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THE SURVEY OF FIRES IN BUILDINGS - THIRD REPORT
THE USE OF INFORMATION OBTAINED FROM FIRE SURVEYS

by

A. SILCOCK

January 1973

LEWIS RESEARCH CENTER
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STATION

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SUMMARY

The previous two reports in this series[1,2] gave details of the general scope of the pilot exercise and methods by which it was carried out. In addition the nature of the information obtained was illustrated by preliminary analyses of the house and industrial fires surveyed. Some brief comments on the use of the information were made.

This report indicates a method of assessing the nation wide effects of applying conclusions drawn from the results of limited numbers of surveys and considers the use of the information for specific purposes.

KEY WORDS: Building, cost-benefit, escape means, regulations, survey, fire.

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DEPARTMENT OF THE ENVIRONMENT AND FIRE OFFICES COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

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1. Introduction

The first two reports in this series[1,2] expounded the principles of fire surveying and illustrated the nature of the information obtained by preliminary analyses of the house and industrial fires surveyed during the pilot exercise. Further analyses of fires surveyed in other purpose groups will be issued. In the meantime sufficient has been accomplished to permit the following review of the role of fire surveys in fire research, the relevance of limited numbers of surveys to fire problems on the national scale and of the practical application and use of the information obtained for specific purposes.

2. The role of fire surveys in fire research

The reports issued so far have demonstrated that surveys at the fire ground can provide:

(1) a data-bank of technical information in which each fire is considered in the context of its environment and,

(2) detailed information and assessments of behaviour for the study of almost any specific fire subject.

The data-bank on its own will have a direct application to many general research purposes but in addition it will form the essential background for more specific studies. For example, there may be little point in a detailed study of structural damage unless that study can be related to data-bank information regarding the nature and circumstances of fires in which structural damage occurs and - perhaps equally important - does not occur. Thus there are two primary methods of compiling information from actual fires - by the fire brigade standard K433 report form of all fires notified and by detailed surveys at the fire ground by Fire Research Station staff. The two methods are complimentary and their separate roles should not be confused. The former provides simple basic facts about distribution and the general nature of fires and the buildings in which they occur; the latter can provide

detailed technical information and assessments of behaviour of both fires and buildings for a representative sample or selected number of fires in any chosen group.

3. The relevance of information obtained

Surveys of the nature contemplated require a works group/scientist team working in close collaboration with the fire brigade officer concerned with the particular fire. Before completing reports the 'back-up' resources of the Research Station are necessary and close liaison maintained with the Building Regulations Division and other interested bodies. Variations in the composition and size of the surveying team are possible to suit specific needs and types of fire but it is clear that only a small proportion of all fires could be surveyed by such means. Thus the results from a relatively small number of surveys must be related to the national scale. One method by which this may be achieved is by considering all available statistical information in conjunction with the broad sub-groups into which buildings can be formed. Thus:

Statistical information - Apart from K433 statistics, information of a statistical nature can be obtained from such sources as:

D.O.E.

H.M. Factory Inspectorate.

Home Office.

Local Authorities.

Department for Trade and Industry.

Trade Associations.

Market Research Organisations.

Universities.

The list is not exhaustive. Such bodies may not necessarily have all the information required in a precise statistical form and some deductions and interpretations may be necessary.

Building sub-groups - All buildings vary in some details but broad groups can be formed within which fire hazards and general fire problems will be similar. These groups are:

(a) Purpose group and sub-group (specific use).

(b) plan type including number of floors and height considerations.

(c) form of construction

Further sub-division may be necessary for specific purposes. Major differences in use and fire hazard which obviously occur in buildings within a group are largely identifiable from existing knowledge or statistics. In many cases the differences relate to specific trades, industries or to customs associated with particular geographical locations. Allowances can be made for such factors when designing a survey programme.

With the aid of the foregoing information it follows that the essential preliminary steps to the design of a survey programme for a specific purpose will be to assess:-

(1) The relative size and importance of the problem considered at the national level.

