Challenges to Drafting a Standard for the Evacuation of Disabled People Using Lifts

Nick Mellor

Lift and Escalator Industry Association, UK.

Keywords: Lifts, elevators, evacuation, codes, standards, capacity assessment, minimum lift car dimension.

Abstract. A standard for the design of a lift to be used for the evacuation of those who cannot easily use the stairs (an evacuation lift) ideally needs to respect different strategies for the evacuation of a building. In the case of evacuation due to fire the building design needs to protect the evacuation lift for at least the duration of the evacuation. Building design and management aspects vary according to the type of building and are subject to national building regulations which vary across different territories (they are not harmonized at a European level). This might partly explain a lack of convergence of evacuation lift solutions during a period where the use of lifts for evacuation has been widely discussed. In looking at evacuation lift provision and capacity, key considerations are: how many people might need or wish to use lifts for evacuation; and how can those most at need be prioritised? These challenges are discussed with reference to the development of a draft European Norm prEN 81-76 for evacuation lifts and in the context of undertaking a capacity assessment for the number of evacuation lifts which might be needed. This paper is written from a UK context.

1 INTRODUCTION

Building Regulations in many territories including the UK have set requirements for accessibility for all including disabled people. While setting the general requirements to consider the means of escape in case of fire, many have lagged in setting such clear requirements for the evacuation of disabled people. Especially in residential buildings, building design is often on the basis that occupants will "*stay put*" in the event of fire, based on effective compartmentation. There is considerable debate in the UK about the provision of means of escape for disabled people, for example, if compartmentation fails. Any changes in regulations or guidance in this area pose considerable challenges, especially for existing buildings.

Building regulation guidance and British Standards have for many years recognized the possibility of using lifts for the evacuation of disabled people [1, 2]. The evacuation lift described in these standards has been based on an evacuation assistant taking control of the lift car by operating an evacuation lift switch and then using the car controls to drive to floors where people await evacuation. This use of an evacuation lift, as part of a managed evacuation, presents challenges when applied to buildings such as residential buildings and (small) multi-tenant buildings where there would not usually be a team which could quickly mobilize and who could take charge of an evacuation.

A number of authors have recognized the potential benefits of using lifts for the evacuation of disabled people. Hewitt [3] reviewed the need for carry-down procedures to evacuate people not able to use stairs unaided and concluded that such procedures presented building management with very significant problems and presented evidence of the cost-effectiveness of using evacuation lifts. O'Loughlin, Wiles and Ryan [4] have advanced alternative concepts for evacuation lifts.

Work has been underway at CEN, the European standardisation body, on the development of a standard describing new lifts used for the evacuation of disabled people and a draft for public comment was recently published [5].

A standard for the design of a lift to be used for the evacuation of disabled people and those with difficulty in using stairs needs to respect different strategies for the management of evacuation of a building. In the case of evacuation due to fire, the building design needs to protect the evacuation lift for at least the duration of the evacuation. Since both the *management* of the lift during an evacuation and the *design of the building* are developed between a number of different specialisms and experts, it is clear that this is a multi-disciplinary and potentially complex task. In Europe, although lift requirements are usually harmonized across CEN countries, building design requirements are determined by national building regulations.

It should be noted that CEN lift standards are limited in the guidance they can provide for aspects beyond the lift specification such as the building design elements necessary for protecting an evacuation lift and interfacing it with the building systems.

In a UK context, the building design elements should follow guidance to the Building Regulations and either follow standards for the fire safety of buildings such as BS 9991 or BS 9999, or take an alternative fire engineered route.

Having identified the importance of the building's evacuation strategy for the operation of evacuation lifts, how might a lift operate in response to commands from the building management system (BMS)? The options include the following.

- **Remove the lift from service**. Lifts not intended to be used in the event of fire, for the use of firefighters or evacuation lifts, could be removed from service e.g. using the methodology of EN 81-73 [6]. The lift car would be recalled to the exit floor, allowing passengers to exit the lift car, and then be removed from service. Since the scope of EN 81-73 specifically excludes lifts that remain in use in the event of fire (lifts for the use of firefighters and evacuation lifts), it is not applicable to these types of lifts. However, a similar methodology to EN 81-73 could be used to remove an evacuation lift from service if it could be unsafe to use e.g. fire detected in the lift spaces by a suitable fire detection and alarm system.
- **Recall to exit floor to await evacuation assistant to take control of the lift**. The evacuation operation described in BS 9999:2017, Annex G [2] is based on an evacuation assistant taking control of the lift. At the time of writing, this is the only evacuation lift operation described in British Standards and has remained relatively unchanged since first included in British Standards in 1988 [1]. After recall to the exit floor, an evacuation assistant/ driver can use the evacuation lift to drive to the floors where there are people needing the lift for evacuation i.e. who cannot readily use the stairs. This has advantages of simplicity.
- **Automatic (self-evacuation operation)**. This was suggested by O'Loughlin, Wiles and Ryan [4] who noted that "*challenges that would need to be addressed include the applicable control logic, prioritisation of the lift response depending upon the fire scenario, the level of information provided to the user(s), and overcoming the traditional instruction of 'do not use the lifts in the event of fire*'". Such an operation would need the BMS to determine whether it would be sufficiently safe, raising questions about its decision making and security. Other questions revolve around ensuring that lifts in an automatic operation are effectively prioritised for the evacuation of those depending on lifts.

