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## Fire Research Note

No 898

COST OF FIRE PROTECTION-TOWARDS  
A DEFINITION

by

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FIRE  
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STATION

COST OF FIRE PROTECTION  
TOWARDS A DEFINITION

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SUMMARY

This is the first part of a study of the cost of fire protection to the nation as a whole aimed at giving details of the various categories that go to make up the account, ie passive, active and indirect measures. Large sections of this account are vague in content or ill defined and before any real cost assessment can be made the subject must first be defined.

This first report offers such a definition which, it is hoped, will form the basis of future cost exercises. Its purpose is essentially that of formulating a framework upon which any cost of fire protection study could be fixed such that in time these studies could be combined to produce an overall picture.

KEY WORDS: Fire protection, economics

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COST OF FIRE PROTECTION  
TOWARDS A DEFINITION

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D V Maskell

INTRODUCTION

Fire is a growing problem. In spite of advancing technology, improved standards -- to new and existing construction -- and further legislation, fire losses are continuing to rise at an enormous rate. The extent of this growth can be seen in the following figures<sup>1</sup> for the direct losses over the last 25 years.

1946	£12 M pounds
1958	£25 M pounds
1959	£44 M pounds
1971	£128 M pounds (Approx)

Allowances must be made for the considerable increase in the prices of property, the inflationary spiral and the larger number of properties, including plant and stock, now at risk. But even these cannot accommodate a ten-fold increase in 25 years.

Yarnwood<sup>1</sup> has suggested that this deterioration is due, in essence, to the incidents involving the larger losses -- more relatively small fires now becoming large fires. Fire damage in private dwellings has remained remarkably constant; what has so sharply increased is the damage in commercial and industrial risks.

From the point of view of the national economy, the destruction of manufacturing assets is of special concern; not only must the building be re-erected and new equipment acquired, but nothing can be produced until this has been done. The stoppage often has an effect far beyond the limits of the burnt out factory, and the cost of this -- the consequential loss -- may be comparable to or even larger than the direct losses.

These direct and consequential losses form a large part of the overall bill to the nation, and in an attempt to reduce their size we have to introduce in the same account, other large figures for the cost of fire protection, the cost of the fire brigades and the more indirect and administrative costs attributable to the fire hazard. Thus we have within our national fire cost bill:

- (1) the cost of our attempts to prevent fire happening, and the cost of our efforts to protect the building, and
- (2) the cost of the fires that occur.

Silcock<sup>2</sup> suggested that the breakdown of the national fire cost for 1965 is roughly as follows:-

Type of cost	1965 total £ million
Direct loss (building and contents)	75
Loss of life and limb	0.3
Insurance (administration and technical services)	50
Fire brigade (public and private)	75
Fire protection to buildings	63
Fire Research (including FRS)	0.5
Consequential loss	(say) 100
cost of fire	364

This situation gives rise to a number of questions:

Is the money we spend on fire protection and prevention justified in terms of the savings made?

Could we spend more and achieve a reduction in fire losses?

What are the relative values of the different aspects of the overall bill and will a different balance result in an increase or a reduction in the fire losses?

The answers to such questions as these hinge on the need to know, reasonably accurately, the cost of fire protection in all its various forms.

#### FROM WHICH POINTS OF VIEW?

The introduction makes it clear that this study will ultimately deal with the costs on a national level but it could be recorded at this stage that there are different levels of interpreting the problem:

The Building Owner: To him the main ingredients of fire protection are those that concern his building and his insurance. He considers the whole subject on his own level and it is then mainly a matter of balancing:- obtaining the optimum degree of fire protection for the most economic insurance premium. Unless there are extenuating circumstances he does not particularly want and perhaps does not need to provide more fire protection than is going to be necessary in obtaining the most economic insurance premium.

Insurance: The insurance companies fix their premiums such that they supposedly cover the fire losses and their overheads. What the building owner pays in premiums he is likely to receive back in payment for losses (less these overheads), spreading the losses sustained by a few amongst many. These costs (excluding overheads) represent only redistribution of resources and are not costs to the Nation.

