Transportation systems in buildings

CIBSE Guide D: 2010

CIBSE

Registered charity number 278104

ISBN: 978-1-906846-16-9

Typeset by CIBSE Publications Department

Printed in Great Britain by Page Bros. (Norwich) Ltd.,
Norwich, Norfolk NR6 6SA

Note from the publisher

This publication is primarily intended to provide guidance to those responsible for the design, installation, commissioning, operation and maintenance of building services. It is not intended to be exhaustive or definitive and it will be necessary for users of the guidance given to exercise their own professional judgement when deciding whether to abide by or depart from it.

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1 Introduction

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Chapter contents

1 Introduction

1.1 Purpose of Guide D

The purpose of the CIBSE Guide D: *Transportation systems in buildings* is to provide guidance to practitioners involved in such systems. Guide D should also be of interest to architects and developers, along with facilities and building managers who may not be directly concerned with the design and installation of lifts and escalators but need to understand the advice offered to them by specialists. Not least, the Guide should be of value to students embarking on a career in mechanical, electrical or building services engineering and those already practising in these disciplines who wish to enhance their knowledge through a programme of continuing professional development.

1.2 Recent developments

During recent years we have seen the machine room-less lift (MRL) become firmly established in the global marketplace with an ever broadening range of applications, speeds and duty loads. Now, for many buildings, the MRL lift is an appropriate provision offering significant benefits in terms of reduced space and capital cost.

Destination control technology (hall call allocation) has also continued to establish itself in the marketplace, especially in 'high-end' office developments where its benefits are typically of most value. This prevalence of destination control systems has in turn catalysed debate on traffic planning and the need for revised design criteria to acknowledge the characteristics and capabilities of such systems, see chapters 3 and 4.

The impact of climate change continues to occupy the minds of many and the vertical transportation industry has continued to develop energy conservation initiatives in order to play its part. The use of variable speed systems, regenerative drive systems, intelligent control and off-peak dormancy are all becoming more prevalent as developers and clients see tangible benefits and shorter payback periods, see chapter 13. The legislative background to energy conservation has evolved considerably and will continue to do so if the aggressive targets agreed by governments around the world are to be met.

The safety of buildings in the event of fire or other potentially catastrophic events has been the subject of a major regulatory and standard revision resulting in the issue of BS 9999: *Code of practice for fire safety in the design, management and use of buildings*(1). This standard supersedes most of the old BS 5588 family of standards consolidating them for the first time into a single document, see chapter 6.

As our society rightfully embraces 'accessibility for all' principles, the spotlight continues to fall on the lift as a means of meeting some of the key legislative and social requirements. Chapter 11 has been aligned with the recently revised British Standard Code of Practice BS 8300: *Design of buildings and their approaches to meet the needs of disabled people*(2) and the new management principles set out in BS 9999.

1.3 Contents of Guide D

The design of any lift or escalator system must commence with a consideration of the traffic flows through the building for which the system is intended. The relevant factors, along with guidance on the location and arrangement of lifts, escalators and moving walks within buildings, are discussed in chapter 2, which considers a range of building types along with some additional guidance principles for disabled circulation.

The assessment of demand and fundamental principles of traffic planning and selection of lift equipment are considered in chapter 3. Guidance tables have been updated to align with current thinking, particularly the trend towards simulation, and to link with the twelve building types considered in chapters 2 and 5. The mathematics has been minimised by the use of referenced material and additional advice provided on system response times for office buildings.

Chapter 4 covers advanced planning techniques and the use of computer simulation. This chapter has been extensively revised to align with current thinking and simplified to remove much of the supporting mathematics now referenced elsewhere. The findings of recent surveys into actual passenger demand in buildings are presented along with new demand templates for use in computer simulations. The value of simulation in assessing potential benefits of modernisation is also discussed. Lift kinematics, supporting chapter 4, is provided in Appendix A2.

Chapter 5 should be considered a pivotal chapter as it gives a thorough review of 16 types of vertical transportation. This chapter should be the first port of call for new entrants into the industry. It presents an overview of the various types of lifting systems and provides advice on planning and design principles. The chapter examines the standard traction drive and hydraulic drive lifts, including machine room-less lifts and the appendix provides guidance on structural well sizing and links with the 12 building types described in chapters 2 and 3.

Firefighting lifts and escape lifts for people with disabilities are particularly important categories. For this reason these are treated separately in chapter 6, which explains the basic requirements for lifts that are intended to be used in fire and emergency situations. This chapter has been extensively updated to include the recommendations of the new BS 9999. Comment and guidance is also provided on the use of lifts for general evacuation.

The principal components of lifts, including both electric traction and hydraulic drives, are described in chapter 7. It now includes safety devices to deal with uncontrolled movement away from a landing with the lift doors open. New sections are also included on inspection controls and guarding.

Lift drive and control techniques are considered in chapter 8. It provides an unbiased guide to controls and drives to allow a better understanding for users and specifiers to ensure they select the correct system for their particular application. Comment on programmable electronic systems in safety related applications for lifts (PESSRAL) is briefly considered.

Lift group traffic control is outlined in chapter 9 and has undergone some revision for this issue. It provides guidance on the traffic control of single lifts, and for groups of lifts through legacy systems, based on relay logic, to modern day systems, utilising microcomputers. Several case studies support the guidance.

Chapter 10 discusses escalators and moving walks, including their safety considerations. Escalator applications range from low-rise installations to accommodate a small change in level within a story of a building to long travel installations in deep underground stations. The updated standard BS EN 115-1[3] and the forthcoming BS EN 115-2 (prEN 115-2)[4] are also discussed.

Transportation systems in buildings should provide independent and equal access for everyone. Chapter 11 has been updated to include recently published standards and provides guidance on the types of disability and design issues that need to be considered along with the standards and regulations that are applicable. A summary of BS EN 81-70[5] is also presented along with guidance on the implications of the new Machinery Directive[6].

Electrical systems and environmental conditions supplies are discussed in chapter 12. This chapter examines the provision of power supplies for the whole building and guidance on key environment conditions, which should be considered during the design process.

Lift, escalator and moving walk energy efficiency and power consumption issues are discussed in chapter 13, which addresses how energy consumption can be minimised through good design, selection and control of the transportation equipment. The current work at ISO level is referenced along with guidance on the current requirements of the BREEAM building classification system.

Chapter 14 offers some guidelines on remote monitoring and remote alarms and suggests ways in which the resulting data can be used to improve the efficiency of vertical transportation systems and their interface with other systems within the building. The British Standard protocol DD 265[7] for lift and rescue centres is described.

The proper commissioning, thorough examination, inspection and preventive maintenance of lifts escalators and moving walks is critical to ensure that the safety and capital value of these assets are maintained. These important issues are dealt with in chapter 15.

Typically, lift installations require upgrading after 15–20 years of service. Chapter 16 has been re-written and examines the reasons for upgrading, which can range from improving the performance in terms of the system's traffic handling, ride quality or energy consumption to improving the safety of the equipment. This chapter also includes easy to read tables for upgrading existing traction and hydraulic drive lifts and includes new guidance on accessibility and vandal resistance considerations.

It is fortunate that safety rules for the construction and installation of lifts and escalators, specifications, codes of practice, commissioning recommendations and safe working are all covered by an extensive range of British, European and international standards and codes. Chapter 17 provides an overview of some of these important documents. The chapter is supported by a comprehensive and up-to-date (at the time of publication) list of legislation, standards, codes of practice etc. in Appendix A3. This annex also includes a list of interpretations to some of the EN 81 family of standards

The Construction (Design and Management) Regulations 1994 signalled a clear message to all those working in the construction industry that safety needed to be improved. Chapter 18 provides a guide to the impact of the 2007 regulations[8] on lifts and escalators. The CIBSE is indebted to the Lift and Escalator Industry Association (LEIA) for permission to reproduce its guidance document.

Appendix A1 provides an extensive glossary of terms. This is not limited to the terms used within this Guide but also includes definitions of many of the terms likely to be encountered when dealing with lift, escalator and moving walk systems. The CIBSE is indebted to GBA Publications for permission to reproduce this valuable glossary.

Finally, a comprehensive index is provided.

1.4 Other sources of information

It is hoped that this fourth edition of CIBSE Guide D: *Transportation systems in buildings* will provide an invaluable reference source for those involved in the design, installation, commissioning, operation and maintenance of transportation systems in buildings. However it cannot be, and does not claim to be, exhaustive. The various chapters contain extensive references to other sources of information, particularly British Standards and associated standards and codes of practice (see Appendix A3), which should be carefully consulted in conjunction with this Guide, together with relevant trade and professional publications.

