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THE EFFECT OF CRIB POROSITY IN RECENT CIB EXPERIMENTS

by

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SUMMARY

Some of the data obtained in the CIB programme on fully developed fires refer to fires controlled by crib porosity. An approximate criterion, based on Nilsson's experiments is suggested for identifying them and so excluding them from general correlations based on fuel surface area and compartment properties.

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JOINT FIRE RESEARCH ORGANIZATION

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INTRODUCTION

As a result of a detailed study of Nilsson's[1] data for the burning of crib fires in compartments, Thomas and Nilsson[2] have suggested that they lie in three regimes of behaviour. These may be provisionally described by Table 1.

Table 1

Regimes of burning

Regime	Approximate formulae
Crib porosity controls	$m'' = k_1 \left[h_c A_v/A_s\right]^{1/2}$
Wood surface controls	$m'' = k_2\, b^{-1/2}$
Compartment window controls	$m'' = k_3\, A_w H_w^{1/2}/A_s$

Approximate values for k_1 k_2 and k_3 in kg m s units are 0.09, 1.2×10^{-3} and 0.09 respectively. For each of these regimes certain dimensional quantities are implicit in the above relations and these involve physical chemical properties of the fuel but their role is not fully understood.

The use of the $\frac{1}{2}$ power of $1/b$ is approximate but convenient. Various values in the range 0.5–0.7 appear in the literature.

On the basis of Table 1 we may construct Fig.1 where the equation for the line separating two regimes is obtained by equating the respective expressions for m'' given in Table 1. The term $b h_c A_v/A_s$ is approximately $\left[b h_c a_v/a_s\right]/(1 + b/2s)$ which may be written $s b/(1 + b/2s)$. Thus the value of $s b$ is effectively a first approximation for the transition between the two crib regimes. On the basis of

Nilsson's data (for which b was exclusively 25 mm) a provisional value of the critical $(sb)^{\frac{1}{2}}$ may be taken as 25–30 mm. A power value is appropriate for low values of $A_w H_w^{1/2}/A_s$ and the critical condition for window control is then

$$\left(h_c A_v/A_s\right)^{1/2} > \frac{k_3}{k_1} \frac{A_w H_w^{1/2}}{A_s}$$

from which, with the above values of k_1 and k_3

$$s > 4\left(\frac{A_w}{A_s}\right)^2 H_w$$

Using rather more precise but more complicated regression equations than those given in Table 1 Thomas and Nilsson[2] derived, as a first approximation, a critical s condition of the same form but with a numerical value about twice as large.

Table 2 shows the values of s and b for the various experimental configurations used in the recent CIB programme[3]. The design of the cribs and their position in relation to the floor and walls were not the same as in Nilsson's experiments and a direct comparison is not strictly permissible but Table 2 should be a useful guide.

Table 2

Experimental conditions in CIB programme[3]

Fuel thickness b mm	Spacing ratio s/b	$(sb)^{1/2}$ mm	Probable controlling factor
10	3	17	Crib porosity controlled unless $\frac{A_w H_w^{1/2}}{A_s}$ is sufficiently small
20	$\frac{1}{3}$	11	
	1	20	
	3	34	Window or surface control
40	1	40	

Analysis of the CIB data showed that stick size as such was not a major variable but that the stick spacing ratio was. Most of the data, however, were for 20 mm sticks so that data for the largest s/b (strictly including those for 10 mm sticks) may be taken as representative of cribs not controlled by the spacing.

A closer examination of the effective duration t_f as calculated by Law[4] in Table 1 of Fire Research Note 877 shows that the distinction is not strictly between $\frac{1}{3}$, 1 and 3 spacing. It is better, though less simply described as between

$(2,\frac{1}{3})$ data (ie 20 mm sticks with s/b as $\frac{1}{3}$) in one group having the highest t_f, the (2.1) data having an intermediate t_f and a group having the least t_f which includes not only the (1.3) and the (2.3) data but also the (4.1) data which are better accommodated with these than with the (2.1) data. This means that the (4.1) data which according to Table 2 have values of $(sb)^{\frac{1}{2}}$ sufficiently high for the cribs to be uninfluenced by porosity can in fact be so regarded.

Hence, what has been given as the 3-spacing correlation for t_f in previous reports, can in fact include the (4.1) data. It is suggested that this correlation be taken as representative of wood fires which are essentially independent of fuel bed design.

