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

THE MINIMUM INTENSITY FOR THE SPONTANEOUS IGNITION OF CELLULOSIC MATERIALS

by

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Summary

Some previous notes on factors which affect the ignition of materials by radiation have mentioned their effect on the minimum intensity of radiation at which ignition occurred. The experimental data is summarised in this note and a qualitative explanation for the effects is given in terms of the loss in volatile content of the solid.

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1. Introduction

The spontaneous ignition of cellulosic materials by radiation may be predicted [1] by assuming that it occurs when the surface or for thin materials when the mean temperature reaches 525°C. However, this temperature must be attained within the range 1–100 seconds, otherwise ignition does not occur at all. Thus, although theoretically there is a critical intensity of radiation [2] which just raises the temperature to 525°C after an infinite time, ignition occurs only if the intensity of irradiation exceeds a certain minimum intensity and this minimum intensity varies with certain conditions.

2. Discussion

A criterion for ignition based on temperature neglects such aspects of ignition as the limited quantity of volatiles available and the necessity of forming a flammable mixture with the air [3]. Volatiles are produced by a reaction that occurs in the temperature region 250 – 350°C [4] so that any factor tending to delay ignition at a given level of irradiation by extending the interval between the temperature at which volatiles are emitted and the temperature at which they ignite, might be expected to increase the probability of their being exhausted before the temperature reaches 525°C.

2.1. Exhaustion of volatiles

One such factor is the size of the area irradiated [5] and both the ignition time and the minimum intensity increase with decreasing size (fig. 1a–b). Another factor is the moisture content [6], and again both ignition time and the minimum intensity increase with increasing moisture content (fig. 2a–b). Another factor would be expected to be the density of the irradiated material, but the experimental evidence is insufficient to confirm any increase of minimum intensity, although the failure to ignite iroko (chlorophora excelsa) in some experiments reported earlier [2] may be due to its high density.

Although the absorptivity does affect the ignition time [7], the minimum intensity does not appear to change significantly. A material with low absorptivity absorbs little of the incident radiation until charring begins, when its absorptivity and therefore the energy absorbed increases rapidly. As charring and the emission of volatiles may be assumed to occur at or about the same temperature, there should have been little loss of volatile before charring occurs. Afterwards there is effectively no difference between the blackened and unblackened material and corresponding there should not be any significant differences in their minimum intensities or irradiation.

Again, although prolonged heating at high temperatures has little effect on the ignition time, the minimum intensity increases [8], (fig. 3). This is a function of the loss in weight of the specimens (fig. 3) which is largely a loss of volatile materials but as long as the minimum quantity of volatiles remains the ignition time is unaffected.

2.3. Formation of a flammable mixture

The results in Fig. 1 were obtained in conditions in which there was an external draught of about 25 cm/s. Where there is no draught the ignition time is unaltered, but the minimum intensity is raised to about 2. cal cm^{-2}s^{-1}. Ignition is known to occur first in the volatile stream and it is presumed the effect of the draught is simply to improve mixing with the air by hastening the onset of turbulence.

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References

1. Simms, D. L. Correlation of ignition time with the physical properties of materials: Part 1, Spontaneous ignition of cellulosic materials. Joint Fire Research Organization, F. R. Note No. 319/1958.

2. Lawson, D. I. and Simms, D. L. The ignition of wood by radiation. Brit. J. App. Phys. 3, 288-92, 1951.

3. Simms, D. L. The effect of external draughts on the ignition of materials by radiation. Joint Fire Research Organization. F.R. Note No. 305/1957.

4. Bunbury, H. M. The destructive distillation of wood, London, Benn Bros. 1923.

5. Simms, D. L., Law, Margaret, Hinkley, P. L. and Pickard, R. W. The effect of irradiated area on the spontaneous ignition of materials: Part 1, The effect on ignition time. Joint Fire Research Organization, F.R. Note No. 307/1957.

6. Thomas, P. H., Simms, D. L. and Law, Margaret. The effect of moisture content on the ignition of wood by radiation. Joint Fire Research Organization, F.R. Note No. 280/1956.