Table 1.1 Summary of changes from the 2000 edition

Chapter	Changes from 2000 edition
1 Introduction	New.
2 Interior circulation	Guidance updated to current thinking and standards. Escalator section amended to include duty categories. Stair usage guidance updated.
3 Traffic planning and selection of lift equipment and performance	Guidance updated to current thinking and standards, particularly trend towards simulation. Mathematical content reduced and style revised to use more referenced material. Additional guidance added on system response time performance in an office building.
4 Advanced planning techniques and computer programs	Extensively revised and updated to current thinking. New design templates proposed based on real world research. Introduction of quality of service criteria for office buildings. Simulation for modernisation discussed.
5 Types of transportation systems	Updated and revised to current technology and standards. Layout and indexing improved.
6 Firefighting lifts and escape lifts for people with disabilities	Updated to current thinking and standards, in particular to BS 9999. Additional comment on use of lifts for general evacuation.
7 Lift components and installation	Updated to current equipment and standards. Car arrest systems added along with expanded guidance on uncontrolled movement from a landing with open doors. Suspension systems expanded to include aramid rope and flat belt. Added sections on inspection controls and guarding.
8 Lift drives and controls	Updated to current technology and standards. New section on programmable electronic systems in safety related application (PESSRAL). Interface with building security systems added. Overview only now provided on rarer equipment (e.g. Ward Leonard and static converter drives).
9 Lift traffic control	Updated to current technology and standards. Expanded comment on hall call allocation (HCA). Addition of an improvement verification case study.
10 Escalators and moving walks	Updated to current technology and the new BS EN 115-1. Reference added to the forthcoming BS EN 115-2 for upgrading existing escalators and moving walks.
11 Transportation facilities for persons with disabilities	Re-titled to focus on persons with disabilities. Updated to current technology and the forthcoming EN 81-41. Expanded content on rated load. New illustrations.
12 Electrical systems and environmental conditions	Updated to current thinking, technology and standards. Added reference to energy efficient car lighting. Human comfort criteria revised. New section on lightning protection.
13 Energy consumption of lifts, escalators and moving walks	Revised and updated to recognise ISO/DIS 24745-1 and provide commentary on work in-hand at ISO level. Added section on BREEAM 2008 requirements.
14 Remote monitoring and remote alarms	Layout revised. The British Standard communication protocol DD 265 is described.
15 Commissioning, preventative maintenance, testing and thorough examination of lifts, escalators and moving walks	Updated to include guidelines on the supplementary tests of in-service lifts.
16 Upgrading of safety, performance and equipment of existing lifts	Re-titled and revised in line with current thinking and standards. Added section on improvement in accessibility and vandal resistance.
17 Legislation, standards and codes of practice	Updated legislation. Updated standards list as an Appendix A3.
18 Construction (Design and Management) Regulations 2007	Updated in line with the requirements of the 2007 legislation.
Appendix A1: Glossary of terms	No changes.
Appendix A2: Lift kinematics	Added guidance on measurement.
Appendix A3: Legislation, standards etc. related to lifts, escalators and moving walks	Updated in line with latest published and planned documents.

References

1 BS 9999: 2008: Code of practice for fire safety in the design, management and use of buildings (London: British Standards Institution) (2008)

2 BS 8300: 2009: *Design of buildings and their approaches to meet the needs of disabled people. Code of practice* (London: British Standards Institution) (2009)

3 BS EN 115-1: 2008 + A1: 2010: *Safety of escalators and moving walks. Construction and installation* (London: British Standards Institution) (2008/2010)

4 prEN 115-2: *Safety of escalators and moving walks. Rules for the improvement of safety of existing escalators and moving walks* Draft for comment 09/30192761 DC (London: British Standards Institution) (2009)

5 BS EN 81-70: 2003: *Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts. Accessibility to lifts for persons including persons with disability* (London: British Standards Institution) (2003)

6 Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast) ('The Machinery Directive') *Official J. of the European Union* **L157** 24–63 (9.6.2006) (available at http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/machinery/index_en.htm) (accessed May 2010)

7 DD 265: 2008: *Protocol for communications between a lift alarm system and an alarm receiving station (rescue centre). Specification* (London: British Standards Institution) (2008)

8 The Construction (Design and Management) Regulations 2007 Statutory Instruments No. 320 2007 (London: The Stationery Office) (2007) (available at http://www.opsi.gov.uk/si/si200703) (accessed June 2010)

2 Interior circulation

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Chapter contents

2 Interior circulation

2.1 Introduction

This chapter provides general guidance regarding the movement of people in buildings. Because it deals with people, many of the recommendations are based on empirical data acquired by observation and the experience gained in their application. Much of what follows cannot be proved theoretically and many of the conclusions have been drawn from the observations made. Reasons are given for the conclusions so that if new evidence comes to hand (or opinions change) the results can be modified. National and local regulations may also affect the circulation design, such as fire and safety codes, and these should be taken into account. Readers are referred to Barney[2] and Fruin[14] for fuller expositions and case studies.

Whilst the reader may apply the guidance given here, specialist design assistance may be needed for complex or unusual situations. Throughout the chapter people are called 'pedestrians' when on foot, and called 'passengers' when being mechanically transported.

Warning: all the tables in this chapter give empirical values and should be considered to be average values only.

2.2 General considerations

2.2.1 Basic factors

The circulation of people in the interior of buildings is a complicated activity (Dober, 1969)[13] and is affected by a number of basic factors:

— *Mode*: horizontal and vertical movement

People generally move horizontally, except where they are using inclined moving walks, they then change to vertical movement to reach a higher or lower level. To change mode they can use stairs, escalators or lifts.

— *Movement type*: natural or mechanically assisted

People are moving naturally when walking along corridors and through portals and are mechanically assisted when using escalators, moving walks and lifts.

— *Complications*: human behaviour

The movement of people around a building is complex because people are complex. Individuals have their concepts of route, their purpose for travel, their level of urgency, their personal characteristics of age, gender, culture, handicaps, etc. There is always unpredictability in human behaviour.

2.2.2 Design factors

A number of design factors affect the interior circulation in a building:

— *Consider all circulation routes*: these include principal and secondary circulation areas, escape routes, service routes and areas.

— *Provide clear and obvious routes*: pedestrians should be able to see the route to take and be assisted by good signage and open vistas.

— *Ensure that the circulation patterns are rational*: an example is the avoidance of pedestrians passing through a lift lobby, where other persons are waiting.

— *Ensure that incompatible types of circulation do not coincide*: this would apply to pushing goods trolleys across a pedestrian mall in a shopping centre.

— *Minimise the movement of people and goods*: the location of related or associated activities is essential, e.g. sales and marketing, and personnel (human resources) and training in an office building.

2.2.3 Coordination factors

The design and location of portals (defined here as entrances, doorways, gates, etc.), corridors, stairs and mechanical handling equipment (horizontal and inclined pedestrian conveyors, escalators, lifts) should be coordinated, i.e:

— *The free flow of people, goods and vehicles*: levels of occupancy and density of usage should be such as to permit the free movement of people and goods.

— *The occupation of the minimum space*: a building owner/tenant wishes to maximise the area in which people may occupy.

— *Bottlenecks and pinch points are prevented*: a bottleneck or pinch point reduces the free movement of people and goods.

— *Sizing of circulation elements*: it is important to size each circulation element. The handling capacities of corridors, which lead to stairs, which in turn lead to a lift, should be adequately sized for their anticipated demand.

(*Note*: the term 'handling capacity' is used here for passive (i.e. non-mechanical) building elements in the same way as it is applied to the mechanical elements and the term 'demand' is used to indicate the level of usage.)

— *Movement space*: in a shopping centre a consideration is the requirement to provide space for the movement of shopping trolleys, wheelchairs, mobility aids and retailers carts. In offices, it may be necessary to make provision for the occasional movement of equipment, plant and refurbishment materials.

2.2.4 Efficiency factors

The efficiency of interior circulation is dependant on building shape. Tall/slender and low/squat buildings are generally inefficient. The ideal shape is 'compact'. Efficiency is also affected by a number of other factors, i.e:

— the relative location of rooms

— the relationship of major spaces with entrances and mechanical people-handling equipment

— the importance of the journey undertaken (e.g. hospital theatre traffic)

— the separation of different traffic types (e.g. clean/dirty)

— the need to group some spaces together

— the conflict of vertical and horizontal circulation modes.

2.3 Human factors

2.3.1 Human physical dimensions

The physical dimensions of the human body vary widely. Females are generally smaller than males. The space an individual occupies depends on the clothing worn and what they might be carrying. To allow for all these factors and other circumstances, such as body sway, it is recommended that the typical occupancy template be considered to be an ellipse 'covering' an area of 0.21 m^2, see Figure 2.1.

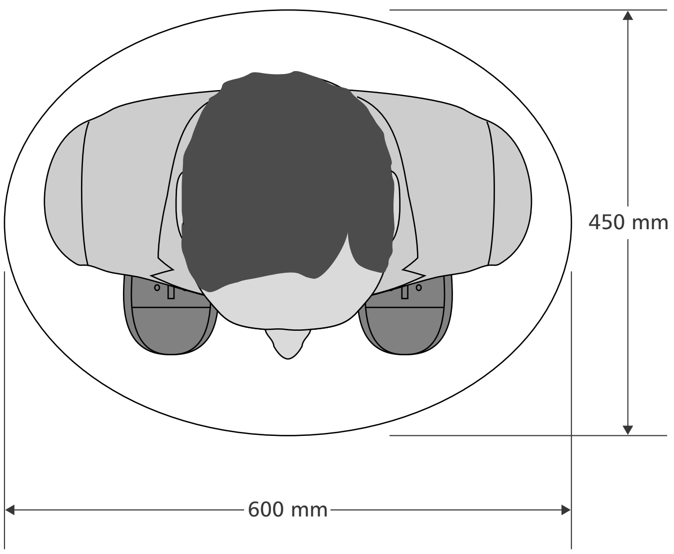

Figure 2.1 Typical occupancy ellipse (showing male subject)

The ellipse is 600 mm wide by 450 mm high. It should be noted that the actual body template of the individual does not fill the ellipse.

If the typical occupancy template is used to represent the average individual, then the larger males and females may be compensated for by smaller males and the females who may be present.

The occupancy ellipse shown in Figure 2.1 is typical for European and North American people. There is growing evidence that over the last few decades more European and North American people have become bigger and taller. Some have become overweight, obese and clinically obese as evidenced by changes in their body mass index (BMI). The average used in this chapter follows Figure 2.1, with an average person considered to weigh 75 kg.

