THE EFFECTS OF WATER INGRESS INTO FIRE FIGHTING ELEVATOR SHAFTS

BY SIMON RUSSETT

Ever since buildings were first constructed, fear has been associated with fire spreading out of control, with the obvious disastrous effects. Over the years, codes and standards have been developed through academic and practical research and from anecdotal evidence to help reduce this risk.

Numerous codes and standards have been written and this has culminated in the current editions of BS 5588 (2004) Fire Precautions in the Design, Construction and Use of Buildings – part 5: Access and Facilities for Fire Fighting; and BS EN81-72 (2003) Safety Rules for the Construction and Installation of Lifts – Particular Applications for Passenger and Goods Passenger Lifts – Part 72: Fire Fighters Lifts.

BS 5588-5 (2004) has been developed from the 1991 edition to omit specific requirements for elevators and to focus primarily on the building requirements. BS EN81-72 (2003) is a national standard and is part of the BS EN 81 series of standards: “Safety rules for the construction and installation of lifts” and is complimentary to the introduction of BS EN 81-1 (1998) and 81-2 (1998); (and future documents in draft at present, pr EN81-5, 6 and 7).

The relevant standards indicate that water will enter the fire fighting elevator shafts during fire fighting operations from hoses, etc. Fire fighting cores that contain an elevator(s) are constructed from materials to provide 120 minutes fire protection and equipped with facilities to prevent ingress of smoke, provide ventilation and to drain water away.

When fire fighters are attacking the source of the fire, they will evaluate the location, use the elevator to get to the level below the fire, connect hoses and test, move up through the stairwell to the fire source level and out through the door onto the floor area. (See figure 1.) They will do this with extreme care so as not to enter a space where opening a door could create a sudden rush of air and the resultant flashback, or if a fire has compromised the fire compartment. (See figure 2.) Once this has been ascertained, they will enter the floor and locate the fire source. Either at the source or a distance before, they will activate the hose(s) to create a wall of water to cool the surrounding area to enable the fire fighters to progress and douse the fire. In discussions with Fire Brigades in the UK, they have confirmed that before the riser is energised via the tender, they will usually visually check the floor valves are closed (not tampered with or vandalised)

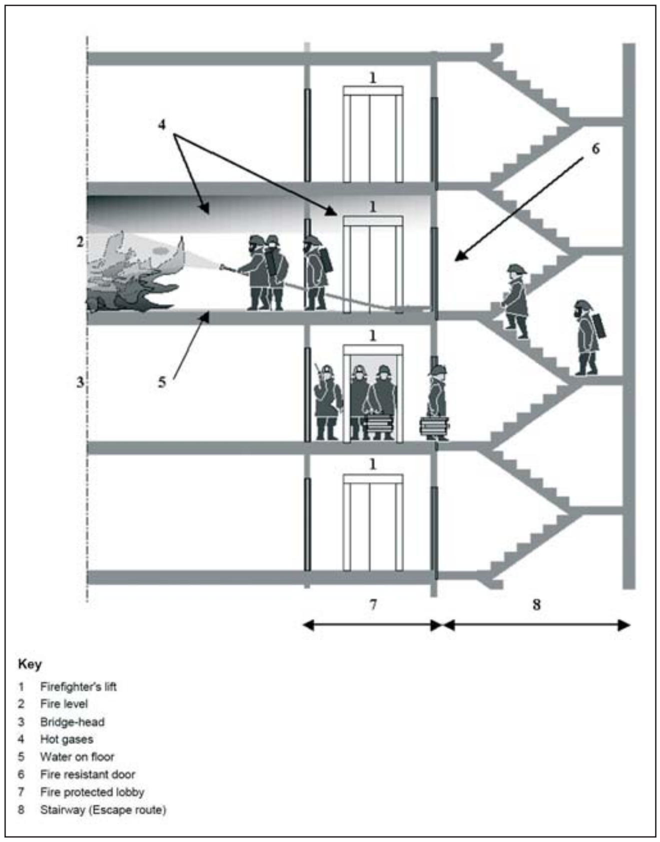

Figure 1.

