F.R. Note No.483

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

FIRE AND SINGLE-STOREY FACTORIES

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October, 1961.

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Introduction

The passing of the Factories Act 1959 and the not inconsiderable increase in the industrial fire losses for the last year or two have high-lighted the hazard from fire in large factory buildings. A number of these fires have resulted in losses of more than a million pounds. An inspection of the ruins of these large fires, the majority of which are single-storey shed type buildings, show many features in common and from which a number of important lessons may be learnt.

In all these large fires the manufacturing process was not the one for which the buildings were originally designed. The result of this is that major alterations have been carried out both to the structure and to the internal layout of the building. To facilitate the movement of goods and equipment from one department to another, individual buildings have been connected by roofing between one and another and in some cases by enclosing walls as well. The size and lay-out of the buildings, as originally planned, was usually adequate to keep possible fire losses within reasonable limits. The interconnection of one building with another has resulted, however, in a continuous and complex conglomeration of space, in many instances constituting many acres under one roof.

To increase accommodation within these vast areas, offices and stores on galleries, have in many cases been constructed. The effect of such alteration to the original shell of the building has been virtually to construct a series of buildings within a building.

The structure of these large factories was of the lightest form of construction, brick or sheeted walls, steel trussed frames, protected metal or asbestos-cement roof coverings and in some cases underdrawn with combustible lining materials. Irrespective of the type of material used and the method of construction, because of the extensive areas at risk, large and very expensive fires developed.

Production and administrative needs of industry require, in many cases, large individed space and administrative compartments within these areas are of course a necessity. How can these needs be met and at the same time provide a reasonable standard of safety for personnel and minimize losses should fire occur?

It is the purpose of this paper to analyse the basic causes and effects of these large fires and to suggest methods of reducing the risk of small fires becoming large and expensive ones.

It must be appreciated that in considering factory design, in relation to the reduction of the hazard from fire, statutory requirements in byelaws and regulations under the Factories Acts must be complied with, all of which are outside the scope of this note.

General

Shed type buildings consisting of light steel frames and sheet cladding have no fire resistance - photographs of these large fires are ample evidence of this fact. If the structure of the building is made fire resisting by encasing all steelwork and constructing the external walls of materials which will contain the fire, will the fire hazard within the building be eliminated? The answer to this question must be "No".

However fire resisting our structure may be, however carefully we select our materials both for the structure and for internal linings, fires can occur if for no other reason than by virtue of the manufacturing process and the materials used and stored in connection with them.

Much, however, can be done to minimize the effects of fire and to keep a small fire from becoming a large and economically disastrous one.

Site planning

The tendency today, on economic grounds, to use a large proportion of the available land, on individual sites, for building tends to produce conditions which are undesirable from the fire-fighting and general fire hazard point of view.

In the siting of factories in relation to fire, these factors must be taken into consideration:

(a) Access roads for fire-fighting appliances;

(b) Distance between buildings to reduce fire spread;

(c) Access from roads and open spaces into the buildings.

(a) Access roads for fire fighting appliances

In a factory layout access to allow the movement of transport within the site is often adequate for the movement of fire appliances. Nevertheless, changes of layout and the erection of temporary structures, connections between buildings by overhead power cables, ducts and piped services can often produce conditions where the close approach of the large fire-fighting appliances to the perimeter of the building is often restricted.

(b) Distance between buildings

The siting of buildings must also be considered from the standpoint of reducing fire spread to the minimum. The threat of fire may come from openings in the roof of an adjoining building which is on fire, or from the building as a whole if the fire resistance of its walls and roof are not adequate to contain the fire. Fire may enter a building through its windows or by penetrating or igniting its external walls or roof.

The extent of the risk depends to a large extent on the distance between buildings, the fire resistance of the external walls, the size, shape, amount of openings in walls and roof and the nature of the contents of the building.

It is also important to consider the position of single-storey buildings in relation to those of adjacent multi-storey buildings. Fire may spread via the roof of the single-storey building to windows of an adjoining high block. If, however, the space about the buildings is adequate for access for the larger types of fire-fighting appliances a reasonable degree of safety may be achieved.

(c) Access into the building

It is often found in these large shed type buildings, that whilst access around the perimeter may be adequate for fire-fighting appliances, the accessibility of the building to actual fire-fighting operations leaves much to be desired. Long runs of unbroken external wall are often found necessitating the entry into the buildings at considerable distances from the actual fire area, with the result that firemen may have to negotiate a heavily smoke-laden atmosphere before being able to bring a jet to the fire area.

Size limits

Spread of fire within a given area can be extremely rapid - much more so than is generally realized. The result of this phenomenon of rapid fire spread can mean that, in the large undivided areas of single storey factories, a very substantial and potentially dangerous fire can develop before full scale fire fighting operations can be put into effect.

