

ELEVATORS AND FIRE: DESIGNING FOR SAFETY

by *Albert J Gatfield*

Crown copyright 1991

ABSTRACT

This paper is based on two recent British Standards which provide comprehensive advice on both engineering and structural design requirements for lifts for firefighting access and address use as means of escape for disabled people. The circumstances of fires which have influenced the work are reviewed, and possible precautions and examples of the UK approach are discussed together with uncertainties which still cause concern.

concern about the conflict between improving and extending access to buildings for disabled people and the consequent need to ensure that they could get out safely in an emergency. The greatest problem was when the means of access to an upper floor was a lift which was then likely to be shut down when the fire alarm sounds.

The initial brief for a small group set up by the government's Fire Service Inspectorates was to consider and formulate guidance for fire authorities on the conditions in which a lift could be approved for escape use. The first task was a:

INTRODUCTION

Because I see the main purpose of this symposium as a forum for those concerned with the development of technical standards and public safety policy I suspect that you are not so much concerned with what the codes recommend as why they do so. I am a fire officer employed by government to further similar aims and that is why I intend to deal with the subject from that perspective: more as a philosophical discussion of the technical background of the work, than as a review of the published standards. The discussion will hinge primarily on the firefighting lift and I will deal firstly with each of the many elements which make up the complete system. Then I shall direct attention to the specific considerations related to use of lifts for escape.

I should also add that having attempted to produce this paper in the American version of the English language as a courtesy to my hosts, I have concluded that I could not keep it up consistently throughout so will now revert to the Queen's english. (But that is not to say a few 'Americanisms' will not slip in from time to time).

It must also be understood that the views expressed in this paper are my own and they do not necessarily reflect those of the Home Office or of the British Standards Institution.

The work in the United Kingdom during the past decade was mainly prompted by increasing

REVIEW OF ESTABLISHED PRACTICE

If a lift is to be used during a fire both structural fire protection and reliability are essential. There is no shortage of experience and expertise in the construction and engineering industries and in the fire service capable of identifying foreseeable hazards or, if they have the motives to do so, of their ability to properly address those hazards in the safety codes once they have been recognised. This is what we have aimed to do in the UK. The 'in government' group included fire service officers, an architect and lift engineer. Later at the British Standards Institution (BSI) other disciplines, together with user and other government interests, were able play their part.

The Problems - Those Experienced and Those Still to Come

The first stage of the work included:

- (1) studying reports of high-rise fires,
- (2) studying reported causes of lift failure,
- (3) assessments of the likely consequences of failure in terms of both personal safety and on their detrimental consequences for fire service operations, and
- (4) the identification and assessment of feasible design and construction measures to

address the unacceptable risks, or 'fall-back' measures to mitigate remaining risks.

In addition to the past experiences of fire services we also identified a number of other foreseeable problems which together presented quite a challenge.

We have adopted the term 'firefighting shaft' for the structural element of our firefighting access which is similar to the smoke-proof enclosure of the US building codes (1, 2, 3) or the smoke-proof tower of NFPA 101 (4).

THE FIREFIGHTING LIFT

Existing Codes

The special protective features to be found in lifts designated for firefighting access were in rather fragmented form and contained in both building design and engineering safety codes. In the United Kingdom we had the Building Regulations (5, 6) and the European lift safety code EN Part 1(7) which is published as BS 5655: Part 1. The only national mandatory requirement for the provision of firefighting lifts was in Scotland but many local jurisdictions in England and Wales had similar requirements in local building legislation. The most well known example was in London (8) where the then Greater London Council published their own code (9).

From the study of technical literature from several parts of the world we found that lift safety standards differed only in detail but there were significant differences in the associated structural requirements. What then are the hazards and what protection did the existing codes offer? Let us consider first the lift and then each of what we believe to be the other essential elements of a high-rise access facility?

Required Performance

Most codes require the lift to serve each floor throughout the height of the building and to be capable of reaching the top in not more than 60 seconds.

Whilst this may at first sight appear to be a reasonable target in very tall buildings it would permit an unacceptably slow speed in buildings of say 30m (100 feet) or so in height. In practice however basic passenger service requirements will normally provide an acceptable speed. In West Germany (10) they specify at least 1m/s for runs of up to 60m and 2m/s in taller buildings.

As buildings get taller and lifts even faster it may be necessary to consider braking distance when operating on emergency service. Although speed is of paramount importance, we do not expect the man driving the fire engine in the dark to go flat out when he knows he may hit fog round the next bend. His speed will be limited to that which he knows will enable him to stop within his field of vision. He should not be expected to ride a lift towards a fire without similar regard? Should, or can we, give firefighters the means to control the speed of the lift?

Another speed related consideration dictates that all levels in the building should be served by the same car and this too is common to most codes. This avoids the inevitable delay where it is necessary to change from one car to another across a 'sky lobby'. The Canadian building code (11) however does permit one change of lift. This movement will take quite a bite out of the 60 seconds permitted running time, but there can be some advantage because if one lift fails, a ride for half the journey is better than walking all the way.

Type and Size Car

Given a choice, which type of lift should be assigned to firefighter service? Although some codes choose a goods lift because of its greater capacity we prefer a passenger lift. This is far less prone to delayed response because of obstructed doors whilst loading or unloading the car than would be the case with a goods lift. The choice also reduces the risk of compromising the access as happened in Liverpool (12) where combustible goods in a designated firefighting lift caught fire.