How the lift might behave under automatic evacuation operation is further considered below.

Note: Control of an evacuation lift described in BS 9999 by an evacuation assistant has superficial similarities to the control of a firefighters lift described in EN 81-72. Although it might be technically feasible to apply evacuation lift requirements in addition to the requirements of EN 81-72, use of the lift for evacuation should cease when the lift is recalled from the firefighters lift switch.

2 EVACUATION LIFT WITH AUTOMATIC EVACUATION OPERATION

A CEN standard is limited in the guidance it can provide for aspects beyond the lift specification. In the case of a driver assisted evacuation described above, the basic specification is mature and well understood [8]. However, in the case of a novel solution such as a lift for self-evacuation, the lack of additional guidance in a CEN standard for interface issues might make the introduction and application of the standard more difficult. There is therefore scope for national standards and guidance to address this gap to help with the safe application of a CEN standard.

The draft BS 9991 [7] recognises that automatic evacuation operation should not be used unless there is a building management system (BMS) in place to:

a) recall the lift;

b) provide the automatic evacuation signal; and

c) where landing calls are to be accepted only from priority floor(s), signal the priority floor(s) to the lift controller.

The safety of the lift also depends on there being a fire alarm and detection system covering the lift spaces and lift lobbies to suspend evacuation service (similar to the operation in EN 81-73).

Clearly, resilience and decision making are essential elements of the BMS.

A crucial consideration for the building design is how long the evacuation lift should be available to operate to evacuate people who would have difficulty using the stairs, and hence the minimum period for which it needs to be protected from fire, minimum autonomy time of a secondary power supply etc. It is assumed to be two hours for a firefighters lift, which is professionally supervised. This is where a consideration of the traffic flow is required using well-established methods based on an estimation of the number of people needing to be evacuated by lift, and the intended use/operation of the lifts.

The proportion of people on a given floor of a building who might need the use of lifts for evacuation can be categorized as:

1. Those unable to use the stairs – even for a single floor.

2. Those who would have difficulty using the stairs to evacuate from their floor of the building. This proportion would increase with floor height to take account of their impairments and factors such as fatigue. For simplicity, this proportion includes those who start to evacuate by stairs but due to fatigue or injury need evacuation lift service from a lower level.

3. There is a further proportion who, although the lift would be designated for those with difficulty using the stairs, would opt to use a lift that is available even though they could use the stairs.

Clearly, in considering the specification of evacuation lifts, it is important to estimate the demand for them, how to prioritise their availability for intended users (items 1 and 2), and how to control or mitigate use by others which might have an undesirable impact on their availability (item 3). This paper reviews a number of sources which have tried to assess the proportions of building population which might use evacuation lifts. It is noted that in these sources, building users were surveyed for their intentions based on the lifts being fully available to all.

There is an underlying concern that specification of the number of evacuation lifts based on estimates of the users in categories 1 and 2 might result in the under-provisioning of evacuation lifts, if used by a significant number of users in category 3.

The strategies available to address demand from the third group above are:

- Evacuation lift controls are for use by evacuation assistants who take control of the lift during an evacuation. This is the approach taken in the UK with the first publication in 1988 of BS 5588-8 [1] through to more recently BS 9999 [2]. This strategy is applicable where suitably trained assistants are available e.g. managed buildings.

- Where lifts are to operate automatically without trained assistants, then their application could be restricted to buildings of up to a maximum height/ number of floors. At such a height, most users would be assumed to opt to evacuate by stairs.

- Where lifts are to remain in operation without trained assistants and the building height is not restricted then all the lifts used for regular access could be specified as evacuation lifts to ensure adequate provision or the number of lifts should be selected according to a more detailed process. This is the basis of ISO/TS 18870 [9] which provides more guidance in this more complex scenario.

3 DEMAND FOR EVACUATION BY LIFT

The implications for the specification and number of evacuation lifts were briefly discussed in section 2. This recognized that demand for use of lifts for evacuation relative to floor height consisted of a fixed demand (item 1) and demand which would vary according to floor height (items 2 and 3).

3.1 Estimate of numbers of population requiring a lift to evacuate

The UK Government [10] estimates that 15% to 22% of people have a disability and that of all disabled people, 46% to 63% are estimated to have a mobility impairment. Multiplying the low and high values gives a range of 6.9% in the low scenario, 13.9% in the high scenario, and a central estimate of 10.1%. Although noting that this assumption is uncertain, and might be an under-estimate if significant numbers had not self-identified. A figure of 10% has been used elsewhere such as DD CEN/TS 81-76 [8].

