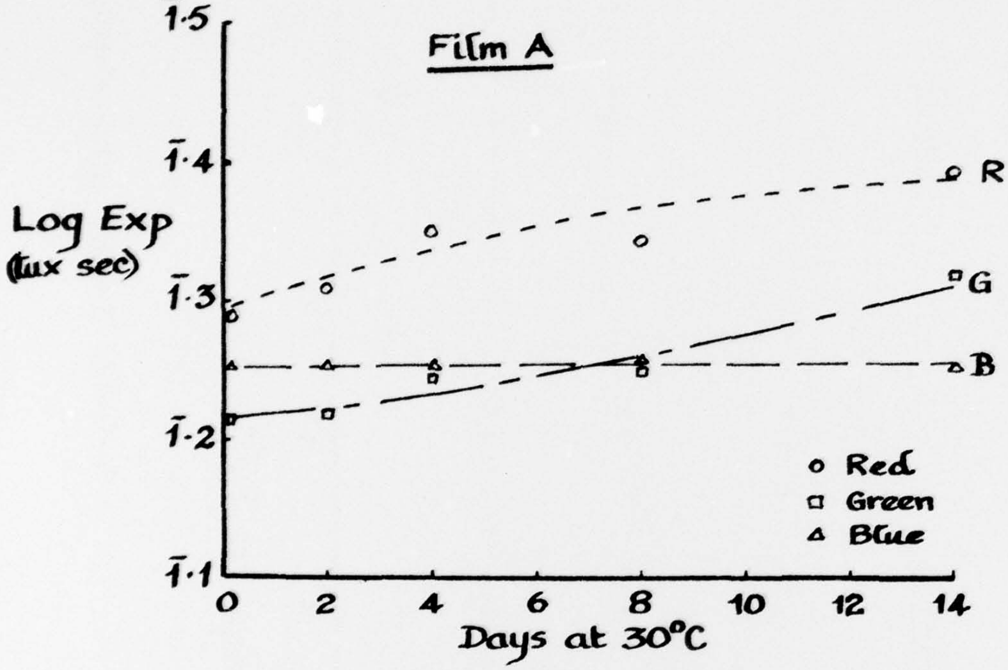


Fig 3 Test. Graph of speed/time stored at 30°C, normalized to film 'A'

Fig 4



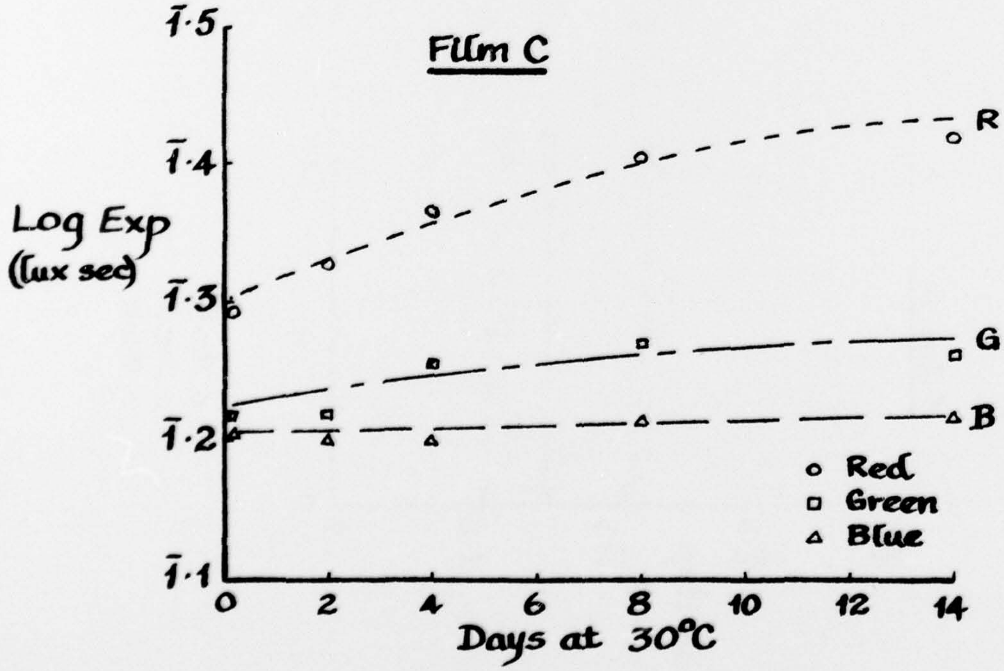
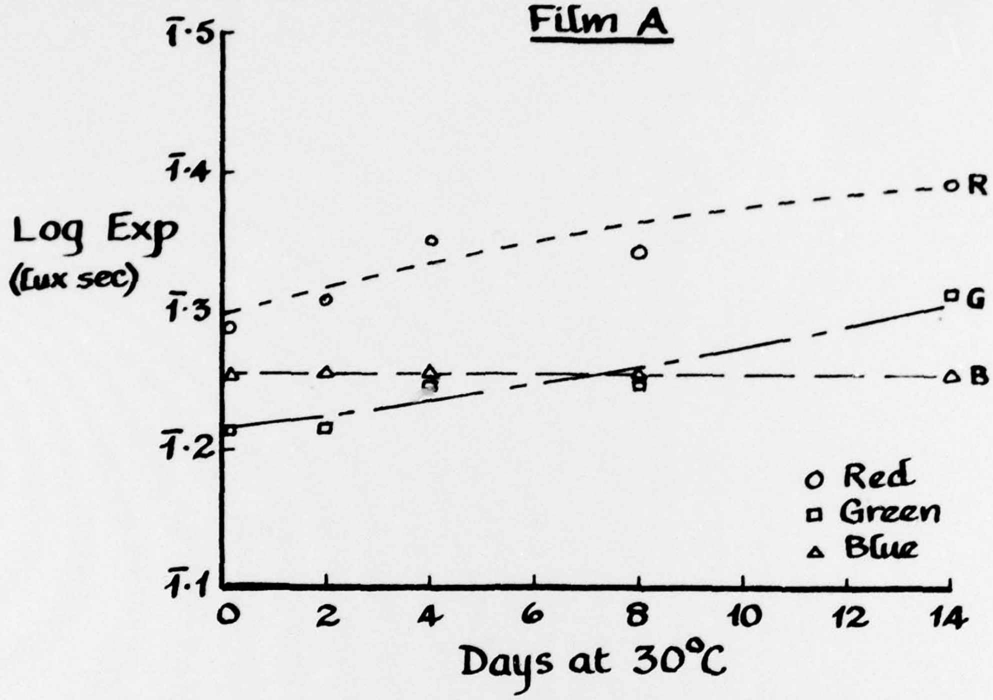