The least generous 'minimum requirement' appears to be for an '8 person' car which, presumably for safety reasons, can only accommodate a fraction of that number comfortably. A crew of 3 or 4 firefighters in the same space with breathing apparatus, hose and the tools and equipment they need for the initial approach to a high-rise fire might justifiably feel ill-served.

The more realistic requirement is for a car which can take an ambulance stretcher. This will also provide space for emergency medical treatment for casualties which would be impossible in many of our firefighting lifts today.

Construction of Car

One of our fundamental aims, to reduce the possibility of fire in the firefighting shaft by limiting combustible materials is supported to

some extent by the European code which, in a rather tortuous translation, requires that "The walls, floor and roof shall not be made of materials likely to become dangerous through too great flammability or through the nature and quantity of gas and fumes they may generate."

That did not stop one UK manufacturer lining the floor and walls of a car with deep pile carpet almost an inch thick because (he said); "the standard does not control linings, only the structure." Some of you will recall the fire at the Las Vegas Hilton (13) where carpet used as wall linings in lobbies was said to have been a significant factor in external spread through 22 floors.

This is an example of where special needs are not always properly addressed. The lesson for code writers and regulators is to be specific about what is required and if you have special needs then you must be sure that they are properly addressed. If the fire load is to be limited not only must the car and frame be of non-combustible construction, but if combustible floor coverings and other decorative linings are permitted they should be of limited thickness and low flame spread classification.

Control and Operation

Firefighters' priority switch

In the United Kingdom we have traditionally used a simple two position toggle switch to recall the lift and to initiate the firefighter service. The switch is usually housed behind a glass cover intended, but not always successfully, to deter misuse. When we learned that one fire brigade were plagued by misuse of the facility in one of their local hospitals we did consider key switch arrangements such as that common in North America (14, 15). This was not done lightly because we do not like having to rely on keys in an emergency if it can reasonably be avoided nor do we like carrying them on our fire appliances.

On the balance of advantage we rejected the key option because:

- (1) Our experience is that keys can and do fall into unauthorized hands and the security advantage is lost;
- (2) If we loose the key we cannot get the priority service of the lift;
- (3) If the lift is running on key operation of the car control station it is absolutely dependent on the attendant in the car for movement and one man must remain with it to deal with fresh calls.

(4) When the firefighter service is activated by a conventional switch the car can be recalled to the entry level by the simple expedient of switching 'off' and the 'on' again. This gives the personnel aloft some freedom of movement because the car can be left unattended yet remain available to those at entry level. This may be particularly important in the early stages of operations when manpower is limited. Also, if the occupants of the car become disabled they can be brought back to entry level by colleagues down below.

In buildings where the 'break glass' box may not provide a sufficient deterrent to unauthorized interference we are proposing a locked box which can be forced by firemen if the key is not available.

Car control

We have no emergency stop switch in modern cars in the UK. When the car is on firefighting service it stops in response to the first registered landing call in its direction of travel and then all other registered calls are cancelled. It was accepted that this gives us an opportunity to correct mistakes and even reverse the car if necessary because it then needs a fresh call before the car will move off again. I have found myself however that stopping the car quickly when relying on landing buttons is easier said than, and whatever the reason for deleting the stop button for normal service control is should be reconsidered for use under firefighting service control.

Control buttons

There have been many reports of landing call switches being activated by fire and of lift cars consequently making un-controlled stops which have exposed passengers to severe fire conditions (16,17,18). This phenomena has been discussed in detail by others including Figiel (19) and Hanlon (20) but it has also been said that fire service concern about 'touch-buttons' has been an over-reaction, that touch buttons do not react to heat, and that any type of electric switch will malfunction if exposed to fire.

It has also been suggested that landing call buttons are not important because they are isolated when the lift is running on the firefighting service. But this ignores experience that if the car has responded to a call initiated by a fire and immobilized before firefighters arrive it will be of no use to them. Furthermore, instead of finding a lift ready to speed them towards the fire they may instead first have to recover casualties from the car

and have to climb the stairs and find it before they can do so.

In the building where I work we have what I am told are 'capacitance' switch buttons on landings and in the cars. If you press a call button when you have gloves on and nothing happens but if you do have gloves on, or your hands are full there is no problem. A little heavy breathing at close range will usually activate the switch. When this can be done in normal conditions I do not trust such switches in hot fire conditions and particularly the humidity which will be generated when water is used. Consider also the effect of a firefighter in wet, hot, steaming turnout gear crowded in the car close to the car control station. They might activate the whole array of call buttons. None of the national lift codes appeared to have addressed this sort of problem despite recommendations from fire investigators (18) as early as 1970.

We must accept that any electrical equipment might malfunction if exposed to the affects of fire. It is a fact of life which we cannot ignore. But what we must do is ensure that equipment controlling the firefighting lift is not going to malfunction at the first whiff of smoke, heat or humidity. If this calls for the old technology and mechanical push buttons instead of the modern electronic ones, then so be it.

Careful selection of control buttons, both in the car and at landings is essential. It is something we have addressed in the BS Part 5 code (21) and what is needed are buttons "which will not register false calls because of the presence of heat, smoke, moisture, flame or any other fire related phenomena".

In one London building they have managed the best of both worlds in their firefighting lifts after concern was expressed about capacitance buttons. The normal service control switches on landings and in the car are touch buttons and are all isolated when the car is running on emergency service. Then a separate car emergency control station utilizing mechanical buttons takes over control (22).

Solid state control systems

Following concerns that modern micro-processor control systems might be less reliable than what was called "traditional hard-wired systems" with mechanical contactors, we sought the specialist advice of our Health and Safety Executive (HSE).