In other parts of the world people are different sizes. For guidance a 65 kg person may occupy 0.18 m^2, a 68 kg person may occupy 0.19 m^2 and an 80 kg person may occupy 0.22 m^2. These sizes need to be considered when designing outside Europe/North America (see chapter 3, Table 3.1).

2.3.2 Human personal space

Humans value personal space (Hall, 1966)[15]. This is measured by a personal buffer zone around each individual. The actual size of the buffer zone varies according to an individual's culture, age, status, gender, handicaps, etc. It has been observed that individual female subjects are comfortable with a personal buffer zone of 0.5 m^2 (i.e. a circle of 0.8 m diameter) and individual male subjects with a personal buffer zone of 0.8 m^2 (i.e. a circle of 1.0 m diameter). To visualise these sizes a woman's umbrella occupies an area of approximately 0.5 m^2 and a man's umbrella occupies approximately 0.9 m^2.

These factors should be borne in mind when designing pedestrian waiting areas. When considering bulk queues, i.e. where people are waiting for an event, the occupation densities shown in Table 2.1 are typical. These values can also be used where pedestrians or passengers are not standing in a confined space.

When considering linear queues, where people are waiting in line for a service, assume two persons per metre length of space. Where a queue is unrestrained it is necessary to assume that they occupy a width of at least 1.5 m. A control barrier, which should be at least 600 mm in width, can used to restrain the queue width.

2.4 Circulation elements

The discussion in this section is mainly applicable to office buildings where a number of factors affect pedestrian movement. These include:

— pedestrian dimensions

— pedestrian velocities

— unidirectional or bidirectional flow

— cross flows

— patterns of waiting

Table 2.1 Occupancy levels in waiting areas (source: Barney, 2003[2], p. 6)

Level of occupancy	Density (person/m^2)	Characteristics
Desirable	0.4	Allows individuals to walk more or less where they wish to go or stand without any interference from other individuals.
Comfortable	1.0	Allows individuals to walk with some deviations necessary where they wish to go and for individuals to stand without any interference from other individuals.
Dense	2.0	Individuals who are walking must now take care not to collide with other persons and persons waiting are aware that other individuals are present.
'Crowding'	3.0	It is only possible to walk at a shuffle and with care at the average rate of the crowd. There is no or little chance of a contra-flow. Individuals waiting are very aware of other individuals.
Crowded	4.0	Walking is almost impossible. Individuals waiting are unhappy to be so close to other individuals. This density is only possible where persons are placed in a confined space, such as a lift car, or a rapid transit train.

— site and environmental conditions

— statutory requirements.

2.4.1 Corridor capacity

The term 'corridor' is defined here to include passageways, walkways, subways, etc.; i.e. areas whose main function is to provide a connection between major spaces and operational areas. They do not include areas where waiting can occur, such as shopping malls. These are dealt with in section 2.5.

The capacity of a straight corridor can be given as:

$$C_c = 60\, v\, D\, W_c \tag{2.1}$$

where C_c is the corridor handling capacity (persons/minute), v is average horizontal pedestrian speed (m/s), D is the average pedestrian density (persons/m^2) and W_c is the effective corridor width (m).

Equation 2.1 is an empirical relationship with a number of qualifications. Pedestrian speed and density are not independent of each other. For densities below 0.3 persons per square metre pedestrians can walk freely, called 'free flow' design. When densities increase above 0.5 persons per square metre there is an approximately linear decrease of average walking speed up to a density of about 3.0 persons per square metre, when walking is reduced to a shuffle. The throughput peaks at densities of about 1.4 persons per square metre, called 'full flow' design.

Walking speeds vary systematically (statistically) with type of population (age, gender, grouping, purpose), ability (fitness, handicap), gradient, flow direction, air temperature, floor finish, etc. Within each group there can be variations in average speed. Table 2.2 indicates empirically derived average values, as guidance.

Table 2.2 shows the possible horizontal pedestrian flows in persons per minute and persons per hour, and typical pedestrian speeds in metres per second (m/s) for a free flow design density of 0.3 person/m^2 and a full flow design density of 1.4 person/m^2.

The flows assume a corridor width of one metre. The corridor should be at least 900 mm wide and is assumed to be one metre. Equation 2.1 allows for the flow rate to increase/decrease as the corridor width increases/decreases. This factor should be used with great care as small changes in corridor width can have little or no effect.

Table 2.3 presents the minimum straight widths of corridors that have been found to be suitable for different purposes and shows the minimum width of corridors to accommodate various types of traffic. Some compensation can be allowed for mixed two-way traffic situations, e.g. a 3.0 metre wide corridor would allow most traffic types to be accommodated.

Traffic can only flow freely along unrestricted routes. Corridors are rarely free of obstructions. For example, a row of seated persons reduces the effective width of a corridor by 1.0 m. Table 2.4 indicates the effect of a number of obstructions. The table shows the reduction in metres of the effective corridor width caused by obstructions

Table 2.2 Possible pedestrian flow rates with grouping

Type of traffic	Pedestrian flow rate at stated pedestrian design density					
	0.3 person/m^2			1.4 person/m^2		
	Speed (m/s)	Flow rate		Speed (m/s)	Flow rate	
		Person/min.	Person/hour		Person/min.	Person/hour
Commuters, working persons	1.5	27	1620	1.0	84	5040
Individual shoppers	1.3	23	1380	0.8	67	4020
Family groups, tourists	1.0	18	1080	0.6	50	3000
School children	1.1–1.8	18–32	1080–1920	0.7–1.1	59–92	3540–5520

Table 2.3 Minimum corridor widths

Usage	Minimum width (m)
One-way traffic flow	1.0
Two-way traffic flow	2.0
Two men abreast	1.2
Man with bag	1.0
Porter with trolley	1.0
Woman with pram	0.8
Woman with pram with child alongside	1.2
Man on crutches	0.9
Wheelchair	0.8†

† Wheeled vehicles require extra width in order to turn at junctions, especially if they are very long, e.g. hospital trolleys

Table 2.4 Reductions in corridor width

Obstruction	Reduction in width (m)
Ordered queue	0.6
Unordered single queue	1.2–1.5
Row of seated persons	1.0
Coin operated machine:	
— one person	0.6
— queue	1.0
Person waiting with bag	0.6
Window shoppers	0.5–0.8
Small fire appliance	0.2–0.4
Wall-mounted radiator	0.2
Rough or dirty wall surface	0.2

2.4.2 Portal capacity

Portals, which are called by various names (i.e. gate, door, entrance, turnstile, etc.), form a division between two areas for reasons of privacy, security, access control, etc. They represent a special restriction in corridor width. Their main effect is to reduce pedestrian flow rates. Table 2.5 indicates probable flow rates for a possible range of pedestrian flows in persons per minute and persons per hour through an opening of 1.0 m. Note that most domestic doors are less than this width (approximately 750 mm) and the flow rates would be likely to be the lower values in the range shown. Doors in non-domestic buildings may be slightly wider than 1.0 m and would permit the higher values in the range shown to be possible.

Table 2.5 Possible portal flow rates

Portal type	Flow rate	
	Person/min.	Person/hour
Gateway	60–110	3600–6600
Clear opening	60–110	3600–6600
Swing door	40–60	2400–3600
Swing door (fastened back)	60–90	3600–5400
Revolving door	25–35	1500–2100
Waist-high turnstile:		
— free admission	40–60	2400–3600
— cashier	12–18	720–1080
— single coin operation	25–50	1200–1800
— card/detector operation	20–30	1200–1800

2.4.3 Stairway capacity

Stairways impose a more stylised and disciplined form of movement on pedestrians. For instance pace length is restricted by tread depth (‘going’). More accurate cones of vision are required for step placement and assistance is often required by the use of handrails. The movement is more regular, as disciplined by the steps, permitting higher densities than are possible on the flat. Whereas for free movement during walking on the flat a pedestrian requires an area of some 2.3 m^2 (0.4 persons per square metre) to account for body sway etc., a stair walker only needs to perceive two vacant treads ahead (and room for body sway) and occupies an area of some 0.7 m^2. Thus free flow design is possible at a density of 0.6 persons per square metre and full flow design is possible at a density of 2.0 persons per square metre.

The speed along the slope is about half that on the flat, but this is compensated by the increased densities possible. Speed, however, is very much dependent on the slowest stair walker owing to the difficulty in overtaking under crowded conditions. Higher walking speeds are generally not possible in the down direction owing to the need for greater care. Speed is also affected by the angle of inclination and step riser height.

The energy consumed walking on stairs is related to the riser height. To enable comfortable walking on a stair a rule of thumb has been to match the average adult stride (on a stairway) of about 600 mm with the sum of twice the riser (rise) height plus the tread (going) depth. This results in a range of riser heights of 100 mm to 180 mm and treads of 360 mm to 280 mm, and a range of possible inclinations from 15° to 33°. A domestic stair often has a rise of 180 mm and a going of 240 mm. An efficient inclination has been found to be 27°.

Stairway handling capacity is 83% of that for a corridor, i.e:

$$C_s = 0.83\,(60\,v\,D\,W_s) \qquad (2.2)$$

where C_s is the stairway handling capacity (persons/minute), v is average pedestrian speed on the slope (m/s), D is the average pedestrian density (persons/m^2) and W_s is the effective stair width (m).

Table 2.6 shows the possible pedestrian flow rates in persons per minute and persons per hour and typical pedestrian stairway speeds along the slope in metres per second for a free flow design density of 0.6 persons per square metre and a full flow design density of 2.0 persons per square metre for each one metre width of stairway.