The UK Government data referenced above estimating that 22% of the population have a disability, also provides details on impairment type with 46% of all disabled people reporting mobility problems and 33% reporting stamina/breathing/fatigue problems. Other categories with temporary impairments should also be considered such as people with injuries, pregnant women and companions/partners of the mobility impaired person. Taken together, these might indicate greater numbers of the population needing to use a lift for evacuation.

While such broad estimates might provide baseline assumptions where no better information is available, figures relating to the type of building and its intended use might be used when available. It is prudent also, in providing fixed assets and building space, to consider how changes over the life of the building could impact the figures used in design. Trends in the general population to longer life expectancy and co-morbidities including obesity would argue for a conservative (higher) figure to be used, noting that in social housing, 40% of occupants might have mobility issues and 40% might have stamina problems.

It is difficult to find accurate data on the numbers of wheelchair users as Hewitt [3] observed but estimated 1.5%. Users of wheelchairs and mobility scooters would need attention not only to ensure a suitable minimum size of evacuation lift car, but also because a wheelchair user would occupy the space of several ambulant disabled passengers.

3.2 Research into assessing the potential demand for evacuation lifts

While some broad conclusions can be drawn from evacuations due to real emergencies, the data available from post evacuation surveys is often not sufficiently detailed so other sources, typically surveys, are useful.

Owing to the lack of use of lifts for evacuation, these studies have been undertaken where the general expectation is not to use lifts. Unless noted otherwise, the surveys were conducted on groups who have not been trained to use lifts as part of an evacuation.

Heyes and Spearpoint [11] reported on post-evacuation drill surveys of students and staff of the University of Canterbury, New Zealand, and online surveys completed by workers (the majority were engineers) from Arup from locations in Perth, San Francisco and Singapore. The post-evacuation drill survey was given to students and staff after evacuating two buildings on campus as part of a drill. 91 people completed surveys about their evacuation experience and were asked if they would consider using lifts if it were acceptable to do so. Participants were divided into two groups; "*educated*" who had been taught that lifts could be used as part of evacuation and "*uneducated*" who were not. In the online survey, 138 participants were asked to judge how imaginary characters would behave within a hypothetical evacuation, their understanding of evacuation procedures in their building, the number of stairs that they would be capable of evacuating down and what concern they would have for using lifts/stairs during an evacuation.

The data, from 5 to 60 floors was presented in a graph to which a linear regression line was fitted to predict the proportion of lift users given the floor level:

$$p = 1.14f + 5.3 \qquad 5 \leq f \leq 60 \text{ floors} \tag{1}$$

where:

p is the percentage of occupants to use the lift (%)

f is the floor level of the building

A goodness of fit value (R^2) of 0.877 was achieved.

Heyes and Spearpoint [11] reported a negative correlation between willingness to use lifts and the waiting time to evacuate. The proportion of occupants willing to use the lift was seen to reduce as waiting time increased and a further linear regression was used to describe the dependence of the proportion on waiting time.

Kinsey 2011 [12] and Kinsey et al 2012 [13] presented data drawn from online surveys on the overall proportion of participants that would consider using a lift/stair for a number of floor ranges. This showed increasing proportions of participants that would consider using the lift increasing as the floor number/height increased. They noted that approximately 10% of the population would use a lift even if located on the lowest floors i.e. 2-10. The proportion of the population that would use the lift increased to approximately 80% at floor range 31-40 and remained at this level for the higher floor ranges. In addition, the results suggested that when located on or above floors 21-30, the majority of people on each floor would elect to use the lift compared to the stairs. Above floor 30, approximately 20% of the population were not prepared to use the lifts to evacuate irrespective of floor number/height.

The relationship between proportion of floor population who would use the lift to evacuate and the floor number presented by Kinsey et al [13] figure 5 is reproduced in Figure 1.