NOTATION

a_v $(= s^2)$	area of cross section of vertical shaft of crib
a_s $(= 4sh_c)$	nominal projected surface area of shaft
A_v	total cross section of vertical shafts
A_s	total surface area of fuel
A_w	window area
b	stick thickness
h_c	crib height
H_w	window height
k_2, k_1, k_3	constants
m''	mass burning rate per unit fuel surface area $(= R/A_s)$
R	mass fuel burning rate
s	horizontal spacing between sticks in crib
$(2, 1/3)$....	gives the relevant values of b (in cm) and s/b as $(b, s/b)$

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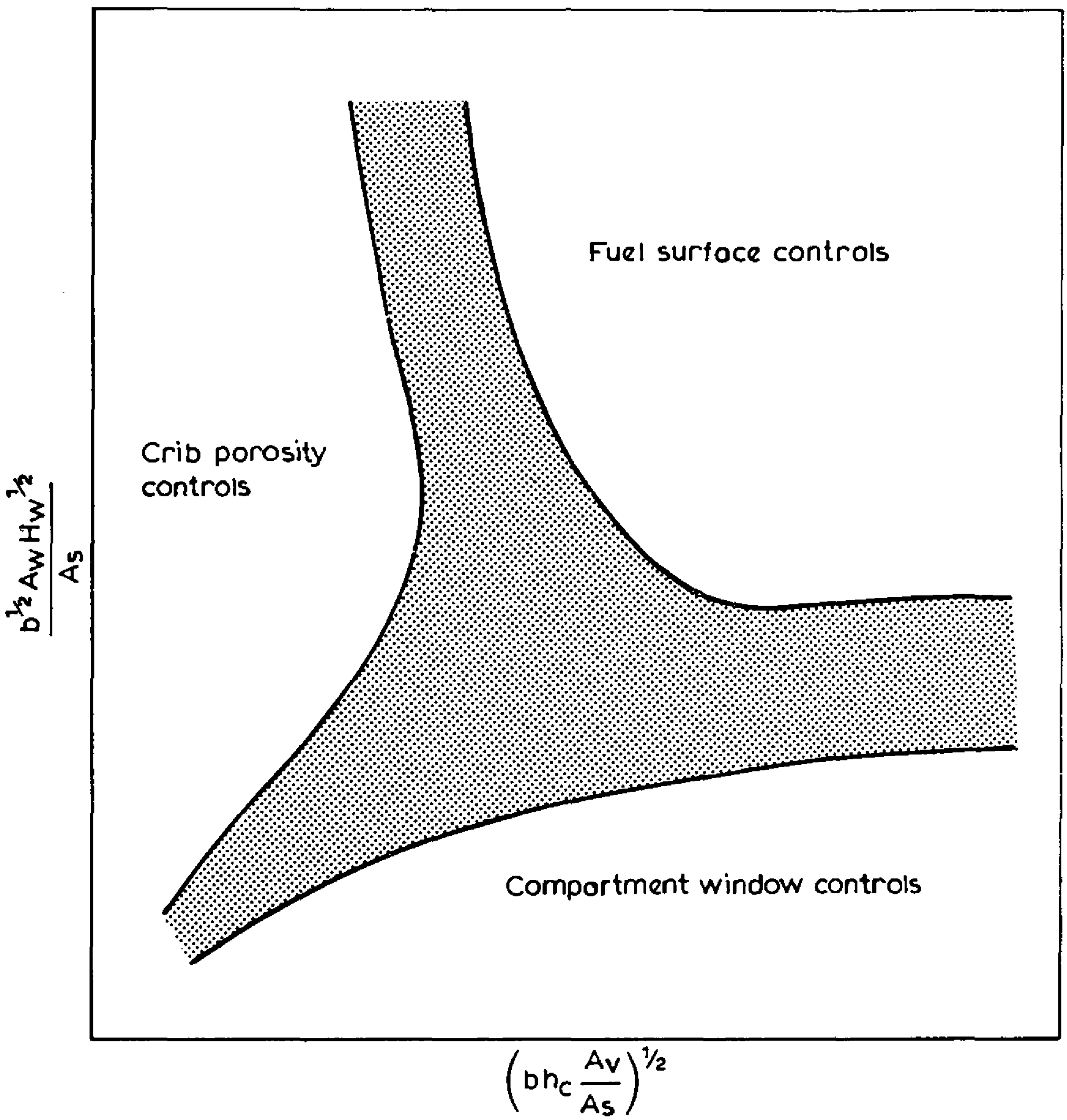

Figure 1 Diagrammatic representation of regimes