(2) The nature, location and extent of surveys considered likely to provide sufficient evidence from which conclusions might be drawn.

And, on completion of the survey programme and analysis of the results:

(3) The national effect of implementing any proposed recommendations.

4. The retrieval of information obtained from surveys

The basis of a fire survey information retrieval system is that:

(1) there should be an individual report for each fire.

(2) each report should contain a self-coding form comprising certain basic information obtained from all fires surveyed and provision for incorporating additional specific information associated with a particular programme.

(3) the information on the coded report form should be transferred to a punch-card index and to magnetic tape.

A system on the above basis will enable the preparation of analysis sheets and tables for specific purposes. The individual report files permit the study in depth of a particular subject by works group or scientific staff who can refer to a series of files of fires related to the subject in question. Some of the possibilities have been demonstrated in previous reports [1,2,3].

5. The use of the information for specific purposes

The main purposes for which survey information can be used are as follows:-

(1) The cost/effectiveness of fire protection measures.

(2) The verification and practical application of the results of scientific research programmes.

(3) The evaluation of the effectiveness of means of escape provisions.

(4) The evaluation of the effectiveness of Building Regulations.

(5) The construction of mathematical models of fires.

Former reports [1,2], gave brief discussions of some application of the results as indicated by the analyses of house and industrial fires. In the following paragraphs the above aspects are considered in detail.

5.1 The cost/effectiveness of fire protection measures

Little information is available to permit 'in depth' studies of cost/effectiveness of fire protection measures. However, in current research programmes the Station has carried out statistical exercises to establish:

(1) the probability of large fire loss for various trades and industries and,

(2) the main factors influencing large losses such as size of compartment, type of construction, failure to provide detectors and so forth.

This work is based upon K433 statistics and other statistical information available from various trades, official and semi-official sources. Such exercises may ultimately determine the general manner in which losses in a particular trade or industry might be reduced by indicating features which are associated with its large fires. However, the method is limited by the information available to it: it does not follow that the identification of an important feature affecting loss means it is possible to state precisely why the feature is important or what remedial measures are required. Statistics alone may show a national trend but will not solve cost/effectiveness problems at the national or individual firm level. If, for example, a certain form of construction proved to be a factor in the large fires of a particular trade the

questions then posed would be - Why is this so and what are the feasible remedies? The form of construction might be totally unsuited to the use of the building but it may be that faults only occur if certain details of construction are unsuitable or the standard of workmanship or fire resistance is insufficient. Any proposed recommendation to deal with the problem must consider:

(i) Is a modified form of the construction still suitable for future building projects in that particular trade? If, so, what should the modifications be?

(ii) What steps should be taken to protect existing properties so constructed which must continue in use for some years?

(iii) What are the cost benefits to the nation and to the individual firm of any proposed solutions under either (i) or (ii)?

As a further example - statistical analysis of K433 information related to a particular trade may indicate the optimum size for a 'compartment' to reduce large financial fire losses in that trade. However, the terms 'room of origin' and 'extent of fire' upon which the analysis would be based are ill-defined. Thus before implementation of the optimum size recommendation on an economic basis at the individual firm level the following steps will be required:

(1) the definition of the nature of the rooms, environment or compartments in typical buildings associated with the trade and, having simplified the meaning,

(2) consideration of economic methods of reducing existing overlarge areas to the optimum size bearing in mind the reasons for fire spread in that type of building and trade and the standards of fire resistance which surveys have shown to be adequate for proposed construction to reduce the overlarge areas.

(3) consideration of what other economic measures are likely to reduce fire spread in particular types of building used in the trade or industry concerned if (2) does not provide a practical solution.