The possible causes of trouble identified included:

- (1) supply voltage fluctuations,
- (2) radio interference from passing taxis, police cars, fire engines, building security systems, etc.
- (3) defective programming which might not show in normal service, and
- (4) the affects of high temperature.

Manufacturers assured us that they design to cater for voltage 'spikes' and radio interference, and we accepted that day-to-day service should show up anything due to local environment which had been missed. The problems of high temperature are addressed in EN 81 (7) which requires temperature control where necessary.

There remained at that time one source of potential trouble which would not show up in normal service, namely interference from the portable radios that firemen would bring with them and manufacturers are now advised to consult with the brigade at design stage and during commissioning.

Discussion of these problems coincided with publication of guidance on "Programmable Electronic Systems in Safety Related Applications" (23) by the HSE. The guidance is called up in the Part 5 code and, although it has no statutory force, it does have strong persuasive influence in the field of safety at work legislation.

Some time after publication of BS 5588 Part 5 we were told that an interruption of the connected supply could erase the memory of the control equipment, and restart could be delayed until the position of the car was re-established. This somewhat surprised us particularly in these days of "uninterruptible power supplies" (UPS) so dear to the computer industry and indeed when emergency lighting and fire alarm systems have survived on float-charged battery power for at least half a century. This has now led to proposals to tighten the performance requirements in this respect.

STRUCTURAL DESIGN AND LAYOUT

Lift well

The first structural design consideration is that of the protection of the lift car. The basic fire protection requirement for vertical shafts is often intended only to restrict fire spread from one floor to another. In this circumstance one hour enclosure of a lift well which penetrates a two hour floor will suffice; and if the lift is approached through a lobby at each level the doors need only be half-hour because there are four of them in series. As a consequence, the two hour separation

of floors would provide only one hour protection for those who must use the lift for prolonged periods during a fire. Having considered this anomaly however we agreed not to increase the door rating because we will have one of at least one hour leading into the accommodation and we expect firefighting operations to protect the opening while it is still intact.

Landing doors

Caution is necessary if we are to rely on the claimed fire rating of sliding landing doors for protecting the lift because few, if any, sliding doors can match a hinged fire door closing against stops when it comes to restricting passage of smoke and hot fire gases. Insulation is not required of landing doors in the UK where the only required criterion of the BS 476 fire resistance test (24) is 'integrity'. In the case of a steel landing door, integrity failure means the appearance of measurable gaps through which fire can spread.

Manufacturers are able to provide a door which will meet the integrity criterion with performances of 1½ to two hours in spite of the gaps, and consequent leakage, which are almost inevitable in the assembly. This is because the distortion is limited by inter-lock profiling which is designed to defeat the standard test probe where door leaves meet each other and the frame.

Seals are now being used which can reduce leakage at temperature up to about 205 degrees celsius but, while this may be within the service exposure range if the doors are not directly exposed to the fire environment, this condition cannot be guaranteed even if there is lobby protection. If we are to get a door which will provide the protection needed a combination of brush and intumescent seals is probably the answer but most important is the need for a realistic leakage test to establish satisfactory performance. Such a test is now being considered in Europe.

There are two final points which should not be overlooked with regard to landing doors. The first is the possibility of plastic or rubber components softening and causing doors to stick, or of the material running into guide channels and solidifying to prevent any movement. The final point is one of determining what fire performance is really needed from a landing door. Is it sensible to continue to accept doors which can quickly become red-hot radiators if exposed to fire? Suspension ropes have been known to part under such conditions, probably with very expensive consequences. There may not be a personal safety

problem if safety systems operate as they should but there may at least be a sound economic case for insulating doors to limit costly damage to the installation.

Machine room

In the United Kingdom, and probably elsewhere, the machine room was seen as a risk to other parts of the building so a requirement for a 30 minute enclosure was common. This might be enough to contain an electrical fire, but it will do little to protect the equipment from a fire in the adjacent space such as firefighters in Brighton, England found when they arrived at a high-rise apartment building and found the roof well alight.

The machine room should be protected within the enclosure of the firefighting shaft and this arrangement also affords the advantage of safe access if necessary during a fire. Whilst having the machine above the well is popular with installers it is also far safer from firefighting water. It may possibly be more at risk from fire but should be insignificant if adequately protected. Basement installation reverses the picture and from a practical safety point of view (although perhaps not for the installer) somewhere in between might offer a better option.

If the unthinkable happens and passengers are trapped in a stalled car they will need speedy assistance. It will necessary to get rescuers to the machine room quickly and their only way may be to climb the stairs to the top of the building. Delays will greatly increase the difficulties for both victims and rescuers and with this in mind should we not consider bringing the machine room nearer to ground level?

Lift/stair interface

Ease of access from the lift to a stairway is obviously an operational advantage for firemen carrying their equipment but there is a more important safety implication if the stair is not very close by. This was demonstrated when a doctor and his family took a lift to escape from a hotel fire in New Orleans (16). The lift stopped at the fire floor and they perished in an attempt to find a stair to complete their escape. Similar incidents have claimed victims from civilians at One New York Plaza (18) and firemen at the Willoughby Tower building in Chicago (25).

If we consider these incidents it is clear that we cannot deal with the lift in isolation. A

stairway is necessary for the final approach to the fire floor and its position in relation to that of the lift is important for operational efficiency, but more importantly as a ready and safe means of escape for those whom the lift may deliver to danger.