The rapidity of fire development will depend upon the size, shape, amount of openings in walls and roof, the nature and disposition of any combustible contents and the nature of the process within the building. These factors will also effect the temperature of the fire and indirectly the rate of burning. The size, e.g. the floor area, which can be tolerated in any particular class of factory building is, therefore, dependent upon the factors noted above.

If the building is of fire resisting construction the contents are non-combustible and the process of a non-hazardous nature, a considerably large area may be tolerated than when combustible materials are used in the structure; the combustible content is high and the process presents a potentially high fire risk. It must be appreciated that the larger the undivided area, at risk, the larger is the potential loss. Where the risk is high and the fire resistance of the structure is low, it should be the aim of production management to keep within a limit of not more than 5,000 sq.ft between fire resisting division walls.

High hazard areas

The majority of factories contain material or carry out processes which present a high fire risk or possibly an explosion hazard. Such areas should preferably be in separate buildings, sufficiently isolated from the main production area that the possibility of fire spread by radiation is suitably reduced. If complete isolation is not possible, the high hazard area should be isolated from the main production area by walls and if not taken to the full height of the building, by ceilings both of which should have a standard of fire resistance comparable with the fire-load. Such areas should, for preference adjoin the external wall.

Construction

In considering the structural requirements of single-storey factory buildings, attention must be given to the following elements of structure:

(a) External walls;

(b) Structural frames;

(c) Fire division walls;

(d) Roofs.

(a) External walls

The function of the external wall in relation to fire is to contain it within the perimeter of the building and by so doing reduce the hazard from fire by radiation to adjoining buildings. The introduction of windows tends to nullify the efficiency of the wall as a fire barrier. Therefore, provided the space separation from adjoining buildings is adequate, the fire resistance of the external wall is not critical.

Where, however, walls are sited on the boundary or in close proximity to other buildings on the same site or adjacent to storage areas of combustible material, it is preferable that the wall should be imperforate and have a fire resistance not less than that appropriate to the fire load of the building. The fire resistance of the external wall unless it is constructed independently of any structural frame, will depend to a large extent upon the fire resistance of the structural members which support it. It may be seen, therefore, that in order that the wall may attain the required fire resistance, encasing of certain structural steelwork may be necessary.

(b) Structural frames

Structural steelwork has a low resistance to the effects of fire and will soften and fail to support its load at a comparatively low temperature.

It has been suggested that the failure of stanchions in a fire would cause progressive collapse in areas well away from the source of a fire. Collapse of this type is likely only where a considerable number of stanchions are involved. If only one or two fail redistribution of the stresses in the other structural members should take place and so tend to localise the damage.

In order to prevent collapse of the structure, as a whole, it would be necessary to do more than encase the stanchions up to truss level. For protection to be effective, the trusses must be encased or provided with fire resisting ceilings below them. The magnitude of this task needs no emphasis. Even if the stanchions are protected, failure of truss members, which can occur at an early stage in a fire, would result in the distortion of the stanchion at the top and it is likely to hinder rather than help a rapid reconstruction of the building.

In factories, however, where the fireload per unit area is high and where a fire of high intensity and long duration may be expected, the fire fighting problem may be aggravated by the lack of fire resistance in the internal structural elements. It is preferable, therefore, that in such buildings all structural elements should be protected to a standard of fire resistance appropriate to the fireload of the building. Where full protection is not practicable, column protection may enable the fire service to continue fire fighting operations within the building for a somewhat longer period than would be possible where no protection was provided to the vertical members. Collapse of trusses over the fire area would still take place unless adequate venting occurred.

(c) Fire division walls

By far the most important structural precaution which can be taken to reduce fire losses is by the use of the fire division wall, used to reduce the area at risk at any one time to the economic minimum. These walls should, where possible, have a fire resistance related to the fire load of the building, be so designed and constructed that they form a complete 'fire-tight' seal within the building and will retain their stability should fire occur.

It is appreciated that such walls may restrict the flexibility of production layout. The effects of this may be reduced by the use of lightweight, prefabricated fire resisting walls many of which have a fire resistance of 1 hour. The use of brick or blockwork for such purposes is usually only necessary where the fireload of the building or portion of the building, such as stores areas, exceeds one hour. Openings may be tolerated in such fire separation provided adequate means of effecting a closure by means of fire-resisting doors or shutters are installed. Such doors or shutters should always be closed when the factory is not in production.

Ducts and services, which must of necessity pass through such walls, should be effectively sealed against spread of fire. Ducts should be designed with fire dampers within the duct at the wall junction or be constructed of fire resisting construction. Service pipes should be sealed into the wall with materials which have a good resistance to the effects of fire.

Whilst it is preferable that the doors or shutters to openings should have the same standard of fire resistance as the wall, small openings, such as normal access doors, may be considered satisfactory if their fire resistance is not less than half the period required for the wall. Glazing, even of wired glass, should not be used in doors or walls of fire divisions if any degree of fire safety is to be obtained from the division wall.

