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THE CHANCE OF AN OUTBREAK OF FIRE
AND THE LIKELIHOOD OF LARGE FIRES IN
VARIOUS OCCUPANCIES

by

R. BALDWIN

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SUMMARY

Published statistics from various sources are brought together in this
paper to evaluate the chance of an outbreak of fire in different occupancies,
and the chance that a fire becomes large. Yearly variations in these data are
used to measure the effectiveness of fire prevention and fire protection in
these occupancies. They suggest that increasing annual fire losses are due in
the Manufacturing Industries mainly to an increase in the number of outbreaks
of fire, and in the Distributive Trades mainly to an increase in the cost of
individual fires.

KEY WORDS: Fire prevention, Fire protection, Large fire loss, Probability

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Introduction

This paper uses published statistics from various sources to estimate two
important parameters for buildings and industries, namely the chance of an
outbreak of fire and the chance that an outbreak becomes large. The first of
these is a measure of the extent to which potential sources of ignition have
been recognised and removed, (fire prevention) and the second is a measure of
the effectiveness of fire protection and fire fighting. The object of the
present paper is to calculate these probabilities for various occupancies,
firstly to compare the relative hazards of different occupancies, and secondly
by examination of year to year changes in the probabilities to give an indication
of significant trends.

Of course, many other factors can have an effect on either probability:
for example the size of a building, the nature and volume of its contents and
the degree of industry taking place will clearly have an influence on both.
However, information is not available on most of these factors and many of them
are characteristic of the occupancy itself. A detailed examination of all factors
involved is outside the scope of the present preliminary investigation.

So far as large fires are concerned the greatest difficulty lies in a
suitable definition of size. Measures currently in use include the spread of
fire up to and beyond some physical barrier such as the room or floor of origin,
the number of jets, or the value of the fire loss. There is no physical criterion
to single out one measure as better than another, but for the purposes of this
paper the direct fire loss will be of greatest utility.

Sources of data

The frequency of fire in different occupancies is given in the annual U.K.
Fire Statistics[1], assembled from the collected statistics of fires attended by
the fire brigades. The number of buildings or establishments can be obtained
from two sources: the number of buildings in different broad occupancy groups
are available from rating information[2], whilst the number of establishments
employing 10 or more people in various industries is given by the Ministry
of Labour[3]. These data have their limitations:

a) The rating information is available yearly, but the system of classification of occupancy is not the Standard Industrial Classification used in the other sources of data described above, and hence the data are not based strictly on the same population. For this reason, although year-to-year data are available from this source, their use for comparisons of yearly variation is not justified.

b) The number of establishments includes only establishments employing more than 10 people, and many of these have more than one building. The numbers at risk obtained from the two sources are thus not comparable. This data is only available for 1961.

In view of these limitations these data may only be used in drawing very broad conclusions, for comparing the hazards in different industries in situations in which no ambiguities can arise, but these reservations, should be kept in mind.

The probabilities are not hard to estimate given adequate sources of data (these are discussed below). The chance of an outbreak of fire is here the frequency of outbreaks divided by the total number of units (buildings or establishments) at risk, whilst the chance of a fire becoming large is the frequency of large fires divided by the frequency of outbreaks of fire. These estimates are only relative because they are based only on fires large enough to call the brigade and approximate because in some establishments many outbreaks are experienced in one year, but they are sufficient for the purposes of this paper.

The most readily available statistics on large fires are those obtained from insurance sources and published annually (from 1962) by the Fire Protection Association[4], giving details of fires in which the loss exceeded £10,000. This is an arbitrary lower limit, and furthermore, owing to the decreasing value of money, one which yearly broadens the basis of the population. Any significant trends in large fire statistics would have to be corrected before any firm conclusions could be drawn. Such corrections as have so far been made have no marked effect on the main conclusions.

Calculation of probabilities

The probability of an outbreak of fire per year and the probability of a fire loss exceeding £10,000 have been calculated using the sources of data described above, and the results are tabulated in Tables 1, 2 and 3. Table 1 gives the probability of fire per building, using rating information, whilst Table 2 gives the same probabilities for different industries based on Ministry of Labour estimates of numbers of establishments. In Table 3 it is possible to give yearly figures for probabilities of large fires, but as discussed above,

this is not possible for the chances of outbreaks of fire. However, the frequency of outbreaks of fire is given in Table 4, and will be sufficient for the purposes of year to year comparisons made below. As discussed above the two sets of data on numbers at risk are not collected on the same basis, and this should be kept in mind in comparing these figures. However, within each table the basis of the data is consistent and no ambiguity arises in comparison of different occupancies.