7. Simms, D. L., Law, Margaret and Hinkley, P. L. The effect of absorptivity on the ignition of materials by radiation. Joint Fire Research Organization F.R. Note No. 308/1957.

8. Simms, D. L., Roberts, Valerie E. and Cook, Constance J. The effect of prolonged heating on the spontaneous ignition of wood. Joint Fire Research Organization, F.R. Note (in preparation)

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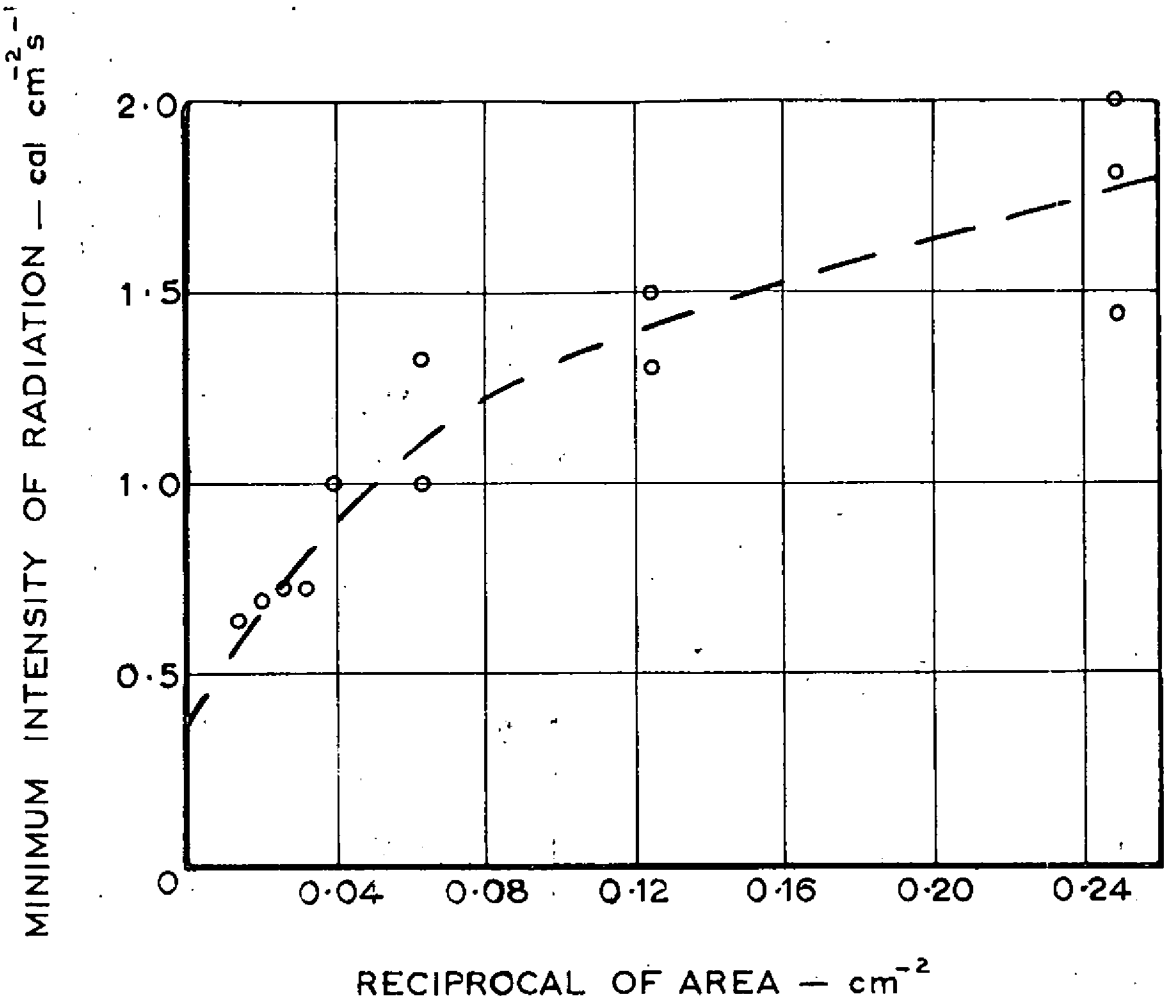