Lifts and stairs are often approached through lobbies. In the UK all exit stairs other than some in low-rise multi-stair buildings are lobbied to enhance the level of protection from fire in the accommodation areas, and the provision of a common access lobby to the lift and stair is an established feature of firefighting access in tall buildings. The physical layout which has been common in the UK and elsewhere for many years has individual protected enclosures for the lift and stair and these, together with the lobbies, are within what we have called a firefighting shaft.

Another important advantage of the collective lift/stairway/lobby configuration is that of fire containment. It is clear that anything which burns in the upper floors of a building has to get there, and out again, through circulation routes which are intended, by design, to be sterile of fire risk.

Nobody would deny that fires in lifts, stairways and lobbies are less frequent than those in other parts of the building but in terms of life hazard, disruption of business and major commitment of firefighting services in difficult conditions their consequences can be far more serious in relation to their size than one in the accommodation.

In the twenty storey Liverpool, England (12) office building, waste paper caught fire in the firefighting lift which kept running out of control for a while and was difficult to locate. The fire should have been contained but faulty construction detailing between the landing door frame and the structural opening permitted fire to spread into an adjacent services duct which ran through the lobbies. This comparatively small fire resulted in loss of power and telephone service to the building. Although the lobby suffered severe damage the fire did not spread into the adjacent stairway and firefighters were able to use it without difficulty.

Lobbies

When the lobby is used as a firefighting bridgehead sufficient space is needed to connect and charge hose before opening doors to tackle a fire in the adjacent accommodation. Siting of fire main outlets has an impact on the protection of both the stair and the lift but for different reasons. If hose has to be laid through or from the stairs

and into the accommodation the smoke will compromise the exit for occupants of upper floors.

This was experienced at the Prudential Building fire in Boston (26) when the fire attack had to be delayed for people to evacuate the upper floors. For this reason we prefer the outlet to be in the lobby but again we find a conflict of advantage because of possible flooding.

Although lobbies are intended to be sterile of fire risk, if they are large enough they may be used as work-space or for storage, so a balance must be struck to provide working space for the firefighters whilst not encouraging others to take it up. An example of the problem was at the Conrad Hilton hotel in Chicago (27) where a lobby area of about 9m by 15m was enclosed on three sides by banks of lifts. This provided convenient storage space for a stack of chairs covering an area 3m by 4.5m which caught fire and caused serious malfunction of the lifts.

Even with small lobbies it is almost impossible to keep them sterile because most will be a route for the movement of goods or furniture, and in offices, the daily collection of waste paper.

Our answer in BS 5588 Part 5 has been to limit the lobby to between 5m² and 20m². A proposed increase in the upper limit would permit 5m² for each the lift is being considered but I am not sure that simple floor area values are the complete answer. It is important not to lose sight of the basic objective which is to provide sufficient room for convenient movement but not spare space, including odd corners or cul-de-sacs, where goods and rubbish can be conveniently deposited. The ideal is probably a large area in which the position of doors makes it impossible to set anything down without its being an intolerable obstruction.

Access into the accommodation

Unless the building is sprinklered, firefighters are likely to find a serious fire by the time they can assemble the resources to start an effective attack. In these conditions they should not have to contemplate fire threatening the firefighting shaft through openings which they cannot over with a hand-line. This means that where any floor is of open plan the access to the accommodation will be limited to one door. There should however be scope for flexibility in design because if the internal sub-division is of fire compartment standard, such as may be found in apartment buildings or mixed office occupancies, a separate access door to each will pose no greater threat.

These restrictions on doors cannot be absolute because there may be times, particularly in 'core' buildings, when overriding egress requirement call for more than one point of access to meet travel distance limitations.

Balcony access

An alternative to the lobby approach is to have both the stairway and lift discharging onto an open balcony. This would also meet the 'smokeproof' principle of the US codes and has been a feature in apartment buildings design in the UK, (28). Balcony access lost favour after a fire which involved extensive combustible external cladding created major firefighting and rescue problems at a London apartment building (29). One answer is of course the control of construction materials which did not apply when that building was erected. Another hazard is that of external flame spread of which we have seen some dramatic examples (13,30). Effective compartmentation should have some affect by reducing fire size but that is not a complete answer. The established principle of protecting external escape stairs from fire exposure provides a starting point but for prolonged use by firefighters more extensive protection must be considered.

CONTROL OF WATER

Firefighters in both the UK and the US have experienced loss of lift service when water gets into a lift well. The report of one incident during a fire on the 24th floor of an apartment building in Glasgow (31) provided an excellent perspective of the problem with the conclusion that "the integrity of lifts is at risk whenever free water is present in the lift lobby. This condition may evolve with a likelihood commensurate with the seriousness of the fire and the scale of operations. Consequently, the greater the need to keep the lift in operation the more likely that the facility will be lost".

That statement would probably be endorsed by Chicago firefighters after a similar incident (32) where they too were faced with a similar climb after the first attack jets from aerial ladders put lifts out of action. EN 81 (7) recommends that "a slight counter slope be provided in front of each landing still to avoid water from washing, sprinkling, etc, draining into the well" but this does nothing to control firefighting water whether it be from hydrant, hose or sprinklers.

The most obvious and likely problem will arise from water pouring into the lift well where it can reach door interlocks and car control circuits. Power supply equipment may also be vulnerable if not sensibly selected and protected.