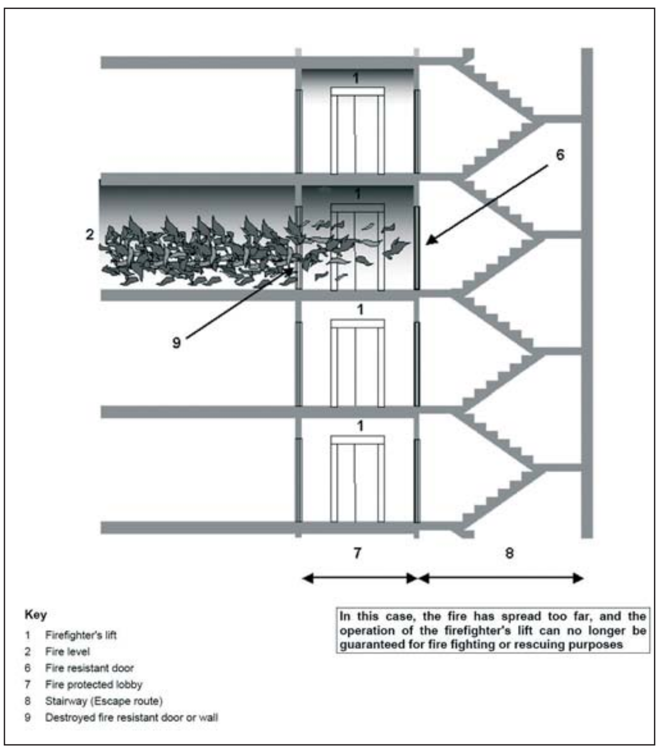

Figure 2.

BY SIMON RUSSETT

at all accessible levels, as this prevents pressure and unwanted water release.

It is imperative that the building design limits the flow of water into the elevator well; and that electrical equipment is protected against water. EN81-72 (2003) makes a clear statement under clause 5.3.4 that "suitable means shall be provided in the pit to ensure that water will not rise above the level of the fully compressed car buffer." And in clause 5.3.5 that "means shall be provided to prevent the water level in the pit from reaching equipment which could create a malfunction of the fire fighters lift."

The standard does not offer what a likely water flow rate is into the elevator well or what 'means' could be utilised. BS 5588-5 (2003) indicates that the minimum flow rate from an energised fire main, as recommended in BS 5306-1 (1987), is 25l/s and this is considered representative of likely flow rates from other sources.

BS 5588-5 (2003) also states that there have been several recorded occasions when water from a landing valve, hose lines, etc. has entered the elevator well and caused malfunction of the installations when it reached electrical door interlocks, car controls, etc. It is therefore necessary to minimise both the effects of water entering the elevator well and on the operation of the elevator.

To minimise the effect of water penetration, electrical equipment within the fire fighting elevator well and on the car should be protected against water in accordance with BS EN81-72 (2003) (See figure 3). "There are a number of ways in which water penetration can be avoided or minimised and the method chosen ought to be appropriate to the building. Suitable methods include the provision of drainage channels and drainpipes, and/or laying the elevator landing to a fall so that any water entering the lobby will not enter the elevator well but will drain away down the stairs and/or into a smoke shaft and/or to gargoyles or scuppers on the outside of the building".

Most Architects do not relish the thought of incorporating drainage channels and drainpipes to the elevator landing threshold, as this causes coordination issues on the routing of the drainage, hazards and maintenance issues. Obviously this is the most inclusive solution as a large proportion of water is drained away from the doors and water is prevented from entering the shaft. BS5588-5 (2003) clearly identifies options, but suggests methods chosen "ought to be appropriate to the building" and that "drainage channels AND/OR laying landing to a fall" could be provided. This can and does usually lead the design team down the route of the simplest solution in providing a 25mm high ramped threshold in front of the landing doors. But the question is "how much water will drain through the elevator lobby and enter the shaft over the threshold and under the landing doors"?