Discussion

The wide variation in the hazard of different occupancies is demonstrated by Table 1, showing that the chance of an outbreak of fire in an industrial building is at least an order of magnitude greater than that in other occupancies. The chance of fire in buildings occupied by Distributive Trades is only about three times as great as the chance of fire in Residential houses. Closer examination of the Manufacturing Industries using Table 2 reveals that there is also wide variation between the fire hazard of different industries, ranging from the 20 per cent chance of fire in establishments in the Chemical and Allied industries to 4.2 per cent in the Leather, Clothing and Footwear industries.

The chance of a fire growing large, exceeding £10,000 loss, shows rather less variation with occupancy (Table 3). Furthermore comparison of Tables 1 and 2 and Table 3 reveals no strong correlations between the two lists, so that the chance of a fire occurring in any particular occupancy bears little relationship to the chance of the fire spreading to become large. These two probabilities thus represent two independent characteristics of an occupancy; the one reflecting the propensity for a fire to occur, the other the propensity for a fire to spread. One probability measured the extent to which potential sources of ignition have been removed, or fire prevention, and the other the effectiveness of fire protection and fire fighting.

We now examine the yearly variations in the hazards of different occupancies. During the period covered by this note there has been a large increase in the estimated annual direct fire loss, reflecting perhaps changing social conditions, new processes and materials, etc. These chances should also be reflected in either or both of the probabilities calculated above. The data can be more readily analysed by using the grouped frequencies for each year, based on total frequencies for all Industry and for all Distributive Trades. These are shown in Tables 5a and 5b, and an examination of the frequency of fire and the chance of a fire becoming large indicates the following:

1) In the Manufacturing Industries there is strong evidence of a sharp increase in the number of outbreaks of fire over the 5 year period (the number of fires in 1966 is 15 per cent higher than in 1962).
However, there is no systematic trend in the chance of a fire becoming large, which has remained fairly constant over the period. On the assumption that the chance of fire remains constant, this data yields a value of χ^2 of 6.3 with 4 degrees of freedom, which is not significant, so the differences that do occur could well happen by chance.
Tables 3 and 4 show that these trends are features of most industries: all, except Food, drink and tobacco, Clothing and footwear, and Ship-building, show an increasing frequency of fire, and there are no strong trends in the chance of a fire becoming large, although there is some indication of a decreasing chance of a large fire im the Textile industry and an increase in Clothing and footwear and in the category marked 'Other'.

2) In the Distributive Trades, the situation is reversed. There is no evidence of an increasing frequency of fire, which is effectively constant over the period ($\chi^2 = 3.4$), but there is very strong evidence of an increasing trend in the chance of a fire becoming large. This trend exists even after correction for the decreasing value of money: the 1965 and 1966 figures then become 25 per cent and 30 per cent respectively. Thus the chance of a fire becoming large has doubled in the fire year period.

Table 3 and Table 4 give more information on these trends. The increase in the chance of a fire becoming large is common to all occupancies in the Distributive Trades, but most of all in the Whole-sale trade. In Wholesale and Other distributive trades, there is also an indication of increasing frequency of fire (the 1962 figures are not available individually).

The interpretation of the results described in this paper is quite plain. In the Manufacturing Industries, there has been a sharp increase in the number of fires, but there is no evidence that individual fires are costing any more. It seems likely that the increase in annual fire loss due to this occupancy, which accounts for nearly $\frac{2}{3}$ the total fire loss, is simply because there are far more fires.

This implies that fire protection and fire fighting are, on the average, holding their own in industry; fire prevention is not. An exception to this is the occupancy marked 'Other', in which the severity of fire is increasing.

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In the Distributive Trades, although there is a slight tendency for increasing fire frequency, it appears that fire prevention is holding its own, but fire protection and fire fighting have been outstripped, particularly in warehouses where the chance of a large fire has doubled since 1963. The increasing annual fire loss here (about 20 per cent of the total), is most likely due to an increase in the proportion of large fires, indicating that fires are becoming more severe, or that there is an increasing concentration of value in shops and warehouses.

It is worth noting that in the category marked 'Other' there is an upward trend in the chance of a large fire. This category will include miscellaneous occupancies falling outside the conventional classification but it may also be expected to include new industries and it is possible that it shows an increasing frequency of large fires because rational fire protective measures are not yet being taken.

Conclusions

1. In the Manufacturing Industries there is, in general, a sharp increase in the annual number of fires from 1962-1966, but the chance of a fire becoming large has remained constant. This implies that fire prevention is becoming less effective, but that fire protection is no less effective. It also implies that, in this occupancy at least, the principal cause of increasing fire losses is probably the increasing number of fires.