The lifts in an apartment building at Slough near London were supplied by bus-bar conductors running not in the lift well but through the lobbies in a duct behind fire resisting closures. The duct was rightly fire-stopped at each floor slab but flooding of the lobby floor from firefighting jets shorted out the power. It is a simple matter to make a list of structural measures which will keep water from running into a lift well. A sill will be very effective but it will rarely be acceptable because it is a constant hazard. In some circumstances stepped or sloping floor surfaces to divert water might be practicable. There is no easy structural answer but the problem cannot be ignored.

Care in the selection and installation of suppression systems can reduce the chances of water putting the lift out of service. The first step should be to seek alternatives in areas where water can cause unacceptable problems. The next is to be selective in choice and siting of individual sprinklers. There is a precedent in a New York City (33) where sprinklers in lobbies are of the automatic re-setting type which cease to flow when temperatures drop.

When using sprinklers with the conventional discharge pattern drenching the landing doors is almost inevitable but if the area can be covered by sidewall sprinklers fitted on the same plane as the doors the risk might be greatly reduced. If fire main outlets are in the lobby, they should be sited where any uncontrolled discharge is least likely to hit landing doors.

Another approach is applied protection to vulnerable electrical equipment. This is done successfully for external wall-climber lifts which must be proofed against rain storms so why not adopt the same measures for the firefighting lift. In BS 5588: Part 5 one of the options is to provide electrical equipment with Class IPO3 protection in accordance with BS 5420 (IEC 144) (34).

RESCUE FROM A STALLED CAR

Although we have tried to make our lift as reliable as practicable we cannot ignore the possibility of passengers being trapped in a stalled car. All of the lift safety codes (7,14,15) appear to offer similar options for rescue and all rely on assistance from outside the car.

Our assessment of these methods was that:

(1) If we are lucky the car will be close to a landing so once it has been located it is a simple matter to open the doors and help the passengers out.

(2) Hand-winding the car to bring it close enough to a landing so that the doors can be opened, is a slow process and may not be available on the larger cars.

(3) Assisting passengers through emergency doors in the sides of the car to an adjacent one needs both the second lift to have survived that which has defeated the protected one and a skilled engineer. This we thought rather unlikely and a chance few of us would like to rely on.

(4) In normal times assisting passengers first through a trap-door in the roof of the car and then up to a landing above is probably the most difficult and hazardous option of all. It is not something to take lightly but it does appear to be the most assuredly available design strategy on offer in existing lift codes. That is what we have recommended for the firefighting lift.

I say 'design strategy on offer' because there is an alternative which has been very effectively used when firefighters have broken their way out of a stalled car. Although this is typical of the ingenuity of firefighters when faced with trouble one might well take the view that such action would not be necessary if the cause of failure had been recognized and addressed beforehand. And perhaps it is possible that the success of such exercises owed something to poor workmanship or materials. Nevertheless, the ability to break out within a few minutes without having to rely on outside assistance must be preferable to the delays inherent in the conventional methods. There is a wide choice of building blocks which will provide all we need in terms of protection and durability, but which can be readily breached with hand tools. Should we perhaps design for break-through panels in the wall of the lift well.

SMOKE CONTROL

Operational Requirements

Keeping the firefighting shaft reasonably clear of smoke is probably our most difficult problem both on the fireground and in the code writing committee. For firefighting access the requirement for smoke control is that firefighters should be able to get as close to the fire level as possible before

smoke slows their progress and they have to use their breathing apparatus.

This is rather different to the requirements for escape routes although there must be some compatibility between both. By the time firefighters reach the fire floor occupants at that level should have moved to safety, so smoke getting into the lobby, which is almost inevitable when hose is taken through, should not present a hazard to those escaping. This has given us a rather smaller target for smoke control, that of keeping the lift and stairway clear, the lift for firefighters and the stairway for both firefighters and for occupants of other floors.

Natural Ventilation

Of the methods available for smoke control, the simplest is the provision of vents in the enclosing structures of lobbies and stairways. To be effective when required vents must be open but experience with those permanently open in early post-war apartment buildings has shown that they do not remain so because occupiers block them to stop draughts. More recently simple openable vents, usually windows, have been favoured but even these are not proof against interference, sometimes by those in authority who do understand their purpose.

In the 12 storey Slough building I have mentioned there have been two fires which demonstrate the problem. The first was in a ground floor store and it filled the stair with smoke. This caused considerable difficulty to occupants evacuating and to firefighters who had to break windows to clear the smoke. It was then found that windows provided for venting had been welded shut after one had been used for a suicide jump. The building owners were pressed to correct the situation but a later fire in the same building proved just as troublesome. Some of the smoke vent windows were now open, but only a few inches and fixed rigidly with a welded steel strut to foil further suicides.

One might think the answer lay in automatic vents activated by smoke detectors, and designed to 'fail safe' by opening in case of power failure. Not quite so unless they are re-set after the power failure. Tenants in a London apartment building objected to the wind blowing through the open vent after such an event and again, when it should have opened by design, firefighters found the vents forced shut, distorted and inoperable and yet another smoke-logged stair. This clearly demonstrates a management and maintenance

failure but designers and engineers should anticipate this sort of problem and provide equipment which can cope with conditions of use and misuse. In this case, vents which can be re-set easily by unskilled people.

Pressurization

In the code we have given designers the option of providing either natural ventilation, or a pressurization system which should comply with principles set out in the pressurization code, BS 5588 Part 4 (35).

Pressurization appeared to offer a more promising means of achieving our objectives but we remain a little suspicious of things mechanical with a potential for failure. The design aim of Part 5 (21) has been stated as achieving a pressure in both the stairway and lift well which is above that of the lobby; and if the lobby in turn has a pressure above that of the fire area then that is a bonus.