In both the above quoted examples statistical analysis may provide the original diagnosis regarding what appear to be major cost factors: the task for a survey programme would be to elucidate the problem, answer the type of question posed above and provide information upon which economically viable solutions can be based. The reasons why fires become large (and therefore costly) are unlikely to be due to some new and as yet undiscovered factors but a question of assessing for particular trades and circumstances

the relative importance of already well known and often somewhat mundane factors which can assist spread and the relationship these bear to the fuel disposition in the fire environment. Preliminary assessments of some of the factors are shown in Tables 18, 19, 30 and 31 of FR Note 948. The manner in which these assessments can be further refined by scientific means is demonstrated by Theobald[3].

The 'effectiveness' of fire protection may be assessed on the lines indicated but the 'cost' element still remains. Little information is available regarding details of fire loss in individual fires and the resources of the survey group did not permit pursuit of this aspect during the pilot exercise. Nevertheless the individual report files of each fire and some co-operation from the firms concerned in the losses offer scope for very comprehensive assessments of cost and the influencing factors. Thus, by a combination of statistical data, fire survey information and costing details the relevant factors would be available for exercises in the cost effectiveness of fire protection methods. The benefits to the nation and to the individual firm could both be shown.

5.2 <u>The verification and practical application of the results of scientific research programme</u>

The two main aspects of research into building fires are:

(1) Laboratory experimental fire programmes.

(2) Statistical analysis of all fires based mainly upon information obtained by the fire brigade K433 report form.

Both these aspects are hampered by lack of knowledge of the precise conditions appertaining in actual fires which survey programmes could remedy. This can be demonstrated as follows:

(1) <u>Laboratory experimental programmes</u> - In any research programme the problem posed must be first defined and a series of experiments planned which are calculated to take account of as many as possible of the known factors - or at least those considered to be most important. However, due to a scarcity of information regarding both actual fires and buildings the facts required to define the problem are not always fully appreciated - nor are the conditions under which actual fires occur. Furthermore, there are practical limitations to the amount of experimentation which can be undertaken. Thus survey information may be required to assist the initial assessment of the nature of the problem; and following the experimental programme the effectiveness of any measures recommended can be assessed by surveying fires in buildings where

the recommendations have been implemented. The recent work on pressurization of escape routes and the current work on smoke movement in buildings are two cases where co-operation between research and fire survey activity is desirable.

An example of the correlation of laboratory experimental results with information from actual fires is given by Theobald[3] who compared the burning rates of some experimental fires in compartments using wood cribs as fuel with the assessed burning rates achieved in actual fires in single storey buildings: in addition he considered the part played by various forms of roof cladding in venting or failing to vent the fires and the general effects these had upon ultimate fire size. A further note under preparation compares fire spread in laboratory experimental fires with the experience of actual fires.

(2) Statistical analysis of fires - Research by statistical analysis of fires is based upon the K433 form which gives some basic facts regarding fires and the buildings concerned. However, apart from some generalisations in Sections 6 and 7, the form does not give assessments of fire and building behaviour. Lack of such assessments seriously hampers the present scope of statistical research as the following two examples demonstrate:

Melinek, Baldwin and Thomas[4] conclude that the probability of a fire becoming large increases rapidly with the probability of spread beyond the room of origin and that small reductions in the chance of spread beyond the room of origin could result in relatively large reductions in the chance of a large fire. They further conclude that the chance of spread can be reduced 'by providing more adequate walls and floors separating compartments, by protecting the compartments with sprinklers or other devices which will ensure early detection or control'. Statistical information is not available - or likely to be available - to enable the authors to take the suggested remedies much beyond these general terms to the point of practical application. No doubt a provision or a general increase in standards of the factors mentioned might reduce some spread from the rooms of origin but the expense incurred is unlikely to be proportional to any savings in fire losses. A better approach would be to assess by surveys the relative importance of the factors

which assist, retard or prevent spread or further spread for specific types of buildings and circumstances and clarify the meaning of the term 'room of origin' in any particular context.