(d) Roofs

The roof of the shed type building if constructed of combustible material is the largest single source of potential fire hazard. Therefore, the most satisfactory roof construction from the standpoint of fire safety is the non-combustible external covering in conjunction with a non-combustible internal lining. Such a form of construction should, wherever possible, be adopted both on new buildings and wherever re-roofing of an existing building is undertaken.

With the advent of the Thermal Insulation (Industrial) Buildings Act, it is necessary, in the majority of factory buildings, to use some form of insulation under the external weather resisting covering. If combustible lining materials are used, in conjunction with a combustible covering, they should be fixed in intimate contact with the covering and in such a way that, should fire occur within the building, the possibility of the lining becoming detached from the covering, at an early stage in the fire, is reduced to a minimum.

The same principle of fixing is also important where combustible linings are used in conjunction with non-combustible external coverings. It is preferable that the lining should be fixed directly in contact with the roof sheeting, as where cavities are formed the possibility of fire developing unseen in the cavity cannot be ignored.

By virtue of its corrosion resisting properties the value of the bitumen protected metals must be recognised as a suitable material for the roofing of industrial buildings. Nevertheless, it must be appreciated that its surface consists of materials that are combustible and can, under certain circumstances, present a considerable fire hazard. It is necessary, therefore, to take precautions to reduce this risk by the use of non-combustible or inherently Class 1 linings.

Fire venting

In the large shed type building roof venting has been advanced as a method of overcoming the problem of fire spread in the very large undivided areas met with today in modern production line factories.

Effective roof venting will facilitate fire fighting by tending to remove smoke and hot gases from near ground level. It may also limit the spread of fire on the underside of a roof and reduce the possibility of collapse of the roof structure. Whilst research into this problem is in the experimental stage, certain general principles are now becoming apparent.

In considering the problem, two important aspects must be taken into account:

(a) the amount, characteristics and disposition of combustible materials on the floor;

(b) the amount and disposition of any combustible material at roof level.

The first is difficult to control, and is dependent upon the process for which the building is designed and used. The second can be controlled at the design stage by the selection of appropriate materials and methods of construction. When only a small area of the floor is involved in fire, it is possible to limit the spread of hot gases at ceiling level and damage to the roof by using non-combustible barriers or curtains, in conjunction with vents to reduce the hot gases trapped between the curtains. The deeper the curtain the larger the area of the fire on the ground that can be effectively vented.

Vents should be sited at the highest point within each controlled area, having regard to the possible exposure hazard to adjacent higher buildings. The percentage per unit floor area of open vent between fire curtains will depend, amongst other things, upon the nature and disposition of the combustible materials at floor level and upon the height of the building. It must not be assumed that this method of fire control will eliminate the possibility of fire spread throughout the building. It is, however, likely that the atmosphere at floor level will be considerably more tolerable to fire fighters. The vents themselves should be controlled by heat-sensitive elements or similar devices. The area of venting required is greater than that normally required for comfort ventilation.

In the design of fire curtains, fire resistance is unlikely to be important and the ability of the material used to withstand high temperatures is all that is usually necessary.

It is of interest to note that in the large fires under consideration, none of the factories were equipped with any form of fire venting or any form of truss infilling. Comfort ventilation, however, was installed in a number of instances but achieved little or no reduction in the rapid spread of fire.

Means of escape

The first consideration in a fire must be the safety of the personnel within the building and its precincts. Fire warning systems, which are obligatory, should be capable of functioning at all times, and must be of such a type that it can be heard throughout the building that they are intended to serve. The meaning of the alarm must be understood by all persons in the building; the alarm must be clearly distinguishable from all other sounds in the factory.

The distance that any operative has to traverse from his place of working to the outside of the building or to a place of safety should be as short as possible. In the modern single-storey factory, the actual distance from the centre of the building to the outside may be considerable and may necessitate a considerably greater travel distance than the direct route on plan would presuppose. To overcome this difficulty fire resisting enclosures around escape routes within the building should be adopted where distances and time to traverse them become excessive.

Even in single-storey factories galleries and basements are often encountered, all of which tend to increase the complexity of planning problems in relation to means of escape. It is necessary, therefore, at the planning stage, to study the building area by area to ascertain that wherever fire may occur it is possible for personnel to reach, in the minimum of time, a place of safety and from such a position direct egress to the open air.

The desirable maximum distance of travel to a protected area, e.g. a suitably enclosed and constructed corridor, lobby or staircase, or to the open air, will vary with the type of building, the number of persons employed and the nature of the manufacturing process.