Because of design difficulties in pressurizing very tall shafts an alternative option of pressurizing selected lobbies was suggested. For this concept to work effectively rather complex detection and control equipment would be needed but there was a more fundamental problem which is common to any pressurization system. What if there is a fire in the pressurized space? Smoke could be pushed into the stair and lift wells and through them into the accommodation on other floors. By comparison fire in the pressurized lift or stair should at least leave one route clear.

Combined Systems

In spite of its uncertainty, natural venting still has some support amongst fire officers in preference to pressurization. A combination of both natural ventilation openings and pressurization might offer maximum advantage. Openable windows in the lobby would provide a more aesthetic environment for occupants and they could serve as an exhaust path for pressurization air from the shafts. Then, if the mechanical system fails they can be utilized as natural ventilation.

De-pressurization

De-pressurizing lobbies is another way of achieving the required pressure differential across

the stair and lift doors and if air is dumped to the outside, along with any heat and smoke generated by a fire in a lobby, then this is perhaps the best of all mechanical methods of control.

In its simplest form this could comprise fan extract to open air with open vents to admit replacement air. A more sophisticated version will be familiar to many of you from the US building codes (1,2,3) where the purge is achieved by a combination of input and extract fans.

ELECTRICAL POWER SUPPLIES

Two reliable sources of power are necessary for the lift with the primary source from a public utility. The essential alternative supply should come from a generator but although the BS code recognizes a supply from a sufficiently diverse public utility circuit, sufficient diversity is very rare.

Both supplies should be protected within the building from their source to the equipment they serve and be sufficiently separated or protected from each other to avoid the risk of any mishap to one also disabling the other. A measure of physical security is also necessary to guard against interference such as the opening of switches by unauthorized persons.

The intention of the Part 5 code had been to run two completely independent supply systems to a change-over switch in the machine room. Whilst the cables may be run partly within the lift well the whole of both supply installations, for example, transformers, switchgear, and normally cables etc, should be enclosed within protective structures equal to that required for the lift itself. Cables classified CWZ to BS 6387 (36), that is, capable of maintaining circuit integrity under fire conditions, are acceptable without protection from fire but precautions against mechanical damage and thermal movement may be necessary.

Two parallel supply circuits obviously make for greater reliability but a common conductor with a high degree of reliability might also be considered. This could permit the supply change-over switch to be sited other than in the machine room but for the connecting conductor to be as reliable as practicable, the conductor should be without joints and have a current rating above that of its maximum load.

Further, it is suggested that all supplies should be transmitted through insulated cables which will make it far less easy both to 'tap' the supply, or to repeat the Slough experience of shorting the bus-bar conductors with firefighting water.

When considering power requirements for the lift it is important to include the needs of the other facilities necessary to ensure that the lift can be used safely and efficiently both in the assessment of capacity and in the necessary measures to protect supply systems. These facilities will include smoke control, communications and lighting equipment, and possibly fire pumps.

CONSTRUCTIONS AND MATERIALS

Durability and Fire Properties

Constructions forming the lift well, machine room, lobbies and stairway etc in the building should be non-combustible to reduce the risk to the access-ways and equipment and must be sufficiently robust to withstand mechanical damage in both day-to-day use and during the course of firefighting. In my view this means brick, concrete or similarly substantial materials and not plasterboard partitions which are more likely to be damaged and too easily perforated. I am also concerned that vibration and movement of board structures can open up joints and permit smoke to penetrate. Reports that lift wells constructed with 'gypsum board', which had no openings where they passed through the fire area, at the First Interstate Bank (30) were filled with smoke does nothing to ease this concern.

The measure of fire-resistance of the protective structures should be such that it will afford safe access within the building, but most importantly the stair must also provide a safe route of egress, possibly up to the time when deteriorating conditions make withdrawal necessary. When considering this time element it might be as well to note that the First Interstate Bank fire lasted over 3½ hours and an extreme experience, of the Hong Kong Fire Service (37) who once had a high-rise factory fire burn for four days.

It is important that any limitations of the fire tests prescribed for the structural elements are not overlooked. If the fire resistance test criteria for the enclosing structures are stability, integrity and insulation; smoke leakage is permitted provided fire cannot get through. Smoke tight-ness of structures is the first essential for smoke control and it must not be omitted by default.

The possibility of a fire within the lift, stair or lobbies should not be ignored. Any fire is likely to be less severe in terms of heat release and duration because of the limited area in which combustibles

can be present. We have chosen as minimum requirements two hour protection for the firefighting shaft structure and 1 hour for separations within the shaft.

The structural protection of enclosures for electrical services, smoke control equipment and other related facilities must equal that of the lift.

LIFTS FOR ESCAPE FOR DISABLED PEOPLE

Escape Lifts

BS 5588 Part 8 (38) is the code which acknowledges that a suitable lift can be used for the evacuation of disabled people in a fire emergency. It is not a code for the use of lifts, but it offers lifts as an available option. Stairs are another option but even where a lift is used stairs must still be readily available for use as a last resort. What the code does say is that any lift to be used for the evacuation of disabled people should be either a firefighting lift, or an "evacuation lift" which it then describes. In all important respects they are very similar.

It has been accepted for many years in the UK that means of escape in case of fire meant that any person should be able to make their way to safety without having to rely on assistance from others or having to use any mechanical or manipulative device. In accepting lifts we have departed from both of those basic understandings.