National: At this level it becomes of less importance what the building owner actually pays since other income may ultimately balance some of his expenditure. Into the picture will also come the indirect and administrative cost - fire brigades and the emergency services generally, education, propaganda and research work. It is from this level that one must calculate the nation's fire protection bill.

To assist in defining the overall problem, this first study will include notes on the two main levels - local (the building owner) and national. It will also high-light their relationship and in particular how costs on a local level can be compensated or even eliminated when considered on the national level.

#### BUILDING LEGISLATION

A large proportion of the fires that occur each year in buildings can be attributed to the contents of the building or the behaviour of the people within that building and not, in fact, to the building itself. Thus, no

matter how comprehensive legislation may be as regards a building and no matter how well the building may have been designed with regard to the fire hazard, it is still impossible to eliminate all such fires simply because most are beyond the control of both the legislators and the designers. Besides which, a building must also perform other functions which will usually be more important, than protecting its contents from fire. These may take the form of, for example, protection from the weather, or, from an internal viewpoint - sound insulation.

Buildings are required to provide the following features to reduce the danger from fire.

1. Means for the occupants to leave the building safely and quickly if a fire starts, and
2. A design which will reduce, as far as is practicable and economical, the spread of fire both within the building and to those adjoining.

A glance at statistics regarding the human and material losses in a fire would present us with our first problem. The human losses are mainly in the residential categories of building structure whilst the material losses tend to fall within the commercial and industrial categories of buildings. To legislate for both problems would impose a most severe strain on the building profession as a whole, thus our existing legislation takes the view point, that the chief concern is human protection, and therefore attempts to minimize such losses within all categories of buildings.

If one considers a building, the degree of fire protection incorporated within it will vary depending upon:

- a) the control exercised by the various regulations
- b) the fire consciousness of the building owner
- c) the fire consciousness of the building designer
- d) the insurance factor

The first point will dictate the size of a building and will determine the fire protection requirements, particularly those appertaining to the structure. As has previously been mentioned, the main concern is for the occupants. Much will depend on the building owner himself - the second point. The tendency is for the average man to assume that unpleasant things - such as fire - cannot happen to him, only to his neighbour. However, once he has had a fire then fire consciousness normally enters the picture and his future buildings will take this into consideration. The building designer, with a keen awareness of the fire hazard, can add considerably to the minimum standards laid down by legislation. However, his design must be functional from many other standpoints besides that of fire

and this can add something of a "designer's strain". The final point is a little more complicated and involves insurance premiums, discounts for a degree of risk, the cover structure and fire protection offered, and the various tax discounts for installations, etc. This aspect will be dealt more fully elsewhere.

Silcock<sup>2</sup> suggested that fire protection is the difference between compliance and non-compliance with all forms of fire regulations and controls, and that one could calculate, on this basis, the cost of fire protection by comparing a conventional building with one designed to the same conditions but without the fire hazard restriction. However, a fire regulation may only restrict the building designer and may not necessarily involve expense. Indeed, if the building owner were given the freedom of choice, he might ask for a more expensive material for the design which, under the fire regulations, would have been rejected. This particularly applies to the prestige buildings where cost may be of less importance than the element of show; or where a particular company has a vested interest in a product and wishes to use it irrespective of its economics.

Total fire protection is essentially made up of three broad categories, which are:

- (i) passive
- (ii) active
- (iii) indirect and administrative

The first - passive - deals with the structure of the building whilst the second - active - includes items, such as detectors and extinguishing installations. The third takes in more indirect methods such as fire brigades and other services. There is a degree of overlap between them, but particularly in the first two.

#### PASSIVE FIRE PROTECTION

This is the form of protection which lies within the design of the building and includes the structural provision. The building would be designed and developed in accordance with the relevant regulations which would include those appertaining to the fire hazard. Inherent within almost all aspects of the structure, would be this fire protection requirement. This makes it very difficult to define what fulfils a fire protective function and what fulfils some other purpose.