FIG. 1a. THE AREA EFFECT FOR WHITE COTTON

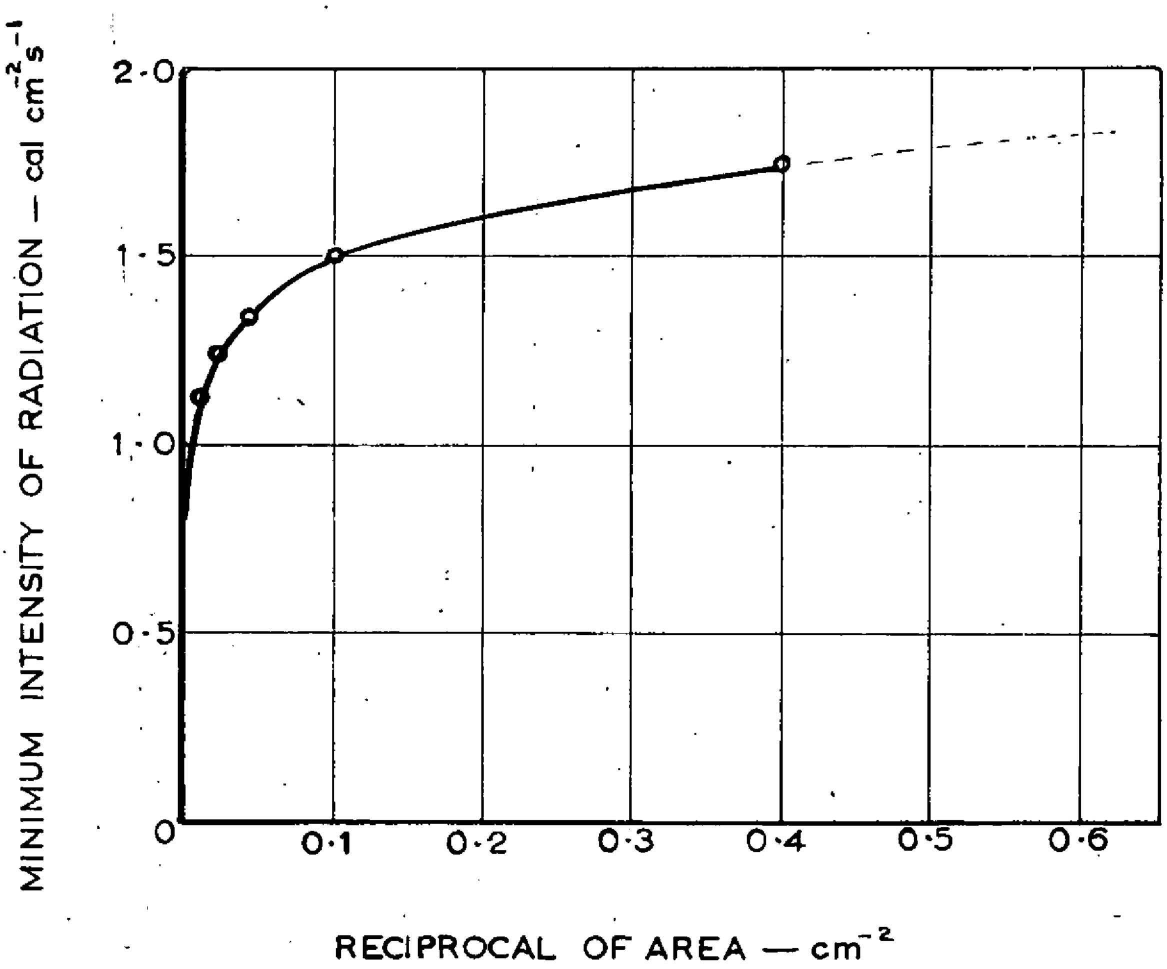

FIG. 1b. THE AREA EFFECT