Fig 4 Test 2. Graph of speed/time stored at 30°C



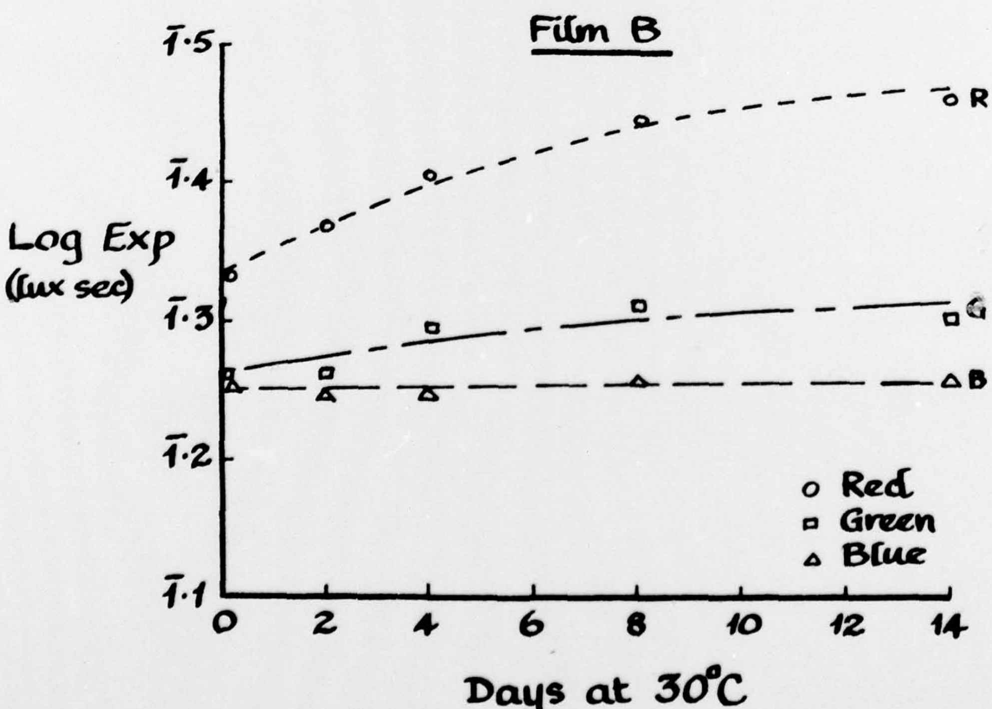


Fig 5 Test 2. Graph of speed/time stored at 30°C, normalized to film 'A'

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17. Abstract

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