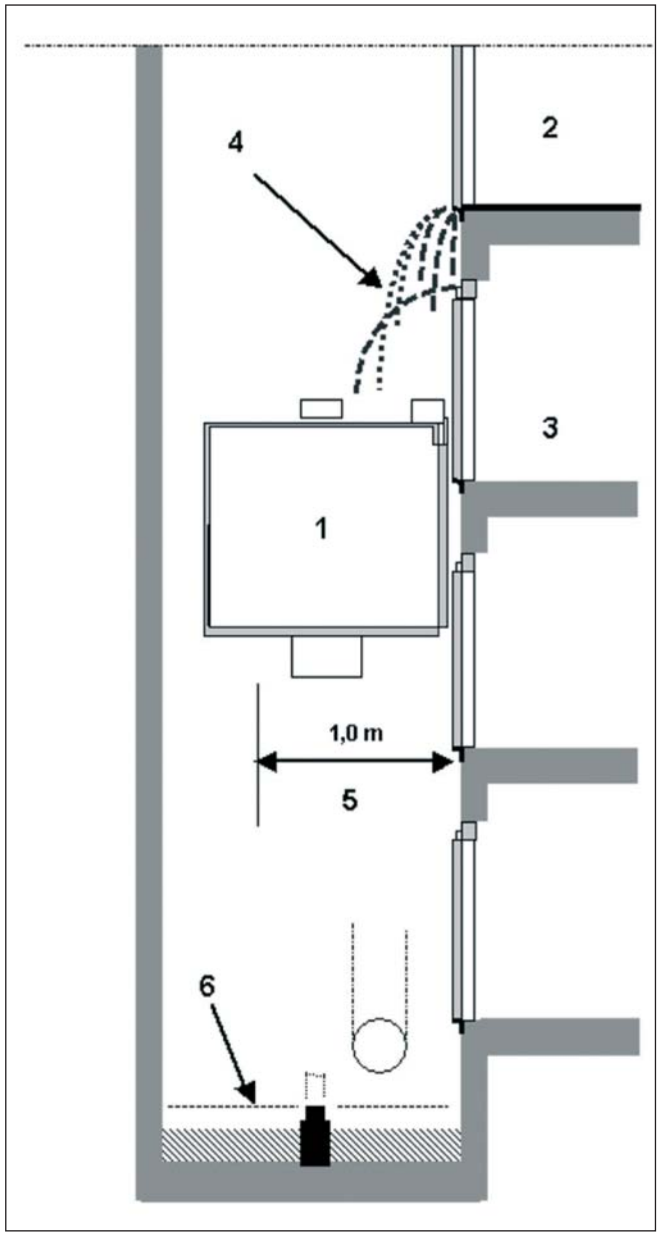

Figure 3.

BY SIMON RUSSETT

CIBSE Guide D - Transportation Systems in Buildings 2005 edition, section 6.0 – Fire fighting lifts and escape lifts for people with disabilities, was updated from the 2000 edition to include changes in BS 5588 parts 5 and 8. Guide D indicates that a standard elevator, fitted with a fire service switch cannot be considered a fire fighting elevator. It goes on to indicate that as early as 1930, it was recognised that fire fighters should be provided with a means of swift access to the upper floors of large buildings. This resulted in conventional elevators being fitted with a break glass key switch at the FSAL which, when operated, brought the elevator quickly to that floor. This then evolved to provide dedicated elevators with features to ensure safe use by and protection of fire personnel during emergency situations. CIBSE Guide D (2005) does provide definitive statements within section 6.0 for compliance with other British Standards, but does not implicitly state that pumped drainage is required in fire fighting elevator pits.

A fire fighting elevator, unlike a normal passenger elevator, is designed to operate for as long as is practicable (for at least 120 minutes) when there is a fire in parts of the building beyond the confines of the fire fighting shaft, as it is used to transport fire fighters and their equipment to a floor of their choice.