FOR FIBRE INSULATION BOARD

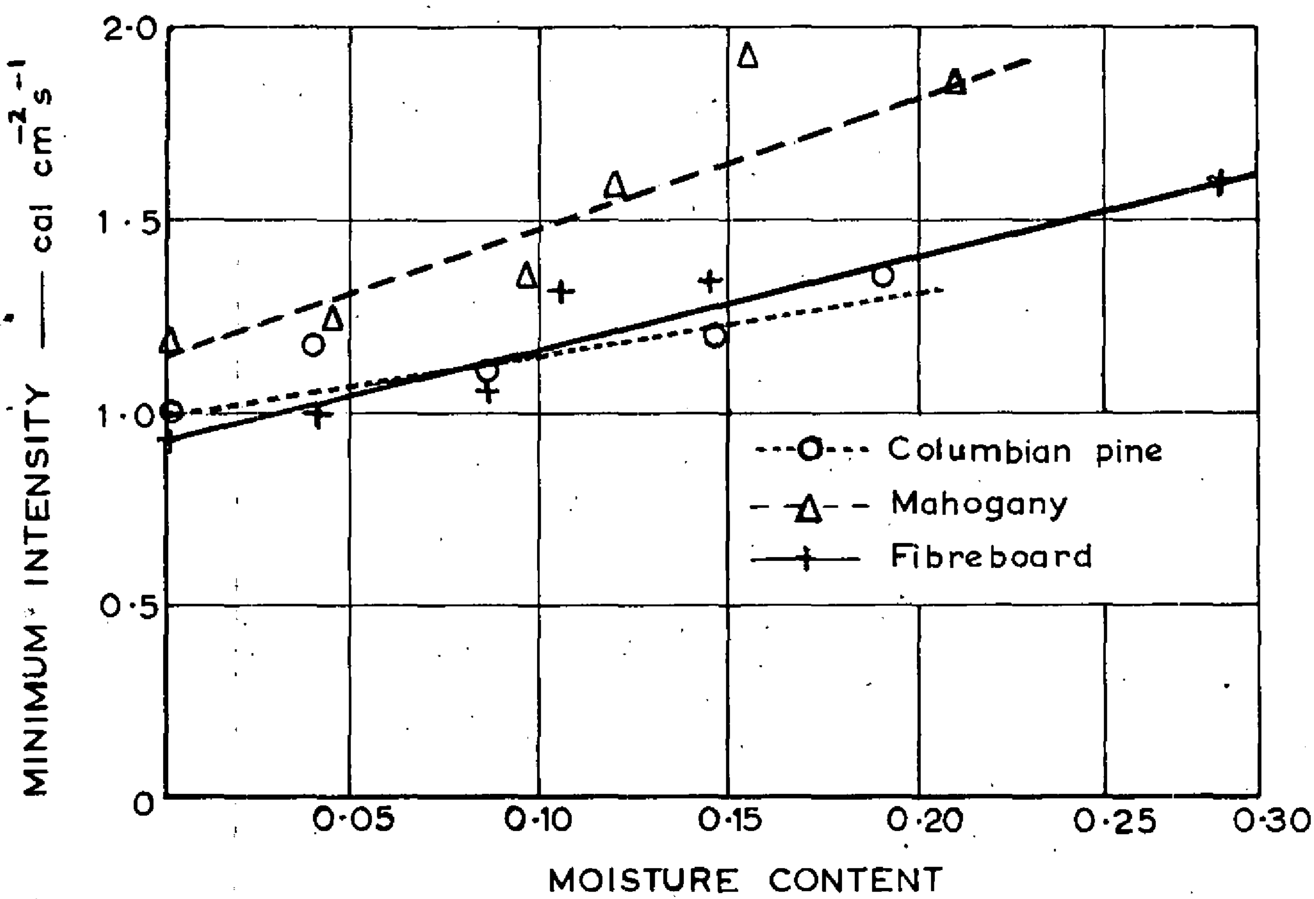

FIG.2a. EFFECT OF MOISTURE CONTENT ON