For example, an architect may require a finish to a wall for aesthetic reasons, but for fire protection, a protective cover may be deemed necessary to provide a particular degree of fire resistance. Thus is posed the problem - where does the finish cease to be a finish and become a protective cover, and, what proportion of the costs of the finish or protective cover can be allocated to fire protection?

Also, for access and communication, the installation of a staircase between floors would be considered essential, but this same staircase could also serve very effectively as the means of escape in the event of fire, and indeed without it, it may be impracticable to provide adequate escape. Again, what proportion, if any, of the costs of the staircase can be allocated to the fire hazard? We can look at this in a slightly different way by considering the use of an additional internal escape staircase, since although safety may demand this as an alternative means of escape, there may well be some benefits to be obtained in the convenience of using such a staircase for communication.

As the fire regulations have imposed their requirements onto the design of the building, some proportion of the cost of these elements must be attributed to the fire hazard.

Another factor which often further complicates the costing of structural fire protection is the existence of other requirements which overrule the needs of fire regulations. Sound insulation, for example, tends to require a form of construction which enhances fire resistance. In providing a reasonably sound-insulating partition of traditional materials, the type of construction required could be more than adequate to meet the necessary fire resistance. Similarly, with reinforced concrete columns in the smaller fire resistance periods, the size of column dictated by the load to be carried is usually sufficient for fire protection. Again, with such columns the need for cover to the steel reinforcement generally results in a concrete cover being adequate for fire protection.

Building legislation<sup>3</sup>, which covers the fire aspect, sets the minimum standards required, and even then, generally speaking, it deals only with the safety of the occupants in the following ways:

- (a) the means by which the fire may be contained in order to facilitate escape and,
- (b) the means by which escape may be speedily carried out.



The first aspect (a) concerns the stability of the building and the containment of the fire to a defined area. This stability ensures that the building remains intact, at least until all the occupants have made good their escape, if not indeed for fighting the fire and for possible reinstatement afterwards. The containment attempts to limit the spread of fire to a particular area, so restricting its influence and allowing evacuation from the affected area and keeping escape routes relatively free from the fire's products.

The second aspect (b) includes the provision of escape routes and alternative means of escape. The alternative route may be in the form of a protected corridor of specified fire resistance, or an escape staircase. The containment of the fire, as covered in the first point, will ensure that in the event of a fire, these escape routes will remain usable.

There are at least ten items in the regulations which contribute to passive fire protection. They are:

- (i) the fire resistance of the structural frame,
- (ii) the fire resistance of separating walls and compartment walls and floors,
- (iii) fire resisting doors and shutters and general fire and smoke stopping,
- (iv) protected shafts and enclosed staircases to ensure fire containment,
- (v) shutters to ducts and other perforations through compartment walls and floors,
- (vi) roof ventilators and smoke extract systems,
- (vii) escape stairs and, in existing buildings, external means of escape,
- (viii) the limitations on the use of materials on external walls and the restricted use of unprotected areas,
- (ix) flame retardant linings, and
- (x) design considerations to restrict the spread of fire from building including separation which gives extra land costs.

#### ACTIVE FIRE PROTECTION

Active fire protection consists of 'built-in' items such as sprinkler systems, fire alarms, water hydrants and first-aid fire-fighting equipment, and could therefore be regarded as the visible means of fire protection.

Indeed, whereas passive fire protection lies within the planning and construction of the structure, active protection tends to be an extra incorporated into the building and is often in existence as an accepted code of safety or is required for insurance. Its provision is not always mandatory. The exertion of pressure will often prevail in getting certain active protection - either by the action of the certifying authorities, or of high fire insurance premiums. The pressure may even be self-induced, especially if the history of a particular firm shows a poor fire record. Once the building owner has experienced the effects of a fire, he is usually more willing to incorporate additional active fire protection.