2.4.4 Escalator handling capacity

Escalators provide a mechanical means of continuously transporting pedestrians from one level to another. Except for deep underground systems escalators provide for short range movement. They are found in offices, stores, shopping centres, railway stations, hospitals, museums, etc. Speed, step widths, inclination and the size of boarding and alighting areas are factors that affect their handling capacity.

Table 2.6 Likely stairway pedestrian flow rates

Type of traffic	Pedestrian flow rate at stated pedestrian design density					
	0.6 person/m^2			2.0 person/m^2		
	Speed (m/s)	Flow rate		Speed (m/s)	Flow rate	
		Person/min.	Person/hour		Person/min.	Person/hour
Young/middle aged men	0.9	27	1620	0.6	60	3600
Young/middle aged women	0.7	21	1260	0.6	60	3600
Elderly people, family groups	0.5	15	900	0.4	40	2400

Table 2.7 Escalator duty categories

Duty category	Typical usage (passengers/day)	Typical locations
Light	Up to 3000	Shops, museums, libraries and leisure facilities
Medium	Up to 10 000	Department stores, shopping centres, regional airports and regional railway stations
Heavy	Up to 20 000	Major railway and metro stations, major international airports and critical locations such as underground railway systems
Intensive	Over 20 000	Ditto

Escalators should be specified against an anticipated duty. The definitions of duty are given in BS 5656-2: 2004[8] and are shown in Table 2.7.

The inclination of an escalator is usually 30°, but can be 35° provided the maximum speed is 0.5 m/s and it serves a maximum rise of 6 m.

The most common rated speed of escalators is 0.5 m/s, although speeds of 0.65 m/s and 0.75 m/s are available. Most escalators run at one speed only, although some heavy duty escalators can switch to the higher speed during heavy traffic.

Step widths of 600 mm, 800 mm and 1000 mm for escalators are available, the latter allowing two columns of passengers to be carried.

The theoretical handling capacity of an escalator is given by:

$$C_e = 60\, V\, k\, s \qquad (2.3)$$

where C_e is the escalator handling capacity (persons/minute), V is speed along the incline (m/s), k is average density of people (persons/escalator step) and s is number of escalator steps per metre (m^{-1}).

The standard escalator step depth is 400 mm and therefore $s = 2.5$. Thus equation 2.3 becomes:

$$C_e = 150\, V\, k \qquad (2.4)$$

The density factor k considers the step occupancy levels and experience has shown that this depends on step width. Practical values for k that have been found satisfactory are:

— for 1000 mm steps: $k = 1.0$ (1 person per 1000 mm step)

— for 800 mm steps: $k = 0.75$ ($1\frac{1}{2}$ persons per two 800 mm steps)

— for 600 mm steps, $k = 0.5$ (1 person per two 600 mm steps).

BS EN 115-1: 2008[6] suggests other informative values, which are slightly larger.

Table 2.8 gives guidance to the practical escalator handling capacities based on the above assumed densities in persons per minute and persons per hour and horizontal speeds in metres per second (m/s).

The practice in the UK of one stationary column and one walking column does not increase an escalator's mechanical handling capacity, but does increase the passenger flow rate and decrease an individual passenger's travelling time.

2.4.5 Moving walk handling capacity

Moving walks can either be horizontal or be inclined. Horizontal moving walks are typically used for medium/long range travel in airports, exhibition centres

Table 2.8 Practical escalator handling capacity (source: BS 5656-2: 2004[8])

Speed (m/s)	Handling capacity for stated step width					
	600 mm		800 mm		1000 mm	
	Person/min.	Person/hour	Person/min.	Person/hour	Person/min.	Person/hour
0.50	37	2250	57	3375	75	4500
0.65	49	2925	73	4388	97	5850
0.75	57	3375	85	5063	113	6750

Table 2.9 Practical handling capacities for moving walks and ramps (source: BS 5656-2: 2004[8])

Inclination (degree)	Speed (m/s)	Handling capacity for stated nominal width					
		800 mm		1000 mm		1400 mm	
		Person/min.	Person/hour	Person/min.	Person/hour	Person/min.	Person/hour
Horizontal moving walks:							
0	0.50	48	2880	60	3600	84	5040
0	0.65	62	3648	78	4560	106	6350
0	0.75	72	4320	90	5400	126	7560
Inclined moving walks:							
6	0.50	48	2880	60	3600	84	5040
10	0.50	48	2880	60	3600	—	—
12	0.50	48	2880	60	3600	—	—

and railway stations. Inclined moving walks are typically used for short range travel in shopping centres, stores and railway stations.

Inclinations range from 6° to 12°, although the safest maximum inclination is generally considered to be 10°. The running speeds for horizontal moving walks are 0.5 m/s, 0.65 m/s and 0.75 m/s. The permitted running speed for an inclined moving walk is 0.5 m/s. The speed is again measured in the direction of movement of the pallets.

Nominal widths for moving walks up to an inclination of 6° are 800 mm, 1000 mm and 1400 mm and above 6° are 800 mm and 1000 mm. A width of 1400 mm allows two columns of passengers and the possibility for some passengers to walk along the moving walk.

It is likely that the maximum occupation density of a moving walk may be about 2.0 person/m^2 (Table 2.1 'dense' level of occupancy). Table 2.9 indicates practical maximum handling capacities in persons per minute and persons per hour assuming a density of 2.0 person/m^2 using equation 2.1, but substituting the equipment speed for pedestrian speed.

2.4.6 Handling capacity of lifts

Lifts cannot handle the traffic volumes handled by other facilities and have a considerable throttling effect on pedestrian movement. For example, the most efficient 8-car group, comprising 21-person capacity cars serving 14 office floors, can provide a handling capacity of only 50 person/min. (3000 person/hour). This is less than a flight of stairs can provide. A 3-car group comprising 10-person cars serving 8 floors can manage only 16 person/min. (960 person/hour). Thus the recommendation to use escalators in bulk transit systems is proven. Fortunately, the high volumes found in bulk transit systems do not occur when populating or emptying a building.

Considerable care should be taken in sizing a lift system to accommodate the worst passenger demands. The method of sizing a lift is given in chapter 3 and is not discussed further here.

2.5 Circulation in particular types of buildings

Important note: this section is concerned with the circulation of people in twelve different types of buildings. Reference to the corresponding sub-sections of section 3.12, which deal with the selection of equipment, and section 5.2.2, which deals with the application of different types of lifts, should also be consulted.

2.5.1 Airports

Many airports are arranged on two main levels with the arrival level below the departure level. There may then be other levels above and below providing various services (e.g. baggage handling, catering, etc.) and facilities (offices). Another common characteristic is an adjacent, underground or elevated railway station. As with shopping centres, the movement of baggage carts/trolleys from one level should be catered for. A solution is to install inclined moving walks and this greatly improves circulation. Lifts, however, are the main means of vertical movement for persons with limited mobility.

Passengers with any significant amount of baggage use the trolleys provided. Most airports have sufficiently large halls and corridors and no problems should arise when they are used on one level. However, when the passenger requires to move from one level to another, e.g. to reach a railway station, then difficulties can arise.

Generally each baggage trolley may be attended by two persons plus their baggage. The weight of the baggage is generally restrained by the 20 kg allowance most (economy) passengers are allowed plus some 5 kg of hand luggage. Thus a loaded trolley can weigh some 75 kg (including its own weight), i.e. equivalent to one person. However, it occupies the space taken by three or four persons. Thus the total weight of two passengers and their trolley can be some 225 kg and occupy the space of some 5 people. This space requirement should be considered when designing the circulation.

It becomes particularly awkward when considering the part lifts play in circulation. Consider a nominal 50-person rated capacity (rated load 3750 kg) lift. According to Table 1.14 of BS EN 81-1[3], the maximum available car area for an electric traction lift should then be 7.0 m^2. According to the body template (Figure 2.1), only 33.3 passengers can be accommodated. They may weigh only 2500 kg, some 67% of the rated load.

If each pair of passengers and their baggage trolley occupy 1.05 m^2 (equivalent to five human spaces) then the nominal 50-person lift can accommodate 13.4 passengers and 6.7 trolleys. The total load may be 1500 kg. This is 40% of the rated load. In these circumstances the lifts are unlikely to be overloaded.

If the lift were to be a nominal 50-person rated capacity, 3750 kg rated load, hydraulic lift then the platform area from Table 1.15 of BS EN 81-2[4] would be exactly the same. However, Table 1.1A of the standard, which can be used 'when there is a low probability of the car being overloaded', allows a maximum area of 13.6 m^2. It is then possible to accommodate 26 passengers and 13 trolleys. This is a load of 2925 kg, which is some 80% of rated load. This would indicate that hydraulic lifts may be the most suitable for large lifts and their poorer dynamic performance would not be a significant disadvantage. For smaller rated loads electric traction lifts are more suitable owing to their ability to deal with intense traffic levels.

2.5.2 Car parks

Car parks can be attached to shopping centres, offices, airports, railway stations, etc. They are often multi-storey, although those at shopping centres and out-of-town railway stations may be a single or at most two levels. The circulation requirements are more likely to be constrained by the entry and exit ramp handling capacities.

For offices the peak demand is often in the evening when occupants are attempting to reach their vehicles. The office lifts, which may not serve the car parking levels, can bring large numbers of people to the lobby. Those with vehicles can make a significant demand on any lifts serving the car park levels. Once the occupants have reached their vehicles they may then spend some time before reaching the exit. Another factor is the vehicle occupancy, which for offices is likely to be about 1.2 persons per vehicle, unless car pools are in operation. The car park lifts should be designed to meet the demand efficiently.