MINIMUM INTENSITY FOR IGNITION

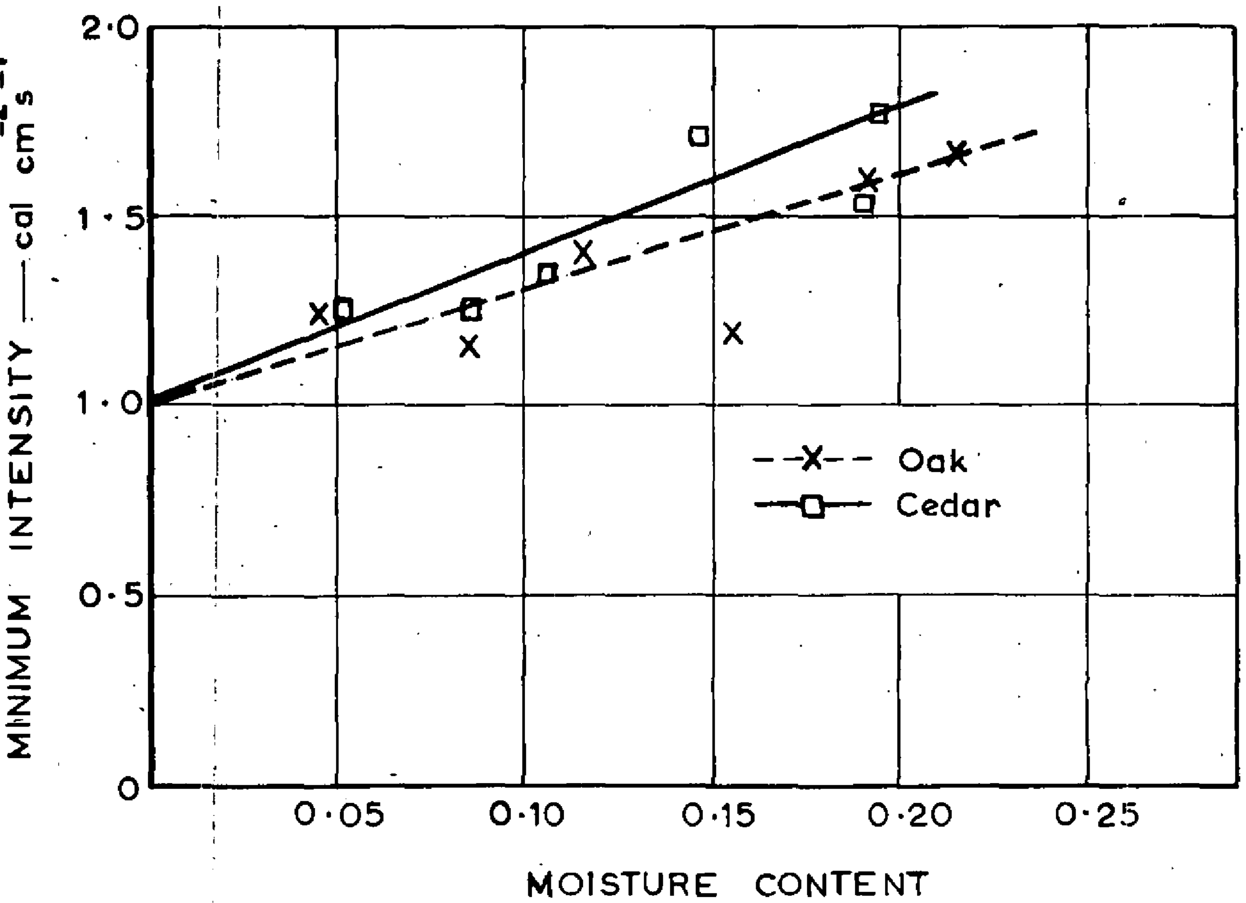

FIG.2b. EFFECT OF MOISTURE CONTENT ON