Another aspect of active fire protection is its need to be checked and maintained. Passive protection, ie protection inherent in the building structure, is usually considered effective for the life of the building, although certain materials of good fire integrity may suffer deterioration by wear-and-tear and vandalism. In these cases general building maintenance will usually take care of any repairs required to maintain the degree of passive protection. However, fairly extensive checks and maintenance procedures need to be adopted for the active measures to ensure that they do not, with time, lose their effectiveness. Sprinkler systems need to be checked, extinguishers likewise, and even the contents of buckets of sand and water tend to disappear over a period of time. This often proves a stumbling block since maintenance cannot readily be enforced.

The cost of fire protection if it is to be comprehensive and all-inclusive should therefore include an allowance that covers the cost of maintaining such protective measures, and indeed, other forms of preventive maintenance where the omission may result in a fire eg electrical apparatus and wiring.

The size of the active element of the fire protection account will vary considerably from buckets and hand extinguishers to an approved<sup>4</sup> automatic sprinkler and alarm system, coupled with first-aid fire-fighting equipment. The degree of fire protection of any building would be influenced by:

- (a) the purpose of the building and the known fire record of the occupancy,
- (b) possible statutory requirements,

- (c) the degree of influence exercised by the insurance world based on this known fire record, and
- (d) the fire-consciousness of the building owner and/or the designer.

Although the first three points will no doubt set a minimum level, the overall active measures usually rest on the final point and in particular on the fire consciousness of the owner - for the degree of protection actually incorporated.

There are at least seven aspects which could contribute to the cost of active protection and they are as follows:

- (i) automatic sprinkler installations,
- (ii) other methods of automatic extinction and separating fire risk areas,
- (iii) automatic detection,
- (iv) fire alarm systems, either manual operation or tied in with an automatic installation,
- (v) external hydrants and wet and dry risers,
- (vi) fire extinguishers and other first-aid fire-fighting equipment, and
- (vii) warning and exit signs.

#### INDIRECT AND ADMINISTRATIVE

The term cost of fire is normally intended to include the main fire losses - life and material and the consequential or indirect, and the costs allocated to the fire hazard leading up to the fire. The cost of fire protection concerns all expenditure on measures which attempt, either directly or indirectly, to prevent the fire occurring or to control or reduce its spread in order to minimise the likely damage. There is overlap but it somewhat simplifies the problem if they are considered as separate entities.

The previous sections - Passive and Active fire protection relate to the building and its contents. What are called indirect and administrative costs include:-

- (i) General protective measures,
- (ii) Research work,
- (iii) Educational propaganda,
- (iv) Insurance,
- (v) Emergency services.

Generally speaking assessing the monetary value of these factors forms the biggest problem in ascertaining the overall cost of fire protection. Some, such as insurance, can play an even bigger part when considered on the local level.

(i) General protective measures: This includes such items as the use of flame arresters, and non-combustible hydraulic fluid which can be considerably more expensive than a similar but flammable liquid. Many of the devices employed on industrial machinery, and which are now taken for granted, owe their existence to the fire hazard. Their use is as a protective measure. It may only be possible to assess a monetary value for the more important of these protective measures or even the addition of an allowance to the overall bill, but nevertheless, their existence demands a position somewhere in the 'cost of fire protection' account.

(ii) Research work: This can be divided into two aspects - research which deals with the formulation of regulations, standards and codes of good practice, and that which concerns the development of materials, components and methods of construction. Research itself can be public, ie government controlled, or sponsored, or private - attached to the research and development sections of firms or large companies. From the national point of view, the former, if it comes out of public funds, is a direct contribution to the cost of fire protection, whilst the latter, which would be included in the cost of the service and may therefore already be included on the local level as a part of an active fire protective measure, would not contribute additionally to the overall bill.

(iii) Advertising and Education: Again, care must be taken to avoid including the same item twice in the account. Thus, from a National level, technical literature and even journals produced by trade associations are, generally speaking paid for by the consumer somewhere in the cost of the service. However, propaganda and advertising directed at the public to produce an awareness of the fire hazard and backed by public funds from one source or another, would be a charge to the cost of fire protection.