Most dedicated single fire fighting elevators are a minimum of 8-person capacity and BS ISO 4190-1 Lift (US Lift) Installation, Part 1 – Class I, II, III and VI Lifts (1999) indicates average shaft dimensions of 1800mm width x 2100mm depth. Depending on rated speed, the pit depth will vary. (It is assumed that 1 cubic metre can hold 1000 litres of water and all dimensions are in millimetres.)

The 'sump zone' below the fully compressed buffer can be derived by calculating the volume using standard shaft dimensions with an increasing depth of pit. The flow rate into the shaft to cater for the maximum minimum operational period of 120 minutes can then be calculated per minute and per second, to correlate with the pit depth, all as indicated in table 1 below:

E.g. a pit depth of 1600mm and a sump zone of 1m:

3.78 x 1000 = 3780 litres

= the storage volume available below the fully compressed buffer

For the elevator to stay in fire fighters operation for 120 minutes, the flow rate into the shaft would have to be:

3780 / 120 = 31.5 litres per minute

31.5 / 60 = 0.525 litres per second

This simple calculation accommodates a rectilinear pit area and the volume in the pit could be further increased if a sump recess is provided for a portable pump to be placed into the pit space.

This is purely a mathematical approach to determine the volume a pit can accommodate for given

Pit Depth (mm)	Shaft Dims & Sump Zone (m)	Available Volume (m^3)	Water Storage (Litres)	Litres Per Minute into Pit	Litres Per Second into Pit
1400	1.8 x 2.1 x 0.8	3.024	3024	25.2	0.42
1500	1.8 x 2.1 x 0.9	3.402	3402	28.3	0.47
1600	1.8 x 2.1 x 1.0	3.780	3780	31.5	0.52
1700	1.8 x 2.1 x 1.1	4.158	4158	34.6	0.57
1800	1.8 x 2.1 x 1.2	4.536	4536	37.8	0.63
1900	1.8 x 2.1 x 1.3	4.914	4914	40.9	0.68
2000	1.8 x 2.1 x 1.4	5.292	5292	44.1	0.73
2100	1.8 x 2.1 x 1.5	5.670	5670	47.2	0.78
2200	1.8 x 2.1 x 1.6	6.048	6048	50.4	0.84

Table 1

BY SIMON RUSSETT

dimensions and the flow rate that will fill the sump zone in a given time period. Most buildings are not internally watertight on a floor to floor basis (e.g. stair wells, riser shafts, connection points and building materials); these elements will have an effect to drain water away from the elevator shaft. By definition this will prevent large quantities of water from entering the shaft.

Some of the major manufacturers have proposed through their notified bodies to supply water detection systems that advise emergency personnel the water level in the pit is rising and a dangerous situation is occurring. When the water level is detected above the height of the compressed buffer, some then go on to restrict service, where possible, to the lowest level. This approach, whilst going some way to tackle the issues, does introduce different solutions that could result in confusion with emergency personnel.

It also does not solve the problem if the elevator passes the last level served at full speed, with the buffer remaining as the final method to retard the downward movement of the car within accepted levels, without injury to passengers. Modern elevator systems can usually detect if movement is uncontrolled and halt the elevator using either electrical means, by engaging the brake, or by mechanical means during over speed, by engaging the safety devices. As fire fighting elevators are relatively recent requirements, most are installed with modern control systems and safety devices that detect and prevent uncontrolled movement.

Anecdotally, the consensus between the Fire Officers responsible for accepting buildings in the UK, where fire fighting elevators are fitted, is to resort to the applicable standards and to assume the only bullet proof method is to install pump(s) and drainage system(s). Most elevator suppliers will require a sump and associated pump in the elevator pit to satisfy the code requirements. If it is simply a sump, what volume is required and how can the water be prevented from rising if a portable pump cannot be used? A fitted sump pump will require duty and standby power supplies, regular testing and fault

BY SIMON RUSSETT

monitoring as it is part of the emergency provisions. I am yet to see one that is provided in this manner and if it was, would it be maintained to ensure operation when required to do so?