A more specific enlargement of the above argument can be indicated by reference to an examination of the statistics of fire damage to buildings by Baldwin and Allen[5]. They note that the failure of a door is not reported by brigades and comments that 'since this is likely to be an important factor in the spread of fire, allowing fire to pass through a fire resisting construction, this is a serious omission'. A number of observations are pertinent. If the failure of a door was noted on the K433 form some ambiguity could arise since the relationship between fire spread and a door involves the following questions:

(1) Where was the door in relation to the fire?
(2) What was the construction of the door and frame assembly and the nature of the 'fit'?
(3) In which direction were the air currents acting around the edges of the doors?
(4) What was the nature of the fire attack upon the door?
(5) At what stage in the fire did the door fail?
(6) Did such failure, in fact, cause spread to occur or was spread due to some less obvious reason?
(7) Was the door definitely closed at the time of the fire or when spread occurred?
(8) Did the door perform better or worse than to be expected?

Survey information and assessments on the above lines can establish the role of a door in fire spread for specific types of buildings and circumstances. The relative importance of doors amongst other factors which can cause fire spread is likely to vary very much with the purpose group. Evidence from all the surveys carried out so far confirms that the importance of the door in house fires is likely to be much greater than it will prove in industrial fires (although this is not to say that it has no significance in the latter). It is likely that the form of construction of the building may also influence the role of the door.

The above arguments indicate the type of information which is necessary if the scope of statistical analysis of fires is to be enlarged. Such information is unlikely to be obtainable on a statistical basis and the method by which information from a

limited number of surveys can be related to the national scale has been referred to in Section 3 (page 2).

5.3 The evaluation of the effectiveness of Building Regulations

The effectiveness of the Building Regulations might be evaluated by two methods:

(1) by comparing fire statistics before and after the present Regulations came into force.

(2) by assessing how effective are the present individual provisions of the Regulations - or certain combinations of them - in performing their intended function.

The former building bye-laws were fundamentally different from the present Regulations which supercede them thus direct comparisons of effectiveness by the first method are not easy and could only take the form of general comparisons between the two systems. Recent changes in living habits and in the contents of buildings would be a further complication although some allowances could be made for these.

The second method will prove more rewarding. In the past two decades many changes have occurred in both building design and constructional techniques: as the sophistication of these changes increases so does the need to rationalise the regulations. a requirement of this process is information and assessments from actual fires regarding the following:

(i) The fire hazards due to new design and planning concepts.

(ii) The fire behaviour of new materials and forms of construction and the effect these have on fire spread, fire severity and standards of fire resistance.

(iii) The effect upon fire resistance of bad workmanship and alterations on site to agreed details of modern construction upon which the fire resistance standard depends.

(iv) The effect upon fire behaviour due to changes in the contents of buildings, new methods of storage and the effectiveness of active and passive measures to prevent fire spread.

(v) The effectiveness of particular provisions of the Building Regulations in relation to the above and the general effectiveness of the fire clauses as a whole to cope with fire problems in modern buildings.

The technical assessments and information required can only be obtained by means of surveys at the fire ground.

5.4 The evaluation of the effectiveness of means of escape provisions.

It has been shown that means of escape provisions can form the most expensive single item in fire protection costs to a building[6]. Whether cost should in any way influence such provisions is beyond the scope of this paper. However, where a choice of method of protecting escape routes is available it is difficult to undertake cost/effectiveness exercises since there is little evidence from which comparisons of effectiveness can be made. The present principles of means of escape are largely traditional in origin and were designed to meet the needs of comparatively low buildings of simple plan and with uncomplicated services. Modern developments show a trend towards taller, larger buildings and building complexes with more hazardous contents. Such buildings usually have sophisticated services and air handling systems and on this account are potentially more dangerous firewise: a further hazard is created since most buildings in this category could not be rapidly evacuated during a fire, whereas from the former buildings last resource ladder rescue was at least a possibility. Thus 'means of escape' may refer to provisions for the complete evacuation of the building or to escape from the immediate fire area only. In the latter case it will form but one facet of a series of complex provisions for life safety which must be thoroughly reliable since the building must remain in partial occupation during the fire. Many recommendations in the current codes of practice relating to means of escape are not scientifically proven and their effectiveness is a matter of opinion. The major problems are concerned with the control of smoke movement and a number of Research Station programmes are related to smoke and its control. The physics of smoke movement are comparatively simple but the complexity of buildings is such that a large number of factors in addition to various human agencies can influence behaviour and smoke patterns: the effects of these are not clearly appreciated. The main task for survey activity in support of the research programmes would be to make assessments of behaviour related to problems such as those listed below. In each case the assessment of the influencing factors will be important.