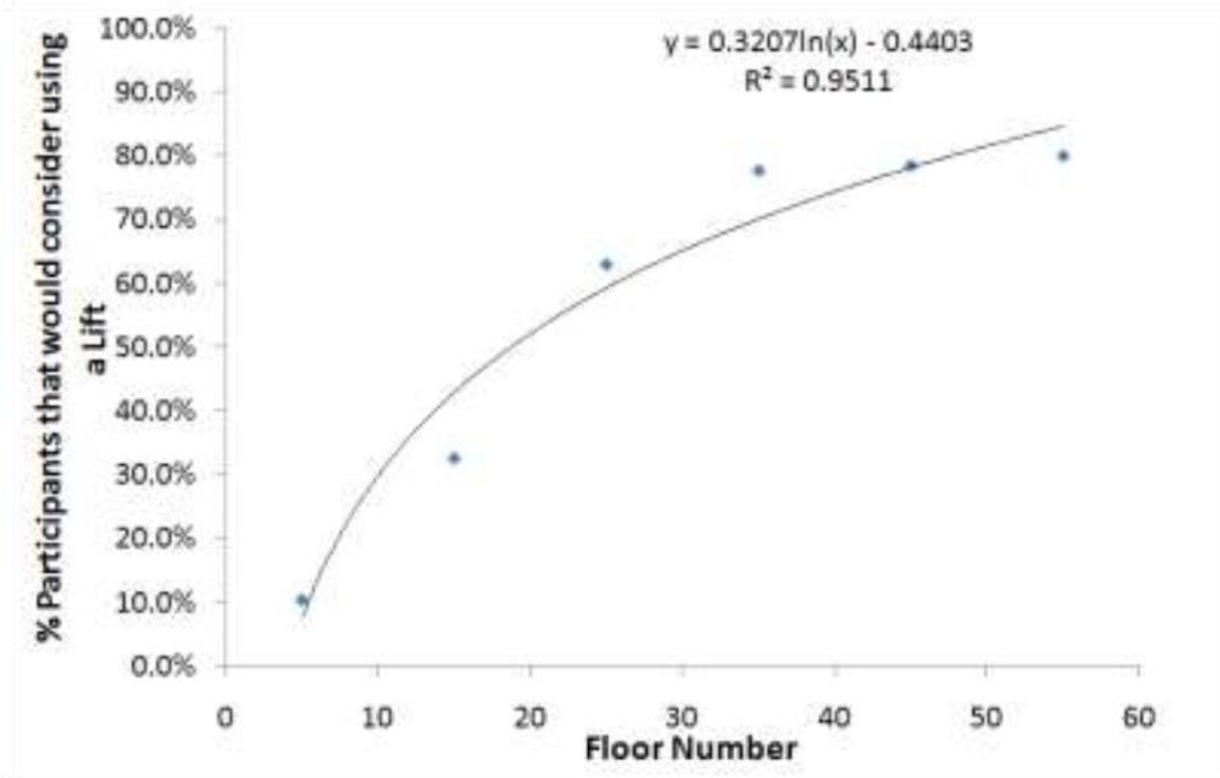

Fig 1: Proportion of participants that would consider using a lift according to floor number
(Figure 5 from Kinsey et al [13])

The data presented in Figure 1, the mid-points of each floor range (e.g. 5, 15, 25 etc) with the respective proportion of participants that would consider using lifts during the evacuation has been plotted. Using regression analysis, the relationship between the floor number and percentage of participants shows the following formula to approximate the data:

$$p = 0.3207 \ln (f) - 0.4403 \text{ for } 5 \leq f \leq 55 \quad (2)$$

Where 'p' equals the proportion of people that would consider using a lift and 'f' represents the floor number that the people are initially located on above ground level. An R^2 goodness of fit value of 0.95 was obtained from this formula which suggests it to be a good predictor according to the data collected. It should be highlighted that this formula is only applicable between floor ranges 5-55 (the lower and upper mid points of the floor ranges).

Jönsson and Andersson [14] in a survey of 10 of Sweden’s tallest buildings found that the floor a respondent was on was a clear factor in their perception of risk and whether they said that they would use a lift to escape. They found that the relationship was linear (2% at 2 floors up to 21% at 24 floors).

Ding et al. [15] reported on experiments in a 10 floor building in Beijing using 45 students; 27% were prepared to use lifts before education and 40% after briefing. They were asked to complete questionnaires which showed the proportion willing to use lifts up to 75% at 20 floor and 100% for 50 floors. Figure 2 reports the results from Ding et al. Although it can be noted that the general form of the results is similar to Kinsey et al., the proportions willing to use lifts are generally 20% or more greater than the equivalent figures reported by Kinsey et al. for the proportions that would consider using the lift. It might be observed that even at large numbers of floors, some residual proportion would be expected to use stairs.

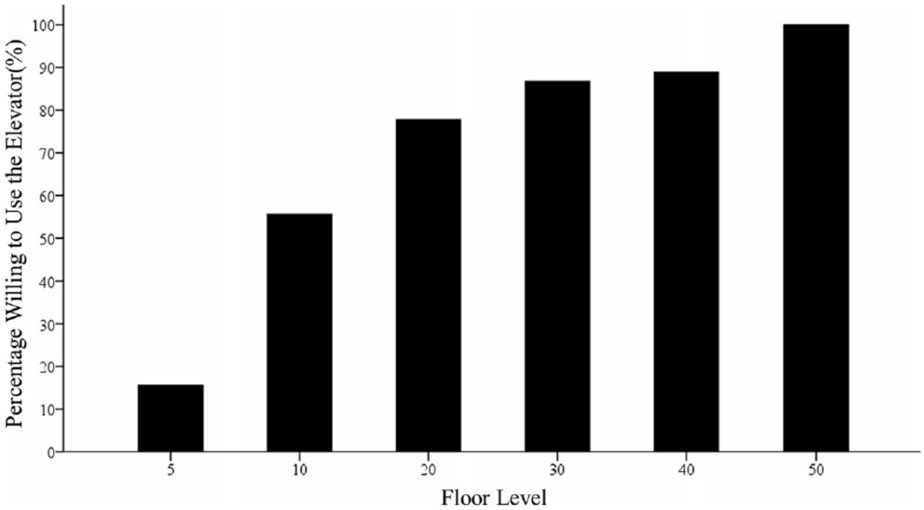

Figure 2: Cumulative percentages of participants who want to use elevators (Figure 3 from Ding et al)

3.3 Demand for lifts for evacuation – conclusion

Except for very low building heights/ lift travel distances, any baseline estimate of numbers of people needing to use lifts for evacuation either owing to not being able to use the stairs or because of stamina/breathing/fatigue issues is likely to be significantly increased by those seeking to use lifts to evacuate – either because of stamina/breathing/fatigue issues or because they have otherwise opted to use lifts.