The provision of a sump pump is outside of the elevator contractor's scope of supply and they identify this on their construction drawings as 'by others'. There have been numerous instances in recent years where elevator contractors have refused to put fire fighting elevators provided by them to BSEN81-72 (2003) into service, as means to prevent water rising above the height of the fully compressed buffer has not "in their opinion" been provided. None of the standards indicate that a sump pump is 'the' solution and it has been widely adopted by the elevator industry that this is the only solution!

In some cases it has been adopted that where a sump pump is not provided, the pit area volume below the compressed buffer, becomes a sump zone. If the water rises, float switches and/or water detection devices can be fitted to first warn that a dangerous situation is approaching and then second to prevent service to the lowest level served. I understand this was suggested on a project, but the fire brigade insisted upon a sump pump being retro-fitted. The pump set and pipework installation as indicated in figure 4, resulted in a contravention of BS EN81-1 as a crushing could occur if maintenance personnel were in the vicinity of the pipework and an uncontrolled car descended. Further reviewing the requirements and if local authorities insist upon pumped drainage being provided, this could be achieved by a packaged pump set located outside and adjacent to the elevator pit. This would enable simple access for maintenance and operation and would not pose any dangers within the shaft.

Figure 4.

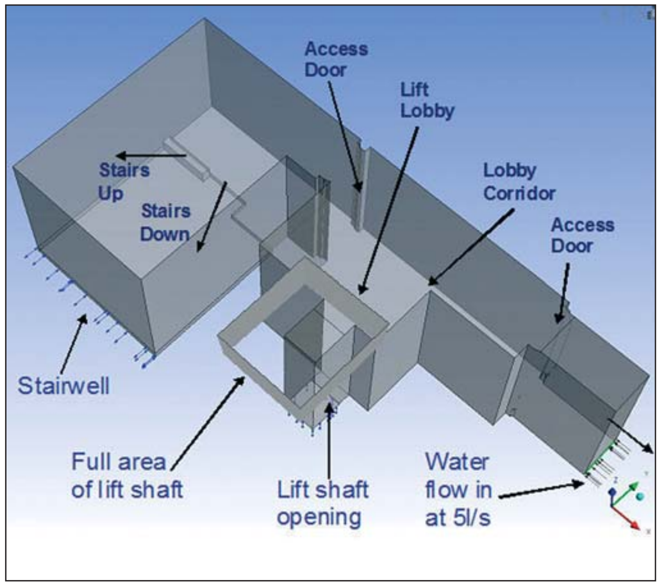

Figure 5.

Research using a Computational Fluid Dynamics (CFD) model of a fire fighting core (see figure 5), with water entering the lobby from various locations has indicated that the majority of water will dissipate through the building and not go near or even enter the fire core. Most commercial buildings are designed with raised computer floors, with fire barriers between floors and cores. This provides a defence to water draining back into fire fighting core areas. All fire fighting lobby floors are constructed from concrete and raised floors are not provided in these areas. Depending on the location of the fire source, a quantity of water will drain back under the lobby door and into the elevator lobby. This water will join with water that has run back along the hose pipe and water that has leaked from the fire main connection. Leakage is a concern and in discussions with local fire authorities, they have advised that the equipment they use is regularly serviced and replaced when damaged beyond repair. They have also advised that in their experience, leakage of water from connected hose pipes is minimal. They have also advised that disconnection of a hose from a fire main during fire fighting is also extremely rare and instances of this occurring had not been reported. This is not saying it has not happened, simply that if it did it was not serious enough to report.

The CFD modelling process has indicated that with minimal water entering the elevator lobby, and a large proportion of this being gravity drained down the stairs away from the elevator landing threshold,

BY SIMON RUSSETT

only a small amount of water will spill over the raised threshold and down the elevator shaft.

The results of the research has indicated that through CFD modelling, much less water than the applicable codes and standards anticipate, will enter the elevator pit and affect the height of the fully compressed buffer (See figure 6). With a probable flow rate of 5l/s into the lift lobby, the CFD model indicates only 0.25l/s enters the shaft, over the 25mm raised landing threshold. This is considerably less than anticipated and using this in conjunction with table 1, a pit depth of 1400mm will be adequate to accommodate the water ingress over a period of 120 minutes and not compromise the height of the fully compressed buffer.