(1) The extent, speed and direction of smoke spread in buildings.

(2) The resistance of various types of doors to fire and smoke penetration and the effect of the position of the door relative

to the fire.

(3) The effectiveness of various means of protecting and ventilating vertical and horizontal escape routes.

(4) The effectiveness of mechanical means of smoke control.

The list is by no means exhaustive and the experience of the pilot exercise confirms that much useful information can be obtained by surveys. The need is highlighted by the new Fire Precautions Act 1971. This Act empowers the Secretary of State to require fire certification for premises he may designate. Already hotels and boarding houses have been so designated and in the future other classes of buildings may be included. If a uniform standard of requirements for life safety is to be maintained new codes of practice may be required and existing codes will require periodic revision.

6. Conclusions

6.1 The need to rationalise the present system of fire protection and the role of fire survey.

Improvements in living standards and working conditions have brought many changes in the contents of buildings and in methods of storage. Similarly fundamental changes have occurred in the planning of buildings, constructional techniques and materials used. The latest design process calls for the complete integration of planning, services and construction at the initial sketch plan stage rather than their previous treatment as somewhat separate entities. Such basic changes raise many fire protection problems and the need to rationalise our complete system of fire protection becomes more urgent as the modernisation process proceeds. Rationalisation calls for the total integration of the major fire protection aspects of means of escape provisions, structural fire protection as controlled by the Building Regulations and active and passive protection measures. In addition complete integration should take into account cost/effectiveness.

The main research effort required to achieve rationalisation will be in the fields of statistical analysis and experimental laboratory fire programmes. However, as this paper indicates, a point is reached when further progress becomes either very difficult or impossible without detailed knowledge of the behaviour of actual fires and of buildings in fires. This detailed knowledge cannot

be obtained statistically by means of the fire brigade K433 report or any revision thereof since it requires technical information and assessments associated with the Works Group and Scientific disciplines plus close liaison with the fire brigades and the specialist back-up resources of the Research Station and the other departments and organisations. The Survey Group has been formed to both serve and co-ordinate the need and this report has indicated the broad application of the information it can provide.

6.2 The results obtained from the pilot exercise so far

The purpose of the pilot exercise was to test the 'field' and for this purpose building fires in all eight Building Regulations purpose groups were included. Obviously a limited exercise with such a wide scope will not produce results which have a practical application to fire protection problems at this stage. Nevertheless the information obtained forms the nucleus of a data bank to which the results of future surveys can be added. Besides what has been indicated in the three FR Notes [1,2,3] issued so far information on the following aspects is accumulating from all the fires surveyed:

(1) The behaviour of modern forms of house construction in fires.

(2) The effect upon the fire resistance of modern constructions due to bad workmanship and the alteration on site of accepted details upon which the fire resistance standard depended.

(3) Smoke movement in buildings.

(4) The early stages of fires and growth of actual fires.

(5) Factors influencing fire spread and the extent of spread.

(6) The nature of fire environments.

(7) The influence of natural air currents upon the fire and smoke resisting properties of timber door assemblies.

(8) The resistance of actual structures to fires of varying severity.

The above and other information will form part of the date-bank for future programmes and further analyses of the results will be issued as the work proceeds.

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