The implications for specification of evacuation lifts specifically allocated for the use of those needing lifts for evacuation are clear:

- Except at very low floor heights, the estimate of floor population needing to use a lift for evacuation should take account of this additional demand if the needs of those relying on lifts are not to be compromised.
- Except in low rise buildings, if there is a simultaneous evacuation strategy, all passenger lifts should be specified to be used for evacuation. This takes the specification of evacuation lifts away from the scope of prEN 81-76 (evacuation of disabled people) [5] and to the scope of ISO/TS 18870 (evacuation of the general building population) [9].
- For modelling purposes, the figures from Kinsey et al. would be a good basis, adjusted to include a minimum demand even for low rise lifts.

4 INFLUENCE OF EVACUATION AND MANAGEMENT STRATEGY

As discussed earlier, evacuation lifts might be specified with at least two generic ways of working:

1. **Driver assisted evacuation lift** An evacuation lift switch is provided which allows a trained evacuation assistant to control the lift. This is not further discussed in this section because the evacuation team should be able to direct the lift to the floors where evacuation is needed.
2. **Automatic evacuation operation** Signals from a Building Management System (BMS) switch the lift into an evacuation operation which shuttles between the exit floor and the priority floor to be evacuated. Key issues are the BMS determining that the environment allows the evacuation lift to operate and how the landing calls are prioritised.

Taking the "automatic evacuation operation" and looking at the way landing calls might be prioritised, prEN 81-76 [5] proposes that the priority of the landing calls would be based on distance from the exit floor with the furthest landing call getting highest priority, if not otherwise specified by the evacuation strategy.

The landing calls would usually be connected directly to the lift control system and so the lift control system could readily prioritise landing calls based on their distance from the exit floor and would need only a simple interface with the BMS to achieve this. Such a landing call prioritisation might be appropriate for very simple low rise buildings but suffers from not being able to prioritise calls from floor(s) where fire is detected and the immediately adjacent floors.

Where a phased evacuation is needed e.g. fire floor and floors immediately adjacent are prioritised for evacuation over those more distant from the fire floor, this would need to be specified as part of the definition of the evacuation lift. The interface between BMS and lift controls in this case would need to be more sophisticated to communicate the prioritisation to the lift controller to allow the lift control system to prioritise the landing calls presented to it.

It is suggested that in many buildings there would be a need to specify the evacuation strategy, the prioritisation for landing calls, and the interface between the BMS and lift control system to accomplish this. Where the prioritisation of landing calls based on their distance from the exit floor is a default, it would be important that these are specified as part of the negotiation of the evacuation lift.

5 PLANNED EVACUATION TIME

Any capacity assessment would be based on an estimated number of people to be evacuated in a given time; the number of lifts required being strongly related to this time. A figure for maximum planned evacuation time is therefore essential for undertaking a capacity assessment.

In the case of evacuation due to fire, a distinction can be made based on the relationship between the maximum planned evacuation time and the expected time for attendance by the fire and rescue services and commencement of firefighting operations.

In the case of simpler buildings and where relatively small numbers need to be evacuated using a lift, it might be feasible to complete the evacuation before commencement of firefighting operations. This would be required for an evacuation lift which is also specified to be firefighters lift so that it is available for use by firefighters, unless other dedicated evacuation lift(s) are provided.

The maximum planned evacuation time would have implications for the evacuation management strategy as well as for building design (beyond the immediate specification of an evacuation lift) to ensure adequate protection and resilience including:

- the level of fire protection to the evacuation lift lobbies, well and machinery spaces;
- the endurance/autonomy time and capacity of secondary power supplies to cope with the planned demand from evacuation lifts and also lifts for firefighters use;
- water management to prevent water from entering the lift well;
- how evacuation would be carried out during firefighting operations.

6 CAPACITY ASSESSMENT

6.1 The need for capacity assessment for evacuation lifts

The new London Plan came into force in March 2021 and set out a framework for how London should develop over the next years. In the new London Plan, policy D5(B5) on inclusive design includes a minimum of one evacuation lift per core (or more subject to capacity assessments) to be provided for the safe and dignified emergency evacuation of people who require level access from the building.

The Greater London Authority published draft Fire Safety London Plan Guidance (LPG) in February 2022 with guidance to support policy D5(B5) [16]. This included the following on capacity assessment.