To accommodate this departure we must attempt to match the reliability of the lift to that of the protected stair for which it is intended to substitute. With a high level of reliability of the lift, the means to get passengers out of the car and the structural protection to hold back the fire we are close to achieving this aim. For the mechanical risks have been greatly reduced, but not entirely eliminated. I am not suggesting that breakdowns are likely, for they are not. But they can happen and have done so too many times in the past for the risks to be ignored.

If the lift stalls, trapped passengers will be subject to severe psychological stress and if they are not released quickly they may in time succumb to fire gases so we only see it's use justified for those who cannot use the stair safely.

It is also our intent that strict control be exercised in operating the lift and in overall management of the evacuation. This requires means of communication so that those waiting for the lift can make their position known and

instructions can be passed to the lift operator. In some circumstances it may be essential to the safe conclusion of the evacuation that the precise position of the danger is known so that appropriate directional instructions can be given. This might call for a fire detection and indicating system.

VARIATIONS ON A THEME

Structural separation

The lobby approach configuration provides a good level of fire protection for the lift and stair and also convenience for those who must use them during a fire emergency. It is what might be called the 'basic' design for compliance with Parts 5 and 8 of BS 5588 for the many reasons which have been discussed and in new work we see little justification for any variation or 'equivalency'. For escape lifts in existing buildings which are not protected by lobbies or which are not close to a stair however equivalency may be considered. In the basic configuration the separation between the lift/stair and a fire in the accommodation can be measured in numerical terms as being of two fire doors which is the minimum requirement. If there are lifts at more than one location in the building constructing lobbies is the best option for safety but if this is impracticable, separation elsewhere between them can usually meet the requirement.

A simple example is that of an office building with an enclosed lift and stair at each end, and a corridor running between the two, an additional fire door across the corridor should ensure that any fire is sufficiently separated from one lift for it to be used safely. If the problem is one of remote stairs the basic tenet is that if people waiting for a lift have to move before it arrives they must be able to get to another safe means of exit from the storey without having to pass through any space affected by the fire from which they are escaping.

Where alternative arrangements of this kind are made the contribution of fire detection and indication systems to quickly establish the position of danger, and the communications and signalling systems to exchange information and instructions between those involved in the evacuation becomes much more important.

Further Information

The physical and human aspects related to the use of lifts for evacuation are discussed in a

separate contribution to this symposium by Pauls et al (39). The inter-relationship between the escape lift, fire alarm and communications systems, possible variations in technical arrangements and evacuation procedures have been discussed in more detail by Gatfield (40).

CONCLUSIONS

This new approach to the design of lifts for emergency use can benefit many people. The hazards facing firefighters when they approach high-rise fires have been evaluated and addressed.

Building owners and designers will have a better understanding of how they can better contribute to the protection of their own property and enhance the safety of those who frequent their buildings.

Disabled people will meet fewer restrictions because building managers should be more able to provide a safe environment for them.

And finally, I believe the Part 8 code will provide valuable support to the fire safety enforcers and building officials. For they have frequently met accusations of being unreasonable in their attitudes to access for disabled people and particularly with regard to the use of lifts during a fire. Their caution has been a natural reaction given their statutory duty to ensure that buildings are safe for all its occupants. There will no longer be a lone judgement against a long entrenched wisdom which, not without justification, forbade the use of lifts for escape.

BS 5588 : Part 8 provides the authoritative guidance and support they need which in turn gives them greater confidence in their decision making. But what is more important, it gives them the sound technical consensus support for their individual judgements which has been lacking in the past.

This presentation has been intended to stimulate discussion by highlighting a number of fire safety problems which may not previously have had the attention they deserve. If it has been short on answers this has been intentional because with proper analysis of the problems you will find the answers with which you can more readily accept lifts as something more than a certain fire trap, and for the wider benefits they can offer.

But we cannot leave the subject of design for fire safety without a final caution. You must be able to assure yourself, and others, that the lift is as safe and reliable as you can reasonably make it. And finally that if it can go wrong in any way, any passengers trapped in the car be released safely.

ACKNOWLEDGEMENT

The author wishes to record his appreciation for the valuable assistance of many fire service officers whose shared experiences have contributed to the understanding and appreciation of the complex problems of lift use during fires. These have included officers of the Toronto, Chicago, St Louis and New York City fire departments during visits to those cities, from Hong Kong where they themselves conducted a survey of current practice in the early 80s; and of others who have shared their experiences through fire service journals. In this connection past and present members of staff at the NFPA; Charles Rule, Joe Redden, Elwood Willey, Tom Klem and Martin Henry have all kept important information flowing and their help is gratefully acknowledged.