2. In the Distributive Trades the annual number of fires has remained fairly constant, but the chance of a fire becoming large has increased considerably. This implies that fire prevention is no less effective, but that fire protection has become less effective, and that the principal cause of increasing fire losses in this occupancy is the increasing size or cost of individual fires.

REFERENCES

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3. Annual Abstract of Statistics No. 104.

4. Fire Protection Association Journal 62 (1964), 67 (1965), 72 (1966),
    75 (1967),78 (1968).

Table 1

Probability of a fire per building in 1962

Occupancy	Probability of fire per building per year
	per cent
Industry	7.1
Distributive Trades	
– Retail	0.63
– Wholesale	0.55
Offices	0.16
Residential Houses	0.20

Sources: U.K. Fire Statistics, 1962
105th Report of the Commissioners
of H.M. Revenue.

Table 2

The chance of an outbreak of fire per establishment for different industries in 1962

Industry	Chance of fire per establishment per year
	per cent
Food, drink, tobacco	9.7
Chemicals and allied industries	20.2
Metal, Engineering, and electrical, metal goods	9.9
Shipbuilding and Marine	10.9
Vehicles	14.5
Textiles	13.0
Leather, clothing and footwear	4.2
Bricks, Pottery and glass	10.1
Paper, Printing and publishing	6.6
Other (including timber and furniture)	19.9

Sources: U.K. Fire Statistics, 1962
Ministry of Labour

Table 3

The chance of a fire loss exceeding £10,000 for different occupancies

Occupancy	Chance of fire loss exceeding £10,000 per cent				
	1962	1963	1964	1965	1966
Food, drink and tobacco	5.1	6.4	6.2	8.5	5.1
Chemicals and allied industries	8.1	6.9	7.5	6.1	5.6
Metal, Metal goods, Engineering and Electrical	3.6	4.4	5.6	3.6	4.9
Shipbuilding and Marine	2.4	1.4	6.5	3.4	4.8
Vehicles	6.8	3.1	3.7	7.2	3.1
Textiles	8.0	6.3	6.0	5.7	5.6
Leather, Leather goods, Fur	14.7	7.1	21.2	5.6	6.6
Clothing and Footwear	7.7	8.5	10.2	14.1	11.0
Bricks, Pottery and Glass	4.5	4.5	6.2	2.4	3.9
Paper, Printing and Publishing	7.5	8.6	7.1	7.1	8.6
Other (including Timber and Furniture)	3.8	3.5	4.4	6.0	5.7
Distributive Trades:					
Retail	1.1	1.0	1.9	1.7	1.6
Wholesale	-	5.9	10.7	8.7	13.2
Other	-	1.9	1.7	3.0	4.8
Residential Houses	0.03	0.05	0.08	0.05	0.05

Source: U.K. Fire Statistics (Annual)
: F.P.A. Journal

Table 4

Yearly frequency of outbreaks of fire in various occupancies

Occupancy	Frequency of Fires				
	1962	1963	1964	1965	1966
Food, drink and tobacco	512	518	500	495	573
Chemicals	496	640	570	653	765
Metal, Metal goods, Engineering and Electrical	1762	1920	2284	2445	2511
Shipbuilding and Marine	82	72	92	87	83
Vehicles	280	318	300	345	383
Textiles	729	790	998	964	1050
Leather, Leather goods and fur	68	84	66	90	106
Clothing and Footwear	232	248	284	251	254
Bricks, Pottery and Glass	266	268	324	373	415
Paper, Printing and Publishing	346	394	462	420	466
Other (including Timber and Furniture)	1242	1268	1458	1396	1280
Distributive Trades:					
Retail	3644	3632	3810	3544	3625
Wholesale	}1420	442	458	520	499
Other		848	906	950	937
Residential Houses	24,274	28,182	25,782	24,970	24,466

Source: U.K. Fire Statistics (Annual)

Table 5a

Chance of a fire becoming large – Manufacturing Industries

Year	1962	1963	1964	1965	1966
Frequency of large fires	322	339	438	416	434
Frequency of fires	6010	6520	7338	7519	7886
Chance of a fire becoming large	5.4	5.2	5.9	5.5	5.5

Table 5b

Chance of a fire becoming large – Distributive Trades

Year	1962	1963	1964	1965	1966
Frequency of large fires	87	79	137	133	170
Frequency of fires	5064	4922	5174	5014	5061
Chance of a fire becoming large	1.7	1.6	2.6	2.7	3.4