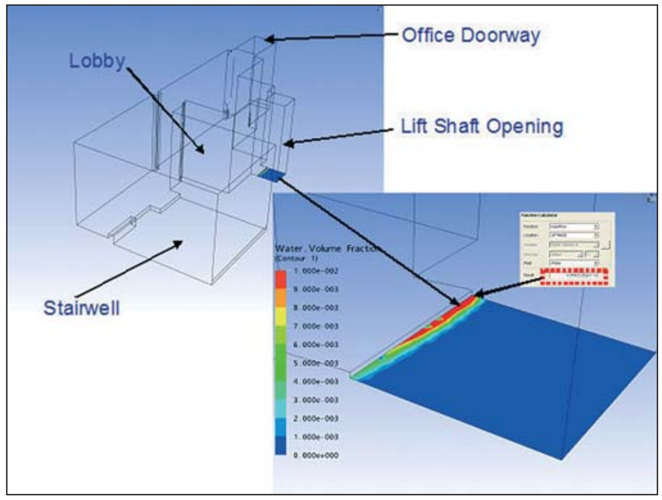

Figure 6.

The CFD model has successfully tested what is largely anecdotal evidence that water will enter the elevator pit in sufficient quantities, so to affect safe elevator operation during emergency conditions. It is on this basis that the requirements of BS EN81-72 (2003) and BS 5588 Part 5 (2004) that deal specifically with the effects of water ingress can be reviewed. The outcome of the research has indicated that the provision of dedicated pump sets in the elevator pits is not necessary, as there is insufficient water to create a hazard.

BY SIMON RUSSETT

It must also be noted that statistically the majority of fires in the UK occur within residential dwellings and not commercial buildings. Changes in statutory codes has also facilitated the provision of sprinkler systems within residential units, that used to be limited to commercial buildings required to comply with the Fire Safety Guide No. 1 – Fire Safety in Section 20 Buildings (1997). All new residential buildings that are designed after 1st January 2007 are required to be provided with sprinkler systems that are achieved through plastic pipe work that is connected only to mains water supply. This has been common in the USA for a number of years and has been proven to initially limit and then prevent the spread of flame from normal fire sources, such as foam and timber.

Used alongside the current requirements of BS EN81-72 (2003) and BS 5588 Part 5 (2004), it is this change in statutory code that will significantly reduce the effects of fires within residential buildings.

The Building Regulations (2000) for England and Wales; Fire Safety Approved Document B (ADB 2000) deals with the design features that are required and the precautions that are to be incorporated to limit the effects of fire in buildings. Recent research concerning modern buildings and there uses, has resulted in changes to ADB (2000) that now facilitates the location of the rising water fire main for residential buildings to be in the stair well and not the elevator lobby area. It allows this because a number of residential buildings have been designed to include the elevator lobby as part of the apartment space, therefore rendering it private and not for general access. It also makes sense as most residential buildings are provided with dual purpose elevators, where one of the main passenger cars will also be designated for fire fighting. Locating the rising water main directly in a residential apartment is not considered a satisfactory solution by Building Regulations. This has been a trend and looks too be consistent with designs for future residential buildings. This arrangement does restrict water escaping from a rising main and draining directly into an elevator lobby and enables the water to drain directly down the stairs.

This methodology has not yet been accepted for commercial buildings as commercial offices are provided with dedicated standalone fire fighting elevators with separated lobby areas. However, changes in ADB (2000) now allow main passenger elevators to be also used as fire fighting elevators, with access from the rear through a protected lobby. This can be applied to all fire fighting elevators, as long as the elevator connects to the stairs and is within a core with 120 minutes fire protection. However, any solution will be subject to agreement with local Building Control Officers.

On all fire fighting cores, stairs have to directly connect to the fire fighting lobby and the simple answer for commercial buildings would be to adopt locating the fire rising mains water in the stair well as residential buildings. This would then keep water away from the elevator and shaft altogether.❑

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