For shopping centres the vehicle occupancy can be much higher with at least 2.0 persons per vehicle. Large lifts should be installed in shopping centres where a large food store is situated in order to provide an adequate service, as considerable numbers of shoppers will take their trolleys in the lifts.

2.5.3 Department stores

This category applies to large departmental and chain stores. These stores may have many entrances, some of which may open onto a main street whilst others open into the mall areas of shopping centres. The opportunity therefore exists for 'leakage' into and out of shopping centres. Many stores own lifts and escalators inside their demise. These facilities may be used by shopping centre shoppers to move between mall areas. Thus store facilities enhance those provided by a shopping centre to the mutual advantage of both.

2.5.4 Entertainment centres, cinemas, theatres, sports centres, stadia and concert halls

This category of building types often accommodates large numbers of people attending public events. Large theatres have many levels and their circulation should be designed to permit the rapid build-up of patrons prior to performances. Usually these entry routes are not large enough for a rapid departure, but this is not usually a problem.

Other buildings in this category are generally lower rise, although stadiums can also have many levels and accommodate many tens of thousands of attendees.

Circulation in these buildings needs to be properly considered at the design stage to ensure that entrances are wide enough and of sufficient number to permit entry and exit. Corridors, stairs and any vertical transportation in addition to that provided for people with special needs should be sized adequately.

With the increased expectation of access for all into all areas of public buildings the requirements for access and, more onerously, for emergency egress for persons with limited mobility must be considered. Also to keep the numbers of evacuation lifts to reasonable numbers may require the provision of large safe havens to accommodate wheelchair-bound and other persons with limited mobility until they can be evacuated.

2.5.5 Hospitals

These are mainly designed in Britain on the 2–3 storey, low-rise principle, although many city hospitals have high-rise elements. In the main, the principal corridors are sized to accommodate bed and trolley movements and therefore present no difficulties when handling pedestrian movements. Lifts are provided mainly as a means of moving bed-bound patients from floor to floor. The use of lifts as a primary circulation element in high-rise hospitals is vital, particularly for theatre traffic, where special arrangements should be made. NHS Health Building Note 00-04[16] may be consulted for additional information on circulation and Health Technical Memorandum 08-02[17] for guidance on the provision of lifts.

2.5.6 Hotels

Lifts play an important part in the circulation of guests and service staff in a hotel. It is recommended that there should be at least one passenger lift per 100 guests in a medium quality hotel, and at least one service/goods lift per two passenger lifts. Ideally there should be at least two service lifts to each floor in large hotels. Escalators should be employed for short range movements, e.g. to connect function levels with the lobby.

For security reasons it is normal practice that the aboveground guest lifts do not serve underground car parks directly. Guests should cross the main lobby in the sight of the hotel staff to access the car park lifts.

2.5.7 Offices

There are significant numbers of lifts installed in offices and without them most office buildings would be untenable. Some locations may also include escalators. The guidance given in section 2.2, some of which is repeated here, should be followed.

The interior circulation in a building should be designed to consider all principal and secondary circulation areas, escape routes, service routes and service areas. Pedestrians should be able to see the route to take, assisted by good signage. Circulation patterns should be rational, e.g. avoid pedestrians passing through a lift lobby, where other persons are waiting. Ensure that incompatible types of circulation do not coincide, e.g. tenants and goods traffic. Minimise the movement of people and goods by locating similar activities close to each other, e.g. sales and marketing, and personnel (human resources) and training.

Consider the levels of occupancy and density of usage so as to permit the free movement of people and goods. Bottlenecks should be prevented. Consider the relationship of major spaces, e.g. meeting and seminar rooms, with entrances and the people handling equipment. Consider the importance of the journey undertaken, e.g. rapid access to trading floors.

The capability of the various circulation elements is given in detail in section 2.4 and guidance on their location is given in section 2.6.

2.5.8 Railway stations

Railway stations may be served mainly by stairs, although the deeper ones use escalators. The main demand occurs as a train arrives, when many hundreds of people can alight. Obviously it would be expensive to install vertical transportation equipment to serve this peak demand. Thus the demand should be spread out in some way. A method of achieving this is to place the stairs/escalators at one end of the platform thus producing a more even demand on the facility. Distractions can be provided along the way, such as shops, kiosks, etc. The width of the platform may be determined by safety considerations rather than circulation requirements and thus should be adequately sized for its purpose.

Railway stations suffer from the same problems as airports (see section 2.5.1) with respect to baggage trolleys. Inclined moving walks may be installed to assist these movements.

In the future all new stations should provide access for limited mobility persons. This may prove challenging to incorporate the necessary shafts.

2.5.9 Residential buildings

Residential buildings include flats (housing association and private), university, college and hospital residencies. Circulation is not normally a problem except in high-rise flats, where sufficient lifts should be installed.

2.5.10 Residential care homes and nursing homes

Residential care homes and nursing homes do not usually present any circulation problems as they are not densely populated and do not experience peak traffic conditions.

2.5.11 Shopping centres

2.5.11.1 General considerations

A shopping centre is unlike the old-fashioned high street, where shops line each side of the road, with shoppers on pavements at the sides and vehicular traffic passing along the middle of the street. A shopping centre is usually a purpose-built building, where all shoppers are protected from the weather in a climatically controlled environment and segregated from vehicular traffic. The shops line each side of the malls with several floors of malls above and below. No two shopping centres have the same structure, population or circulation patterns.

In the UK, shopping centres are generally on one, two or three floors but in Asian countries shopping centres often have 7 or 8 mall levels. Two floors are generally considered as much as the average UK shopper is prepared to contemplate. Centres with three floors often have food courts at the upper or lower floors to form an attraction and a contrast to the main sales areas. There are places set aside for rest, sustenance and amusement. See chapter 2 of the *Elevator traffic handbook* (Barney, 2003)[(2)] for a detailed discussion of good practice and design.

Shoppers do not populate a shopping centre to the high levels (in density terms) found in other public places, e.g. railway stations. Two traffic conditions can be observed: a low level of shopper occupancy (uncrowded, free flow), and a peak value of shopper occupancy (crowded, full flow). Also, although the walking speeds vary widely, they are generally less than the natural (comfortable) speed of 1.3 m/s (3 mph). Contrast these values with those given in section 2.4.

2.5.11.2 Practical levels of shopper movements

Entrances

— Walking speeds reduce to 0.7 m/s when shoppers pass through entrances, otherwise the shopper flows remain similar to those given in Table 2.5.

Malls

— The density of shoppers in uncrowded conditions is 0.2 person/m^2 and 0.45 person/m^2 during crowded conditions. The density can increase to 1.0 person/m^2 at pinch points (i.e. areas where the mall size is inadequate, e.g. at a food court).

— The walking speed of shoppers in uncrowded conditions is generally 1.3 m/s and in crowded conditions is generally 1.0 m/s.

— Pedestrian flow rates are shown in Table 2.10.

— Counterflows reduce mall capacity by 15% compared to unidirectional flows.

Table 2.10 Actual mall pedestrian flow rates per metre width of mall

Traffic type	Uncrowded (0.2 person/m^2)		Crowded (0.45 person/m^2)	
	Speed (m/s)	Flow rate (person/h)	Speed (m/s)	Flow rate (person/h)
All shoppers	1.3	936	1.0	1620

— The effective mall width reduces (equal to actual mall width minus street furniture and window shoppers), as the condition changes from uncrowded to crowded. This results from more stationary shoppers looking into shop windows.

— Mall widths should be of the order of 6–8 m wide as a compromise between too wide to cross and too narrow to pass along.

Stairs

— Uncrowded density on stairs is found to be approximately 0.4 person/m^2 and crowded density on stairs reaches 0.8 person/m^2.

— Shoppers' speeds when using stairs varies according to traffic type.

— The stair capacity under uncrowded conditions and under crowded conditions varies according to traffic type, see Table 2.11.

— There is a tendency for more down traffic than up traffic in the ratio 60:40.

— A minor contraflow can reduce a major flow by effectively reducing the stairway width by some 750 mm.

Table 2.11 Stairway pedestrian flows per metre width of stair

Traffic type	Speed (m/s)	Uncrowded (0.4 person/m^2)	Crowded (0.8 person/m^2)
Men	0.8	960	1920
Elderly men	0.5	600	1200
Women	0.7	840	1680
Elderly women	0.6	720	1440
Children	0.8	960	1920
Push chairs	0.5	600	1200

Escalators and moving walks

— About 80% of shoppers may use the escalators to quickly reach other floors in a shopping centre, as they rarely have to wait.

— The 800 mm step width escalators (commonly used in stores) have a theoretical step utilisation of $k = 1.5$. However, shopping centre escalators are observed to load to only $k = 0.5$ step utilisation under uncrowded conditions and to $k = 1.0$ step utilisation under very crowded conditions. The width of an 800 mm step is not large enough to accommodate two adult people side by side. To achieve this, an escalator with a step width of 1000 mm (commonly used in malls) is required, when a higher step utilisation can be achieved. Escalator handling capacities are shown in Table 2.12.

— In some shops only an up-travelling escalator is provided, with stairs alongside for downward circulation.

— There is a tendency for stores and shopping centres to install inclined moving walks, which allows shoppers to keep their purchases with them in trolleys as they circulate. For safety, the moving walks should be designed to accept trolleys that lock onto the pallets.