REFERENCES

- 1 Building Officials & Code Administrators International, Inc. 1987 "The BOCA National Building Code". BOCA, Country Club Hills, IL
- 2 International Conference of Building Officials, 1979 "Uniform Building Code." ICBO, Whittier, CA
- 3 Southern Building Code Congress International, 1979 "Standard Building Code." SBCCI, Birmingham, AL
- 4 National Fire Protection Association, 1988 "NFPA 101 Life Safety Code" NFPA, Quincy, MA
- 5 Department of the Environment/Welsh Office, 1985 "The Building Regulations 1985" HMSO, London
- 6 Scottish Home and Health Department, "The Building Standards (Scotland) Regulations 1981 & 1982." HMSO, London
- 7 "BSI, 1979," EN 81 Part 1 (BS 5655 Part 1) Safety rules for the construction and installation of electric lifts." British Standards Institution, London
- 8 Greater London Council, 1939 "The London Building Acts (Amendment) Act 1939," HMSO, London
- 9 Greater London Council, "London Building Acts (Amendment) Act 1939 - Section 20 Code of Practice." GLC, London
- 10 Gunther, K P, 1979, "High-rise buildings - a German approach.." 'Fire International' (UK) September 1979
- 11 Associate Committee on the National Building Code, National Research Council of Canada, Ottawa, 1985 "The National Building Code of Canada"
- 12 Merseyside Fire Brigade, 1981, "Fire at Metropolitan House, Liverpool" Internal Report
- 13 "Anon, 1982, Investigation report on the Las Vegas Hilton Fire." 'Fire Command' January 1982 pp52-63
- 14 Canadian Standards Association, "CSA B44 Safety Code for Elevators, Dumbwaiters, Escalators and Moving Walks." CSA, Rexdale Ontario
- 15 American National Standards Institute, "ANSI/ASME A17.1 Safety Code for Elevators, Dumbwaiters, Escalators and Moving Walks." ANSI New York, NY
- 16 Watrous, L D, 1972, "Fatal Hotel Fire: New Orleans" 'High-rise Building Fires and Fire Safety' 1972 pp21-24 NFPA, Quincy MA
- 17 Powers, C, 1971 "3 in Elevator Die As Contents Blaze In Fire-Resistive New York Building." 'Fire Engineering'. (US) pp 40-42 March 1971
- 18 New York Board of Fire Underwriters 1970. "One New York Plaza Fire" New York, NY
- 19 Figiel, W J, "The control of elevators during a high rise building fire." 'Fire Protection Science and Technology' (UK) No 5, pp24-27. Fire Protection Association, London (Reprint from Elevator World [US]).
- 20 Hanlon, J, 1972, "Lift ride to death". 'New Scientist' (UK). February 1972
- 21 BSI, 1986, "BS 5588 Part 5 Code of practice for firefighting stairways and firefighting lifts." British Standards Institution, London

- 22 Western, F, 1981, "Pre-planned fire safety for the people in Nat-West's tower." 'Fire' (UK) April 1987 pp 1981 pp551-552
- 23 Health and Safety Executive, 1987. "PES Programmable Electronic Systems in Safety Related Applications"
1. An Introductory Guide.
2. General Technical Guidelines"
- 24 BSI, 1972, "BS 476 Fire tests on building materials and structures." British Standards Institution, London
- 25 Anon, 1985, "How trapped firemen fought for their lives." A Chicago newspaper report
- 26 Klem, T and Kyte, G, "Fire at the Prudential Building." 'Fire Command', March 1988 pp14-19
- 27 Grimes, M E, 1972, "Hotel Fire : Chicago", 'High-rise Building Fires and Fire Safety', pp16-20 NFPA, Quincy, MA
- 28 BSI, 1971, "CP 3 Chapter IV Precautions against fire Part 1 Flats and maisonettes (in blocks over two storeys)." British Standards Institution. London
- 29 British Standards Institution Committee paper.
- 30 Chapman, P, 1988 "High-Rise: An Analysis." (1st Interstate Bank, Los Angeles, Fire) 'Fire Engineering' (USA) August 1988 pp55-61
- 31 Strathclyde Fire Brigade 1979, "High-rise flats - Disablement of lifts by water during firefighting operations." unpublished internal report.
- 32 Best, R, 1975, "High-rise Apartment Fire in Chicago Leaves One Dead." 'Fire Journal' (US). September 1975
- 33 Gorton, J and Laffey, M F, "The better to fight high-rise fires." 'Fire Service Today' (US). pp19-21.
- 34 BSI, 1988, "BS 5420 Specification for degrees of protection of enclosures of switchgear and controlgear for voltages up to and including 1000 V a.c. and 1200 V d.c." (Equates with IEC 144) British Standards Institution, London
- 35 BSI, 1978, "BS 5588 : Part 4 Code of practice for smoke control in protected escape routes using pressurization." British Standards Institution, London
- 36 BSI, 1983, "BS 6387 Specification for performance requirements for cables required to maintain circuit integrity under fire conditions." British Standards Institution, London
- 37 Fender, B G, "Fighting fires in high rise industrial buildings." 'Fire International' (UK) February/March 1988 pp25-27. (Paper presented at the 'Fire East '87 Conference')
- 38 BSI, 1988, BS5588 : Part 8 Code of practice for means of escape for disabled people. British Standards Institution, London
- 39 Pauls J L, Gatfield A J and Juillet E, 1991, "Elevators for Egress : The Human-Factors Problems and Prospects" Paper for Symposium on Elevators and Fire, Baltimore, MD
- 40 Gatfield A J, 1989 "Principles of Fire Safety for Disabled People in Buildings" Paper presented at the National Fire Protection Association Annual Meeting, Washington, DC.

Albert Gatfield has been involved in fire prevention work since 1949. In 1976 he joined the government's Property Services Agency Fire Branch and in 1978 was appointed as an Assistant Inspector of Fire Services in HM Fire Service Inspectorate, Home Office, London. Mr Gatfield has experience across a wide range of fire prevention duties including enforcement of fire safety legislation, fire survey, advisory and plan scrutiny work. In his present appointment he has been engaged in technical fire safety policy work and has contributed to the production of fire safety guidance published by the UK government whom he represents on a number of technical committees including those of the British Standards Institution, The Institution of Electrical Engineers and the Institution of Gas Engineers. Mr Gatfield is a corporate Member of the Institution of Fire Engineers and an Affiliate of the UK Chapter of the Society of Fire Protection Engineers. He has also served on the LAFC Fire Safety Codes and Standards and Fire Prevention Committees.