Fire resisting construction to all corridors and staircases, glazed with the minimum of wired glass, are essential to provide a reasonable degree of fire safety, corridors should be straight, contain as few turns as possible and be of adequate width. All linings to both walls and ceilings should be non-combustible or inherently Class 1, as defined in B.S. 476. Staircases should be in straight flights between floor and gallery. They should be placed preferably on an outside wall and provided with natural ventilation. Doors to escape routes should be designed and constructed to reduce to the minimum the penetration of smoke and hot gases.

Active fire precautions

Passive fire precautions are the siting of the building to reduce fire spread, internal design and sub-division to reduce fire loss and the fire resistance standards of elements of structure. Such methods only become effective if and when a fire gains a hold on the building. It is desirable to prevent the fire ever reaching the stage when structural precautions become significant.

To this end active fire fighting measures should form part of every factory equipment and routine. It may be said that lack of efficient and suitable equipment and availability of staff to carry out these active measures was, to a large extent, responsible for a number of the recent large fire losses in single-storey factory buildings.

Many more fire occur annually in industry than are ever reported to the Fire Authority, the majority of the fires being small in size and effectively dealt with by employed personnel. It is, however, the small insignificant fire caused by careless disposal of waste, faulty electrical equipment, sparks from cutting tools and many other causes which in themselves may seem unimportant which unless tackled promptly and effectively, can turn a loss of a few pounds into one of millions.

The complexity of modern industrial production methods cannot economically tolerate the destruction, by fire, of even one sub-division of a building. It is, therefore, necessary at the design stage, to consider the installation of fire fighting equipment of all kinds both manual and automatic.

First aid appliances

Buckets of water, sand, hose reels and fire extinguishers of all kinds should form the first line of defence against fire. Such appliances should be strategically sited throughout the building and prominently displayed. The practice of concealing such equipment in cupboards and behind decorative panels, in the administrative sections of the building, may lead to serious consequences.

Sprinkler installations

The most satisfactory automatic equipment for the reduction of fire hazard in the majority of industrial buildings, is the automatic sprinkler installation. These installations provide a means of detecting a fire, sounding an alarm, and delivering water to the seat of the fire, thus helping to keep the fire in check.

It is sometimes felt that such automatic installations may create extensive water damage. This is not usually so as water is discharged only through those sprinkler heads in the vicinity of the fire where the rise in temperature is sufficient to operate them. An adequate water supply is essential for the efficient operation of sprinkler systems and the availability of supplies or means of supplementing them should be carefully considered at the design stage.

Where installations have failed to achieve the expected protection it is usually traceable to causes other than efficacy of the sprinkler itself. Such causes may be unsuitable stacking and storage methods, the installation of suspended ceilings beneath the sprinkler heads or by the erection of walls around storage areas, after the installation is installed, so cutting off the sprinkler head from the source of the fire. Here again it is interesting to note that in most of the large fires under consideration, no sprinkler system was installed.

Chemical foam and water-spray installations

In certain cases water may be either ineffective as an extinguishing agent, or possibly dangerous, and one or other of the following automatic fire protection measures should be considered.

Carbon dioxide gas may be used in areas such as electrical switch rooms or highly flammable paint spraying or dipping plants. These installations should be controlled by heat-sensitive devices.

Foam installations should be used when petrol or other highly flammable liquids are used or stored. Water spray installations may also be used to control oil fires, and particularly those in oil-filled electrical transformers, oil-processing plants and paint and varnish works. Such systems may be automatic or hand operated.

Fire fighting

A private fire brigade can play an important part in safeguarding factory premises and form a very useful first link in the chain of fire safety. In the larger industrial undertakings the private brigade may well constitute a major fire-fighting unit, capable of dealing with the majority of fires which may occur. It is extremely important that close liaison should be established and maintained between such private brigades and the public fire service.

In order that the public brigade can fight a fire satisfactorily within the larger industrial building, it is necessary, amongst other things, to provide adequate hydrant outlets throughout all sections of the building. Alterations to plant layout and the erection of partitions and walls within production areas, which may restrict the use of or require the re-siting of hydrant outlets, should be notified to the Fire Authority.

Conclusions

Many single-storey factories are extensive in area, under one roof, and it may be expected that they will become even larger as automation becomes more widespread. Structures may be expected to be light in weight, tending to become merely weather protecting, and having little or no fire resistance.

From the fire safety standpoint these tendencies are undesirable. However, if the recommendations that have been suggested are implemented at the design stage and subsequently during the life of the building, the risk of the small fire, should it occur, becoming a large one may be substantially reduced.

The prevention of fire in industry is a matter for factory management and is closely related to good housekeeping, the importance of which cannot be too highly stressed. Lack of cleanliness and tidiness within the factory premises can soon produce conditions which may turn a normally non-hazardous factory into a high fire risk. Adequate maintenance and the training of personnel in an awareness of the potential hazard from fire can assist greatly in reducing the risk.