Table 2.12 Actual escalator handling capacity

Speed (m/s)	Handling capacity (person/h) for 800 mm step	
	Uncrowded	Crowded
0.50	2250	4500

Lifts

Observation (scenic) lifts, pram lifts, car park and other lifts are provided in shopping centres, but not in sufficient quantities to serve more than a fraction of the shoppers. They are mainly used by the elderly, infirm, disabled, mothers with children and push chairs, and people with heavy packages. Observation lifts are sometimes installed as a feature to provide a visual impact in retail complexes. They do contribute to the circulation aspects of a shopping centre, but cannot be considered as a major handling capacity provider as passengers often use one simply for the ride.

2.5.12 Universities and other education buildings

Most university buildings can be classified as institutional buildings, where the occupants receive a service. A university campus often has a mixed collection of lecture blocks, office type buildings, halls of residence, catering services and factory-like units containing teaching and research equipment (e.g. reactors, high voltage laboratories, telescopes). Where universities occupy city sites many have tall buildings (10–20 stories) and even those on out-of-town sites follow suit in order to reduce land use and keep a compact campus. The office type buildings can be treated in the same way as detailed earlier in section 2.4. Halls of residence can be treated in a similar way to hotels, although perhaps at lower levels of demand and performance. The catering services can be attached to either the office type buildings or halls of residence and should be treated as office facilities or hotel facilities. The factory-like buildings may be low-rise and may be subject to special movement provisions associated with the equipment installed, e.g. barriers to radioactive areas.

The main feature of the university campus is the lecture changeover periods. There are hourly cycles of 10 minutes of demand at the end of each 50-minute lecture, tutorial or seminar. In between the peaks the activity levels are low. To install lifts in a tall building to suit this demand is not cost effective (and universities do not have large capital budgets). A better solution is to try to re-arrange the activities in the building to reduce the load on the lifts. An example in Adler[1] illustrates the relationship chart for a small firm; a similar set of relationships can be formed for a university building. It would be possible to reduce the demands made for 10 minutes every hour by the following:

— Place lecture facilities on the lower levels, say basement, ground and three to four floors above the entrance level. Students can be encouraged to use stairs if they are wide, well lit and visible.

— Laboratory, bulk service facilities (computer clusters, libraries) and student administration (registrar, bursar, careers advisory, etc. can be placed from the fourth floor upwards. These are either used for periods longer than one hour (laboratories), shorter than one hour (administration) or randomly (libraries).

— Offices should be placed at the top of the building. Their occupants generally use the lifts on a more random basis.

2.6 Location and arrangement of transportation facilities

2.6.1 General

Having discussed the various passive circulation elements (corridors, stairs, portals, etc.) and the active circulation elements (moving walks, escalators and lifts) in the previous sections, it is now necessary to consider their location and arrangement, which should take account of:

— the location of entrances and stairs

— the location of lifts, escalators and moving walks

— the distribution of the occupants in the building

— safe circulation

— car parks with minimum or no facilities at ground level.

The main principles, as given in section 2.2, are:

— to minimise the movements of people

— to minimise the movements of goods

— to prevent clashes between people and goods

— to prevent bottlenecks.

Ideally, all circulation activities should be centralised in a main core of a building. This is clearly not always possible when access into a building is considered. Sometimes the main lobby is close to the main entrance and sometimes the main lobby is some distance into the building. This latter case requires occupants and visitors to walk some distance in order to reach the transportation facilities. However, it may be better for occupants to walk to the centre of a building to access stairs and lifts, since their central location during the day may outweigh the comparative inconvenience during arrival and departure. Generally the maximum distance to a lift or stair from an occupant's work place should not exceed 60 m with a distance of less than 45 m being preferred. Emergency escape routes are usually closer, but do not necessarily form part of the normally used circulatory routes.

2.6.2 Stairs

Stairs should not lead directly off corridors, but be accessed from landing and lobby areas where people may congregate without obstructing a circulation route. Thus the vertical and horizontal modes of circulation can be allowed to merge smoothly. If it is the intention to encourage the use of stairs for short journeys to/from adjacent floors (interfloor movement), then the stairs should be of sufficient size, clearly visible, adequately signed, and encountered before reaching the lifts.

The provision of well signed and positioned stairs can considerably lessen the demands made on the lifts. In general lifts may be used for travel over a large number of floors and stairs for travel over a small number of floors. A judgement is made by the passenger with respect to the waiting time for a lift versus the walking time (and walking effort) with respect to stairs. In office environments they can be a advantageous where (say) heavily populated trading floors need to be accessed. They are also very useful for access to car parks, relieving the lifts of travelling below the main terminal, and may be used for access to double-deck lifts.

Table 2.13 provides guidance on the division of passenger demand between lifts and stairs. Although stairs are an 'always available' facility, their attraction diminishes with the number of floors a person needs to travel. Designers should take these factors into account.

Table 2.13 Comparison of usage of stairs and lift

Floors travelled	Usage (stair:lift)	
	Up (%)	Down (%)
1	10:90	15:85
2	5:95	10:90

2.6.3 Escalators and moving walks

Escalators are typically used for short range movement between adjacent floors (except in underground railway systems). They are found in offices between principal levels, in shops between trading floors, in shopping centres between malls and elsewhere such as railway stations, hospitals, museums, etc. They are usually sited in an obvious circulation path making it easy for pedestrians to board them.

Escalators and moving walks should only be accessed from adjacent corridors/walkways, landing and lobby areas, where people do not obstruct other pedestrian circulation routes. Space should be available to accommodate queuing at the boarding point. Again the intention is to ensure that the vertical and horizontal modes of circulation can merge smoothly.

It is especially important that the boarding and alighting areas adjacent to an escalator or moving walk are not part of another circulation route, in order to provide a safe area for passengers to board and alight. This obligation is required by Annex A.2.5 of BS EN 115-1: 2008(6), which requires a sufficient unrestricted area be available to accommodate passengers at the landings. The area of this space is defined as the distance between the handrails plus 160 mm, multiplied by a depth of from 2.0 m to 2.5 m, depending on the configuration of the escalator or moving walk.

Figure 2.2 illustrates Clause A.2.5 with Option 1 being a 2.5 m landing depth and Option 2 being a 2.0 m landing depth. Where successive units(8) are installed each successive escalator, or moving walk, should have its own individual unrestricted area.

Escalators occupy more space than stairs in order to accommodate their inclination. There are several standard escalator arrangements as shown in Figure 2.3. Types (a) and (b) provide efficient circulation by providing the shortest transition path and time from one escalator and the next. Type (b) requires a larger structural opening than types (a) and (c) and presents users with a higher risk of falling into the void. Type (c) is typical of a store as it allows the store to lengthen the circulation route past goods for sale. This configuration also takes up less space.

Some moving walks are adapted to receive and lock-on shopping/baggage trolleys. In these cases the unrestricted area at the landings should be increased to at least five metres and the number of flat/horizontal steps at the boarding and alighting points increased. The most significant effect is the increased footprint required for the equipment. Shopping/baggage trolleys are not permitted on escalators.

In order to encourage pedestrian confidence and to assist the efficient and safe boarding and alighting of escalators, the start and end of the escalator should present a number of horizontal (flat) steps. BS EN 115-1: 2008(6) specifies at least two flat steps are provided for escalator speeds up to 0.5 m/s, at least three flat steps for speeds above 0.5 m/s and up to 0.65 m/s and at least four flat steps for speeds above 0.65 m/s. In locations where it is anticipated that the escalators may be used by persons with impaired mobility additional flat steps should be considered.

2.6.4 Lifts

The grouping of passenger lifts is particularly important where they provide the main means of vertical transportation within a building. Lifts should always be placed together rather than distributed around a building. This provides a better service (shorter intervals), mitigates the failure of one car (availability of adjacent cars) and leads to improved traffic control (group systems). Eight lifts are the recommended maximum number of lifts that should be grouped together, using conventional landing call stations(2), especially if large lifts are used (>2000 kg). This allows passengers to determine when a lift arrives (from the lantern and gong signals), to walk to the car (across the lobby) and to enter it before the lift doors start to close.

The distance across a lobby is usually 1½ to 2 times the car depth. According to BS ISO 4190-1(7) where lifts are placed side by side this distance should not be less than 2400 mm and, where facing, not less than 4500 mm. However, if the lift lobby is too large, passengers have too far to walk and the closure of the car doors has to be delayed (increased door dwell time) to accommodate the increased walking time.