> *"**i) Capacity assessment***
>
> *6.3.3 A capacity assessment should be carried out to establish the number and size of evacuation lifts that the development will need to provide. This assessment should set out:*
>
> - *the likely number of occupants and visitors*
> - *the nature of the occupants (for example the likelihood that occupants may require evacuation in a wheelchair or bed) and any other assumptions the capacity is based on*
> - *the calculation of the evacuation lift capacity required*
> - *the evacuation lift capacity that would be provided*
> - *any potential risks during evacuation due to the anticipated capacity".*

In addition to these items, a number of other important determinants should be considered which were discussed above:

- The evacuation strategy which will determine the type of evacuation and how the evacuation lift is used e.g. if driver assisted, the presence of the driver needs to be considered;
- A planned evacuation time is an essential requirement for any capacity assessment seeking to establish the number and size of evacuation lifts to evacuate a given number of people in the planned evacuation time.

The draft LPG does not seek to provide guidance on how such a capacity assessment should be undertaken. It can be observed that specialist guidance on evacuation lift capacity assessment would not be appropriate to sit in the LPG or standards such as BS 9999 [2] or draft standards such as the revision of BS 9991 [7] or prEN 81-76 [5]. Hence other guidance is needed.

The draft LPG in relation to evacuation lift car size includes: "No specified lift size, but likely to be larger to accommodate beds or stretchers". BS 9999:2017 and prEN 81-76 refer to BS EN 81-70 [18] for lift car sizes. It can be noted that car sizes 1 and 2 in BS EN 81-70 could not accommodate a stretcher or bed. This suggests that the smallest size of evacuation lift which should be considered is type 3 in BS EN 81-70:2021. See also Appendix 1 "Consideration of minimum evacuation lift car sizes – UK context".

Unpublished data from a BRE study has been used to estimate the likely space used by a range of users with different disability types based on published UK data such as in reference [10]. Based on these, an average area for each disabled user of 0.42 m^2 is suggested. This represents a packing factor of two compared with the average space occupied by an adult for lift traffic considerations of 0.21m^2 from Barney [17]. A packing factor of two has been assumed to account for factors which might increase the space needed by people being evacuated e.g. to access and hold a handrail, account for any walking aids, to account for additional area taken by people with higher body mass index, space taken by those with helpers, those using wheelchairs etc.

Table 1 lists the car sizes listed in BS EN 81-70 [18] and uses the average area per user of 0.42 m^2 to arrive at maximum average passenger occupancy for each car size. In the case of the driver assisted car, the driver has been assumed to require 0.21 m^2. The resulting number of people has been rounded down to the next lowest integer.

TABLE 1: Disabled persons occupancy during emergency operation

Rated load, Q (kg)	Car type from BS EN 81-70:2021	Car dimensions width (m) x depth (m)	Nominal available car area, A_c (m^2)	Driver assisted car capacity, P_{de}	Automatic evacuation car capacity, P_{ae}
630	2	1.1 x 1.4	1.54	3	3
1000	3	1.1 x 2.1	2.30	5	5
1000	4	1.4 x 1.6 1.6 x 1.4	2.24	5	5
1275	5	1.4 x 2.0 2.0 x 1.4	2.80	6	6

Notes:
P_{de} and P_{ae} are the integer values of A_c/0.42 taking account of a small area in the car entrances.

The resulting car capacity is a key determinant of the capacity assessment for evacuation of disabled people. As was discussed in section 3, even from moderately low floor heights, this demand for evacuation lifts is likely to be supplemented by those opting to use lifts. The capacity assessment would need to take account of this demand and its increasing proportions of floor populations as floor height increases. When estimating their space taken, it would be reasonable to assume a packing factor of one, i.e. the cars would accommodate approximately twice the automatic evacuation car capacity.

The following material in this section is adapted from material from Dr Gina Barney, who is acknowledged with thanks. The following proposes two methods of capacity assessment:

1. A simple calculation suitable for non-lift specialists e.g. architects, fire consultants and fire engineers giving a "ball park" view;
2. a more advanced method for competent lift traffic designers to use and where the results of the simple method need to be elaborated such as for a more complex building design. For example to fit the "jigsaw" of irregular spaces into a rectangular car.

The calculation method below is based on established measures to assess the round trip time and handling capacity of lifts adapted for use in the evacuation situation.

Assumptions made to provide the simple calculation method are:

- The automatic evacuation lift shuttles between the exit floor and the floor for evacuation where the middle floor evacuated is a distance d_m from the exit floor;
- Rated speed (v) is 1.0 m/s (increasing rated speed has only a small benefit);
- Round Trip time (RTT) consists of:

Time to travel between exit floor and evacuation floor and back	$2*d_m/v$
Time to open and close doors (t_d = 6 seconds) at the two stops	$+ 2*t_d$
Time for passengers to board and exit (t_l = 5 seconds per passenger)	$+ 2*P_{ae}*t_l$

Round Trip time (RTT) = $2*d_m + 2*6 + 2*P_{ae}*5 = 2d_m + 12 + 10*P_{ae}$

- Round trips per 5 minutes = $300/RTT$
- Persons evacuated per 5 minutes = $(P_{ae}*300)/(2*d_m+12+10P_{ae})$ (1)

6.2 Simple calculation method for buildings with highest floor not greater than 18 m

$$\text{Number of persons evacuated in 5 minutes per evacuation lift} = \frac{300 \times P_{ae}}{2 \times d_m + 12 + 10 P_{ae}} \qquad (2)$$

P_{ae} is the possible occupancy of the lift car taken from Table 1. For a driver assisted operation, P_{de} can be used.