Similarly, educating the public, whether through the medium of television, print, or lecturing, would also constitute fire protection where it was supported by public funds, either from the local authority, or central government. The employment of fire and safety officers or the use of fire propaganda within private companies may also contribute to the fire protection bill, since it is unlikely that the expenditure for such provisions would be included in the bill in any other form.

(iv) Insurance: The expenses incurred in providing insurance facilities and all its attendant services viz:

- a) insurers expenses and margin of profit,
  - b) agent's commission,
  - c) reserve for loss,
  - d) Propaganda and Education, and
  - e) fire surveys and fire protection services (eg salvage work)
- might constitute costs of fire protection. The work resulting from a claim and the consequent damages paid would come under the cost of fire. Since the provision of insurance enables the cost of the fire damage suffered by a few to be spread over many, from a national point of view, the cost of fire should not include the payments for losses and the premiums.

(v) Emergency services: These include:-

- a) local/works fire brigades,
- b) The Fire Service,
- c) The Ambulance Service, and
- d) General medical facilities, eg hospitals.

The maintenance and upkeep of the works brigade and the public Fire Service are obviously charges on the cost of fire protection, although for the latter some allowances can be made for the other services performed.

The ambulance and general medical provisions must contribute in part to the cost of fire protection since they too have to be prepared to deal with fire casualties. It would need to be borne in mind that only the provision of such facilities are fire protective measures and not the expenses actually executed on fire casualties.

## DISCUSSION

The purpose of this report has been to survey the problem of fire protection costs.

Silcock's table of national fire costs considered in the introduction of this report, allocated £53M to fire protection for 1965, or about  $2\frac{1}{2}$  per cent of the total construction for that year. However, this 'percentage of total construction' figure for individual buildings varied from anything between 1 per cent for housing and residential categories to more than

8 per cent for commercial properties or, using the 1965 total construction figure, from about £13M to more than £250M. This range can have an enormous effect on the overall cost of fire. Hence the attempt within the passive and active sections of this bill to establish accurately how much of the building cost can be attributed to the fire hazard.

In assessing any costs within the major categories - ie passive and active measures - it should be possible to carry out exercises in off-setting one form of fire protection with another, for example, using detectors at the expense of reducing the standard of fire resistance of the structure. A certain standard of fire protection may well be deemed desirable but one form of fire protection could possibly be balanced against another

Within the active measures cost studies could be carried out comparing one form of active measure with the others. These would take into consideration all the favourable and unfavourable points for each of the systems considered. Indeed, on the basis of their first costs alone ie material and labour costs in installing the system, comparison may be very misleading.

Work is in progress regarding the cost of active and passive measures and some indication of this work is included within this report as Appendix A.

The main conclusion that one can derive is the difficulty that is likely to be experienced in deciding what actually constitutes fire protection particularly in the case of the passive and the indirect and administrative sections of the account.

#### ACKNOWLEDGMENTS

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## APPENDIX A

An edited version of the Research Memorandum No 40 which provides an analysis of passive and active fire protection

To arrive at a fairly accurate appreciation of the cost of fire protection for a building it is necessary to analyse the building cost and extract those items which are connected with fire protection.

With active measures this forms no problem since they are normally self-contained and easily evaluated and can be allocated en bloc to the overall fire protection bill of the building. With passive protection, however, problems arise with the difficulty in defining what constitutes fire protection. The building would have been constructed in accordance with the regulations, such that some proportion of the building costs would need to be attributed to the requirement of fire protection but the size of this proportion forms the problem. To illustrate this point - an architect may specify a particular finish to a wall for aesthetic reasons but at the same time a protective cover may be deemed necessary to provide a certain degree of fire resistance.

Analysing the building cost in some detail does at least minimise the possibility of any large errors in assessing this proportion. An example of the analysis sheet is included suitably filled in and, as can be seen, the individual elemental costs are sufficiently small to render <sup>negligible</sup> the effects of any error. At the same time the sheet also shows that quite a number of elements contribute to the overall cost of protecting that particular building.