Lift lobbies should not be part of a through circulation route, either to other lifts, or other areas in the building. Lobbies should be provided that are dedicated to

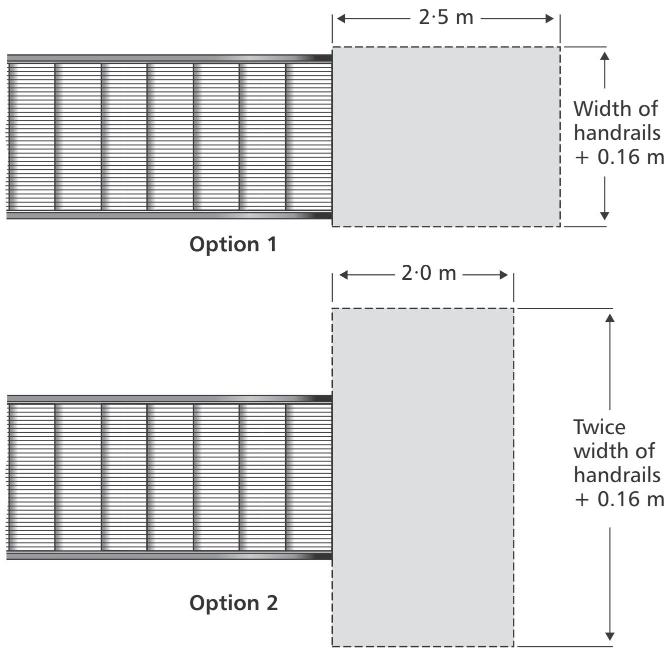

Figure 2.2 Illustration of unrestricted free space according to BS EN 115-1: 2008(6)

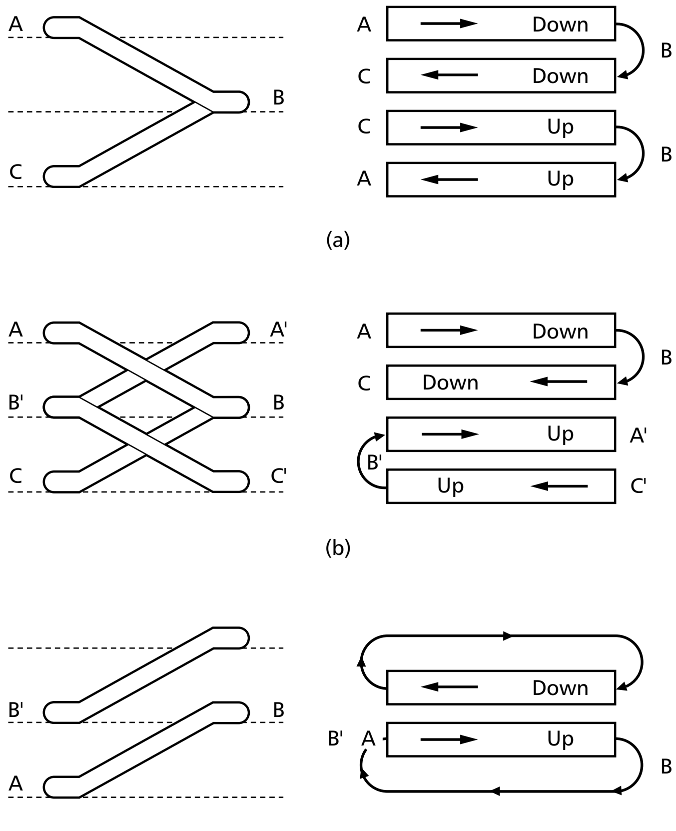

Figure 2.3 Escalator configurations; (a) parallel, (b) cross-over, (c) walk round

passengers waiting for the lifts. The ideal lobby size would be one that could accommodate one full car load of passengers waiting and permit the simultaneous disembarkation of one full car load of arriving passengers. This area can be calculated using the density information given in section 2.2.2 at between 'comfortable' and 'dense' (say 1.4 person/m^2).

The shape of lobbies is most important. For example, a group of lifts whose doors are fitted to a convex shaped lobby would be most inefficient, whereas if the doors were fitted to a concave shaped lobby the lobby design would be nearly perfect. Zoning a building requires more lobby space at the main terminal level. The positioning of the groups is very important. Adequate signs should be provided to quickly and simply direct the passengers to the correct group.

Some buildings may be designed with their main entry points at more than one level. The presence of more than one main terminal level for the lift system does not lead to efficient circulation and, where possible, buildings should not be designed in this way. Means should be provided to bring the two entrance routes together at a single lift lobby. Except in special cases it is recommended that the main terminal floor should be used as an interchange for the different circulation modes.

BS 5655-6[9] gives recommended layouts and limitations for groups of lifts. The preferred arrangements of between two and four lifts arranged in line are given in Figure 2.4 and between two and eight lifts arranged opposite each other are shown in Figure 2.5. Note all the lobbies (indicated by 'L') are waiting areas with no through circulation.

It is suggested that the position of any central lift core should be towards the centre of the building in order to reduce the walking distances from any point in the building.

Some floor plates are very large. Ideally all circulation activities should be centralised in a main core of a building. This is not always possible when access into a building is considered. Sometimes the main lobby is close to the main entrance; sometimes the building design places the main lobby some distance into the building. This latter case involves occupants and visitors in a long walk to reach the transportation facilities. However it may be better for occupants to walk to the centre of a building to access stairs and lifts, since their usage during the day may outweigh the comparative inconvenience during arrival and departure.

Generally the maximum distance to a lift or stair from an occupant's work place should not exceed 60 m with a distance of less than 45 m being preferred. Emergency escape routes are usually closer, but do not necessarily form part of the normally used circulation routes.

Where a building layout cannot accommodate these arrangements the following factors should be considered to optimise the accessibility and visual links to all lifts within a group to the passengers:

— lobby size
— location of push buttons
— location and type of landing indicators
— walking distances to lift entrances in a lift lobby
— additional structural costs of fragmented lift cores.

2.6.5 Lifts versus escalators

In general lifts are used for travel over a large number of floors and escalators for travel over a small number of floors. A judgement is made by the passenger with respect to the waiting time for a lift versus the length of time walking (and walking effort) with respect to escalators.

Low-rise structures such as shopping centres, sports complexes, conference and exhibition centres, railway stations, airports, hospitals, etc. are good examples of buildings where the provision of escalators considerably aids circulation (and is used by the passengers).

In office environments the usefulness of escalators is lessened, although they can be a advantageous where (say) heavily populated trading floors need to be assessed. They are also very useful for access to car parks, relieving the lifts of travelling below the main terminal, and may be used for access to double-deck lifts. Table 2.14 provides some guidance on the division of traffic between lifts and escalators.

Table 2.14 Likely division of traffic between lifts and escalators

Floors travelled	Escalator (%)	Lift (%)
1	90	10
2	75	25
3	50	50
4	25	75
5	10	90

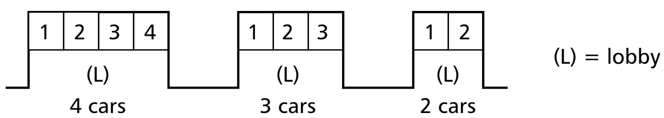

Figure 2.4 Preferred arrangement for 2 to 4 lifts (in line)

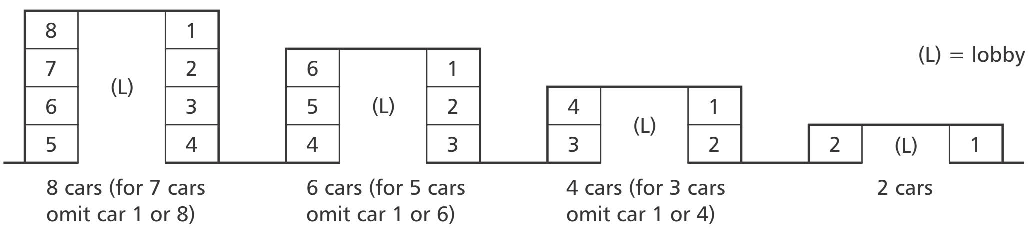

Figure 2.5 Preferred arrangement for 2 to 8 lifts (facing)

2.7 Facilities for persons with special needs

The discussion so far has assumed that all persons circulating in a building are fully able-bodied. However, a large proportion of the population are disadvantaged in some way. BS EN 81-70: 2003: *Accessibility to lifts for persons including persons with disability*[5] categorises disabilities into physical, sensory and intellectual. BS 8300: 2009: *Design of buildings and their approaches to meet the needs of disabled people*[10] gives some guidance for facilities within buildings. The Disability Discrimination Acts 1995[11] and 2005[12] lay down various provisions, regulations and penalties for non-conformance. Building Regulations Approved Document M[18] provides guidance on compliance in the UK.

Generally, arrangements made to allow persons with special needs to make use of circulation elements assist the able-bodied and should be implemented wherever possible. Chapter 11 of this Guide discusses lifting facilities for persons with special needs.

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3 Traffic planning and selection of lift equipment and performance

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Chapter contents

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3 Traffic planning and selection of lift equipment and performance

3.1 Introduction

This chapter provides a general guide to UK and European practice, which may differ from North American practice (Strakosch, 1998)[14]. It is recommended that Barney (2003)[2] be consulted for the detailed theory and as a source of the primary references. The various terms commonly encountered are defined in section 3.2, and other definitions may be found in the glossary (Appendix A1 to this Guide).

The transportation capacity of the lift group in a building is a major factor in the success or failure of a building as a place to work, to live or to receive a service. Building occupants expect lifts to be available and easy to use without a second thought. Unfortunately this is not always the case and speculative building often results in the installation of an imperfect lift system.

The planning and selection of transportation equipment is a very involved subject. Although the basic calculations are relatively simple, the theory on which they are based is complex. The results obtained should always be tempered with a great deal of working experience of existing buildings, in order to ensure that a satisfactory design results.

The difficulty in planning a lift installation is not in calculating its probable performance, but in estimating the passenger demand that is likely to occur. Quite often the building has yet to be built and estimates have to be based on the experience gained with previous similar structures. Existing buildings can be surveyed, by observation, or by means of an attached data logger, to determine the current activity. However, even this is prone to error as the building's population may have adapted to a poor (or good) lift performance.

It is essential, therefore, that all the parties involved in the planning of a lift installation should have a clear understanding of the basis for the planning. The architect or planner should establish the lift system required at a very early stage, in consultation with a lift specialist, and not after the rest of the building has been designed, as has often happened in the past.

A design that is tightly planned, may prove inadequate once a new building becomes fully occupied. It is important to remember that the distribution and size of the population of any large building can alter regularly, for example, as tenants change. To understand the effect of any of these changes on a building, it is essential to document the design criteria and the reasons for decisions taken at all stages of a design.