6.3 Advanced calculation

A more complex calculation or simulation is needed where automatic evacuation operation is used and where the floor heights are such that part of the building population is likely to use the lifts. There are well established principles on which advanced calculation or simulation would be based [19]. No doubt the introduction of a standard for automatic evacuation lifts would be a catalyst for more work in this area and further guidance.

7 CONCLUSIONS AND FURTHER WORK

In a UK context, documents such as the London Plan are likely to lead to a larger proportion of passenger lifts in new buildings being specified for disabled people to evacuate. A new European Norm (EN) is expected which will provide a much enhanced specification for driver assisted evacuation (compared with legacy evacuation lifts described in British Standards) and an entirely new (in standards) specification for an automatic evacuation operation.

A number of issues linked to the specification and planning of evacuation lifts have been discussed. It is suggested that guidance on these and other issues should be developed to support the implementation of a European Norm for evacuation lifts. A European Norm for lifts would set normative requirements for an evacuation lift and would be constrained in the guidance it could give for building design aspects. However, much of this guidance would be more appropriately implemented at national level.

The following areas are highlighted for further guidance to be developed especially to support the introduction of a new evacuation lift standard.

1. Guidance on capacity assessment to estimate the likely number of evacuation lifts based on a number of factors considered in this paper. This could include simple tools for low-rise buildings and more sophisticated methods for taller and more complex buildings.

2. Guidance on estimating the proportion of floor populations who could be expected to use lifts for evacuation in addition to disabled people depending on the lifts for evacuation with default figures to be used where more specific and detailed studies are available.

3. Consideration of the maximum planned evacuation time as a key determinant of the number of evacuation lifts needed with guidance on the implications for protection to be specified for evacuation lifts to achieve the required level of resilience.

4. Recommendation that evacuation lifts have minimum lift car dimensions as BS EN 81-70:2021, type 3 (1100 mm x 2100 mm).

5. The introduction of automatic evacuation operation would be a significant change which should be supported by further guidance. Landing call prioritisation must be specified based on the evacuation strategy and suitable interfaces between the building management system and lift controls specified accordingly.

These are all in the context of developing standards and guidance for new evacuation lifts in new buildings. It might be anticipated that there could be a call for guidance for how existing passenger lifts could be improved to provide for the evacuation of disabled people from existing buildings. In a UK context, this would need to consider not only the improvement of existing evacuation lifts (installed since 1988) but also the improvement of existing passenger lifts to provide for the evacuation of disabled people. Framing useful guidance in this area will be a challenge.

8 REFERENCES

[1] British Standards Institution (1988) BS 5588-8:1988; *Fire precautions in the design and construction of buildings —Part 8: Code of practice for means of escape for disabled people*. London: BSI.

[2] British Standards Institution (2017) BS 9999:2017; *Fire safety in the design, management and use of buildings - Code of practice.* London, BSI.

[3] Hewitt, J *Accessibility for everyone – evacuation for only some?* MSc Dissertation – the University of Reading (2009)

[4] O'Loughlin, E, Wiles, H and Ryan, M *Alternative Escape Route* In; CIBSE Journal July 2021 pp40-42 accessed 08.05.2022: http://portfolio.cpl.co.uk/CIBSE/202107/40/

[5] British Standards Institution (2022) Draft for public comment: prEN 81-76: *Evacuation of persons with disabilities using lifts*. London, BSI.

[6] British Standards Institution (2020) BS EN 81-73:2020; *Safety rules for the construction and installation of lifts — Particular applications for passenger and goods passenger lifts — Part 73: Behaviour of lifts in the event of fire*. London, BSI.

[7] British Standards Institution (2021) Draft for public comment: *Draft BS 9991 Fire safety in the design, management and use of residential buildings – Code of Practice*. London, BSI.

[8] British Standards Institution (2011) DD CEN/TS 81-76:2011; *Safety rules for the construction and installation of lifts — Particular applications for passengers and goods passenger lifts — Part 76: Evacuation of disabled persons using lifts*. London, BSI.

[9] British Standards Institution (2014) PD ISO/TS 18870:2014. *Lifts (elevators) — Requirements for lifts used to assist in building evacuation*. London, BSI.

[10] HM Government (2022) Family Resources Survey: financial year 2020 to 2021, 31 March 2022. Accessed 2 June 2022: https://www.gov.uk/government/statistics/family-resources-survey-financial-year-2020-to-2021/family-resources-survey-financial-year-2020-to-2021

[11] Heyes, E and Spearpoint, M, *Human behaviour considerations in the use of lifts for evacuation from high rise commercial buildings*, 2009: Department of Civil Engineering, University of Canterbury

[12] Kinsey, M J *Vertical transport evacuation modelling* PhD Thesis, University of Greenwich 2011

[13] Kinsey, M J, Galea, E R and Lawrence, P J *Human Factors Associated with the Selection of* 1*Lifts/Elevators or Stairs in Emergency and Normal Usage Conditions* In: Fire Technology, August 2012.