MINIMUM INTENSITY FOR IGNITION

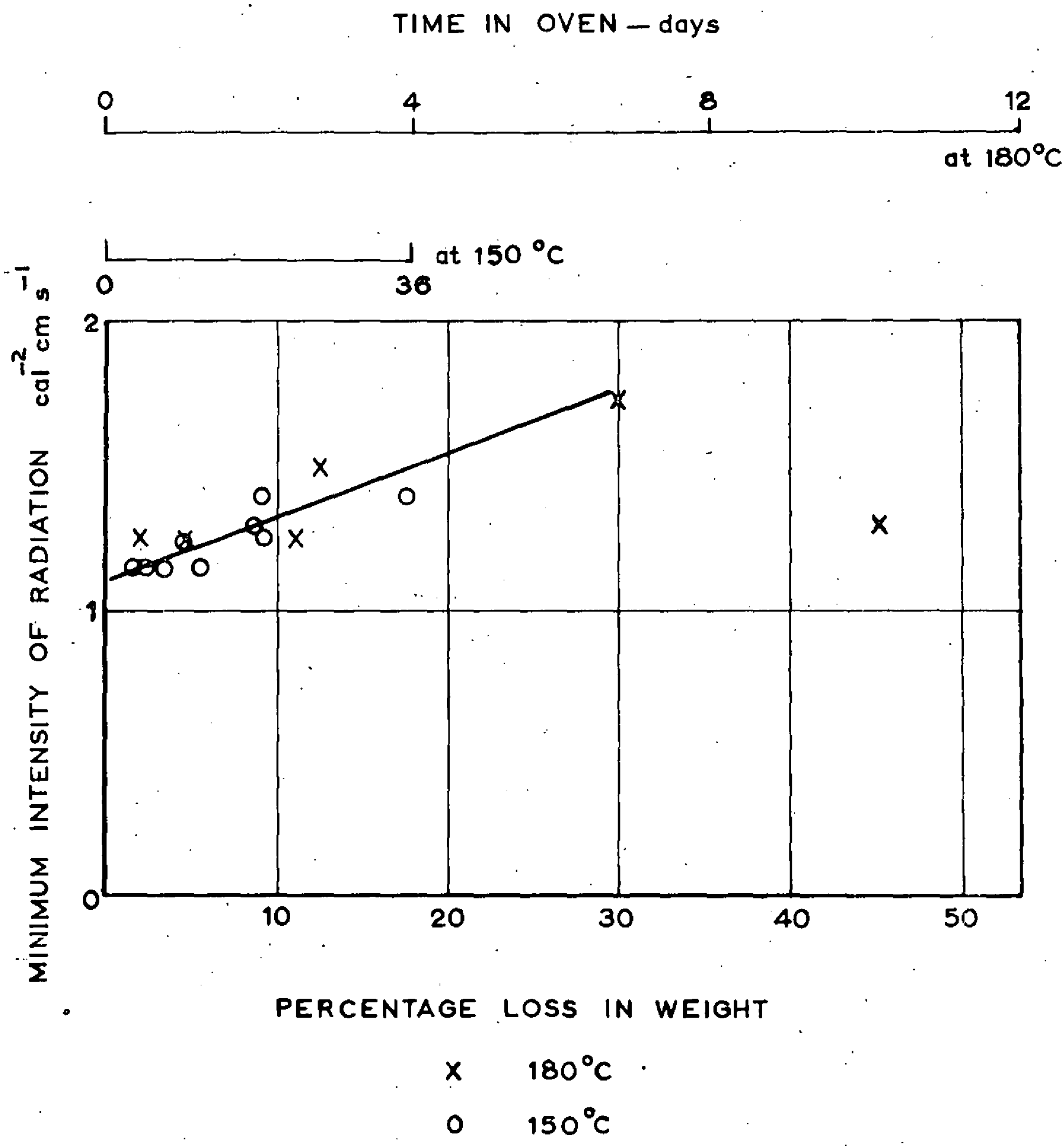

FIG. 3. EFFECT OF PROLONGED HEATING