Using these analyses it should be possible over a period of time to produce a library of cost information dealing with these active and passive fire protective measures. Various technical journals etc provide accurate building cost analyses from which these fire protection costs can be extracted.



APPENDIX A

COST OF FIRE PROTECTION: -ANALYSIS

Type of building:	Offices	Sheet No.1.
Client:	-	Gross floor area: 23,634 ft <sup>2</sup>
Date of tender:	2.2.70	Location: Derby
Number of storeys (i) above ground:	6	Source of information: -
(ii) below ground:	None	
Contract sum:	£148,000	Notes:

No.	Fire protection element	Cost of element (£)	% of total
	<u>Passive fire protection</u>		
1a	Structural elements: frame )		
b	Separating wall )		
c	Compartment walls )		
d	Compartment floors )		
e	Galleries )		
f	Protected shafts, including the protecting structures:		
	(i) staircases - (Enclosed staircase (common brick walls	25	0.017
	(ii) lifts		
	(iii) escalators (8½ in x 9 in r.c. (slabs (2%)	52	0.035
	(iv) conveyors		
	(v) chutes		
	(vi) ducts		
	(vii) others		
2	Special safety considerations for heating and heat producing appliances	-	
3	Fire resisting doors and shutters:		
	(i) internal: (2½ in fire check (70%)	475	0.322
	(ii) external: (metal doors to escape stairs (70%)	300	0.203
4	Other forms of fire stopping or smoke checking	-	
5	Smoke ventilation in basements	-	
6	Fire venting: (a) to control smoke spread (b) to control fire spread )	None	
	C/F	852	0.577

No	Fire protection element	cost of element (£)	% of total
7	Control of smoke spread (i) natural ventilation (ii) mechanical ventilation including pressurization (iii) others	852 None	0.577
8	Design considerations related to escape:		
a	Non-loadbearing fire resisting partitions and construction considerations		
b	Supplementary lighting to staircases	48	0.032
c	Special walkways		
d	Others		
9	External escape stairways: metal staircase including foundations	5,550	3.775
10	Other external means of escape		
11	Access for reaching the fire within the building (eg fireman's lifts and fire-fighting stairs, etc)	-	
12	Design and constructions to prevent the spread of fire through external walls to other buildings (eg unprotected areas, etc)	None	
13	Special or treated linings, to inhibit the spread of flames fixed to: (a) walls - None (b) ceilings - (Asbestolux and light-weight plaster)	100	0.068
14	Construction considerations to prevent the spread of fire from roofs (external exposure)	None	
15	Site planning and access for fire-fighting	-	
16	Other passive provisions of fire protection	-	
	<u>Active fire protection</u>		
17	Mechanical extinguishing installations:		
a	Sprinklers		
b	Other water forms (fine spray, droplets etc)	None	
c	Carbon dioxide		
d	Other gases or chemicals		
		C/F	
		6,550	4.452

No	Fire protection element	Cost of element (£)	% of total
	B/F	6,550	4.452
18	Separation of special fire risk areas	-	
19	Drenching systems	-	
20	Automatic detectors: (i) smoke ) (ii) heat ) none (iii) others )	-	
21	Fire alarms: (other than those arising from detection or automatic extinction)	775	0.524
22	Water hydrants	-	
23	Wet and dry risers	-	
24	First aid fire-fighting equipment:		
a	Hose reels - 6 No. (1 each floor) including builders work	300	0.203
b	Portable extinguishers:		
	(i) water )		
	(ii) foam )		
	(iii) carbon dioxide ) 12 No (not defined)		
	(iv) powder ) including builders work	100	0.068
	(v) others )		
c	Buckets, blankets etc		
25	Warning and exit signs 60%	175	0.118
26	Other active forms of fire protection		
	TOTAL	7,900	5.365

Note: The figure (percentage) in brackets indicates the proportion of the total cost of the element attributed to fire protection.