[14] Jönsson, A, Andersson, J and Nilsson, D *A Risk Perception Analysis Of Elevator Evacuation* In High-Rise Buildings in Fifth International Symposium on Human Behaviour in Fire. 2012. Cambridge, UK: Interscience Communications.

[15] Ding, N., Zhang, H. & Chen, T. *Experimental study of egress selection behavior between stairs and elevators during high-rise building evacuation*. In: Fire Technology 55, 2019.

[16] Fire Safety London Plan Guidance (LPG), https://www.london.gov.uk/sites/default/files/fire_safety_lpg_consultation_version_-_planning_11_feb_22.pdf Greater London Authority, February 2022

[17] Barney, G *Rated Load and Maximum Available Car Area* In: Elevator World UK, 2022/02, Issue 111 pp60-62, 64.

[18] British Standards Institution (2021) BS EN 81-70:2021: *Safety rules for the construction and installation of lifts — Particular applications for passenger and goods passenger lift Part 70: Accessibility to lifts for persons including persons with disability*. London, BSI.

[19] CIBSE Guide D:2020, *Transportation systems in buildings*. London: CIBSE

BIOGRAPHICAL DETAILS

Nick Mellor is the Managing Director of the Lift and Escalator Industry Association (LEIA) where he has worked since 2012 and has been in the lift industry since 1992. LEIA is the trade association in the UK for the lift and escalator sector which, along with the University of Northampton and the CIBSE Lifts Group, co-organise the Lift & Escalator Symposium. Nick was in the inaugural cohort on the MSc in Lift Engineering from the (now) University of Northampton from which he graduated in 2002. He is an Associate Lecturer and visiting fellow at the University of Northampton. Nick chairs the BSI’s MHE/4 lift and escalator committee where he has been involved in the development of various British Standards. He is a BSI delegate to various European (CEN) and International (ISO) working groups including those considering firefighters lifts and lifts for evacuation. Nick is the principal author of two chapters of CIBSE Guide D:2020 and has published a number of papers.

APPENDIX 1: Consideration of minimum evacuation lift car sizes – UK context

This appendix considers the current standards in a UK context and whether the minimum lift car dimensions currently specified are sufficient for moving a person on stretcher.

It is understood that many UK ambulance trusts use stretchers which have lengths between 1450 mm and 1680 mm when "fully shortened" with total lengths when fully extended of between 1930 mm and 2045 mm (depending on make and type). A car depth of 2100 mm would therefore be sufficient to accommodate these.

Minimum lift car sizes for accessibility to buildings are listed with their accessibility levels in BS EN 81-70:2021; *Accessibility to buildings Accessibility to lifts for persons including persons with disability*. Car type 3 (1100 mm x 2100 mm) is listed as allowing transport of stretchers. However, the standard does not specify minimum lift car dimensions for access to and use of buildings; this is left to Building Regulations guidance such as, in England, Approved Document M; *Access to and use of buildings*. The minimum car sizes (such as 1100 mm x 1400 mm) in Approved Document M do not allow for a person being moved on a stretcher.

Minimum lift car dimensions to allow for people on stretchers to be extracted from a building is related to the use of lifts for evacuation. BS 9991:2015; *Fire safety in the design, management and use of residential buildings – Code of practice* points to the recommendations in BS 9999:2017; *Fire safety in the design, management and use of buildings – Code of practice* which recommends that evacuation lifts are in accordance with the relevant provisions in BS EN 81-20 and BS EN 81-70. Building Regulations guidance, such as Approved Document B; *Fire safety* does not specify a minimum evacuation lift car size and references BS 9999. The conclusion is that these fire safety documents reference to BS EN 81-70 but do not specify which car type in that standard should be selected.

BS EN 81-72:2020; *Firefighters lifts* details a minimum car dimensions for firefighters lifts and has the following: *Where the intended use of the firefighters lift is to include evacuation, to accommodate such items as a stretcher or bed, then the minimum rated load shall be 1 000 kg and the minimum dimensions of the car 1 100 mm wide by 2 100 mm deep*.

At the time of writing a draft European standard, prEN 81-76; *Evacuation of persons with disabilities using lifts* is out for public comment. This document includes a minimum evacuation lift car size of type 2 according to EN 81-70:2003, Table 3 (car dimensions of 1100 mm x 1400 mm). If published as a British Standard, a future BS EN 81-76 would be referenced by standards such as BS 9991 and BS 9999 and by Building Regulations guidance.

If new lifts need to be specified to have minimum car dimensions to accommodate a person on a stretcher, at least car type 3 from BS EN 81-70:2021 will need to be referenced from Building Regulation guidance for fire safety and accessibility, and British Standards such as BS 9991 and BS 9999.