Two key factors affect the demand that a building's occupants may make on a lift system: the quantity of service and the quality of service required. The quantity of service factor (i.e. how many people might use the lift system over a defined period of time) is represented by the handling capacity. The quality of service factor (i.e. how well the lift system deals with its passengers) is represented by passenger waiting time and lobby queuing. These factors are interrelated and depend, amongst other things, on the type of building and its use, and on the type of occupier. This makes the design task very difficult for buildings of a speculative nature.

Two models can be used for lift traffic design and analysis:

- The first model uses a calculation method based on mathematical formulae. This classical model has been used for nearly 80 years and results in a satisfactory solution for 90–95% of designs. The pure up-peak traffic condition (i.e. only incoming traffic) is used for this method as it provides a well defined, simple traffic pattern, amenable to mathematical analysis. These calculations can be carried out by hand, using a program, a spreadsheet or a simulation program. The fastest method is a spreadsheet, an example of which is used to illustrate this chapter. It provides instant results to each change of input.

- The second model, which has been used for over 45 years, is based on a discrete digital simulation of the movement of lifts in a building and the passenger dynamics. This simulation model allows very complex situations to be analysed. At present, simulations are very slow to carry out compared to the instant answers provided using a spreadsheet. For example, the simulation of Example 3.1, averaged over 10 runs (for accuracy), takes some 40 seconds. An 8-car group serving 15 floors with a hall call allocation control system (see chapter 9) takes 250 seconds.

It is recommended that calculations should always be carried out in order to refine a design and obtain an understanding of the various, sometimes conflicting, factors. A simulation may then be performed if the system being considered has any unusual aspects, or in order to obtain information not provided by the calculation method, e.g. passenger queues etc.

This chapter deals with the classical model based on calculation. Chapter 4 deals with the simulation model.

The two most frequently asked questions, when sizing a lift system are:

- *Question 1*: What is the handling capacity of the lift?

- *Question 2*: What size of lift installation is needed?

Question 1 is answered in section 3.5 and question 2 in section 3.8. The analysis is mainly relevant to commercial office buildings. Refer to section 3.12 for other types of buildings.

3.2 Symbols

AC	Actual capacity (persons)
A_d	Average down-peak passenger arrival rate (person/5-minutes)
A_i	Average interfloor passenger arrival rate (person/5-minutes)
A_r	Average up-peak passenger arrival rate (person/5-minutes)
AJT	Passenger average journey time (s)
ATTD	Passenger average time to destination (s)
ATT	Passenger average travel time to destination (s)
AWT	Passenger average waiting time (s)
CA	Car area (m^2)
CC	Rated (contract) capacity (persons)
CF	Capacity factor
%CF	Percentage capacity factor (%)
D_T	Distance between terminal floors (m)
d_f	Average interfloor height (m)
DNPHC	Down-peak handling capacity (person/5-minutes)
DNPAWT	Down-peak passenger average waiting time (s)
H	Average highest reversal floor
H_M	Average lowest basement reversal floor
IFAWT	Interfloor passenger average waiting time (s)
INT	Average interval with defined car load (s)
k	Hall call allocation look-ahead factor
L	Number of lifts
MIDAWT	Mid-day passenger average waiting time (s)
MIDHC	Mid-day handling capacity (person/5-minutes)
MIDINT	Mid-day average interval (s)
N	Number of served floors above the main terminal
NIA	Net internal area (m^2)
NUA	Net usable area (m^2)
P	Average number of passengers (persons)
%POP	Percentage population (%)
Q	Rated load (kg)
RTT	Average round trip time (s)
RTT_d	Average down-peak round trip time (s)
RTT_m	Average mid-day round trip time (s)
S	Average number of stops
S_M	Average number of basement stops
SRT	System response time (s)
T	Performance time (s)
T_M	Basement floor to floor cycle time (s)
t_{ad}	Advance door opening time (s)
t_c	Door closing time (s)
t_{cyc}	Cycle time (s)
t_e	Main terminal to express zone terminal flight time (s)
$t_f(1)$	Single (1) floor flight time (s)
t_o	Door opening time (s)
t_p	Passenger average transfer time (entry or exit) (s)
t_{sd}	Start delay time (s)
t_u	Passenger unloading time (s)
t_v	Time to transit two adjacent floors at rated speed (s)
t_{vM}	Time to transit two adjacent basement floors at rated speed (s)
U	Effective building population (persons)
UPPHC	Average up-peak handling capacity (person/5-minutes)
UPPINT	Average up-peak interval with 80% car load (s)
v	Rated speed (m/s)

3.3 Definitions

advanced door opening (t_{ad})

period from the time the lift is level at a landing until the doors are 800 mm open

Note: this feature overlaps the final motion, the levelling operation, with the first part of the opening of the doors to reduce door opening time.

door closing time (t_c)

period measured from the instant the car doors start to close until the doors are locked

door opening time (t_o)

period measured from the instant that the car doors start to open until they are open 800 mm

interval (INT)

period between successive car arrivals at the main terminal with cars loaded to any value

lift system cycle time (t_{cyc})

period from the instant the car doors begin to close until the instant the car doors begin to close again at the next adjacent floor provided no passengers have crossed the threshold

performance time (T)

period between the instant the car doors start to close and the instant that the car doors are open 800 mm at the next adjacent floor

Note: sometimes called 'door-to-door' time.

passenger arrival rate

rate at which passengers arrive for service by a lift system.

Note: often given as a percentage of a building's population arriving within a 5-minute period

passenger average journey time (AJT)[3]

average period of time from when a passenger either registers a landing call, or joins a queue, until the passenger alights at the destination floor (see Figure 3.1)

Note: a passenger is deemed to have alighted, when any passenger detection device is interrupted or the passenger physically crosses the door sills.

passenger average time to destination (ATTD)[3]

average period of time from when a passenger either registers a landing call, or joins a queue, until the responding lift begins to open its doors at the destination floor (see Figure 3.1).

passenger average transfer time (t_p)

average period of time for a single passenger to enter or leave a lift car

passenger average transit time (ATT)

average period of time from when a responding lift begins to open its doors at the boarding floor until the doors begin to open again at the destination floor (see Figure 3.1)

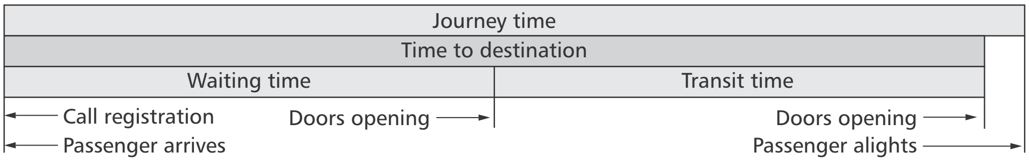

Figure 3.1 Illustration of passenger time relationships

Note: the passenger transit time commences, if the responding lift doors are open, when a passenger arrives.

passenger average waiting time (AWT)

average period of time from when a passenger either registers a landing call, or joins a queue, until the responding lift begins to open its doors at the boarding floor (see Figure 3.1)

Notes:

(1) The passenger waiting time continues if a passenger does not enter the responding lift, e.g. because the lift is full.

(2) The passenger waiting time is zero if the responding lift doors are open when a passenger arrives.

(3) If a passenger may register a destination call before arriving at the lift lobby, waiting time may be divided into two components: walking time (time to reach the lobby) and standing time (time waiting in the lobby).

single floor flight time ($t_f(1)$)

period of time measured from the instant that the car doors are locked until the lift is level at the next adjacent floor

system response time (SRT)

time that it takes a lift group to respond to the first registered landing call at a floor

Note: sometimes taken as the period between a passenger registering a call at a landing and the subsequent cancellation of that call by the traffic controller.

up-peak handling capacity (UPPHC)

number of passengers that a lift system can theoretically transport during the up-peak traffic condition with a car occupancy of 80% of the actual capacity

Note: this is calculated by determining the number of trips made by the lifts, which occur over the worst five minute (300 second) period and then multiplying it by the average number of passengers (P) carried in that five minutes.

up-peak interval (UPPINT)

average time between successive car arrivals at the main terminal (or other defined) floor with cars assumed to be loaded to 80% of actual capacity during the up-peak traffic condition

3.4 Traffic patterns

Figure 3.2 illustrates a classical traffic pattern of passenger demand in an office building as would be seen from the main terminal, or main access, floor. It shows the number of up landing calls and down landing calls registered during the working day. Today this pattern is rarely observed as shown, as many companies have adopted a 'flexitime' attendance regime. It does, however, serve as a model for discussion.

Figure 3.1 shows four distinct classic traffic patterns:

— At the start of the day there are a larger than average number of up landing calls. This demand is due to the building's occupants arriving to start work. This traffic pattern is called the morning up-peak. Industry practice is to size a lift installation to handle the number of passengers requesting service during the heaviest five minutes of the up-peak traffic condition. This is a sound recommendation. To size the lift system to handle the actual peak would require too large a system, which would be very expensive and much of the equipment would be under-utilised during large periods of the working day. The duration of the classical up-peak traffic condition is typically five minutes.

— Late in the day there is a larger than average number of down landing calls. This demand is due to the building's population leaving at the end of the working day. This traffic pattern is called the evening down-peak. The profile of the down-peak traffic is larger in size and longer in duration than the up-peak profile. Fortunately a lift system inherently possesses about 60% more handling capacity during down-peak than during up-peak. This is due to lifts filling to capacity at three to five floors and then making an express run to the main terminal. This reduction in the number of stops allows the lift to serve other waiting passengers more quickly. The duration of the classical down-peak condition is typically 10 minutes.

— In the middle of the day there may be a number of up-peaks and down-peaks. This represents a situation where the occupants of the building take their lunch breaks. This pattern is called mid-day traffic. Today this traffic pattern can be very

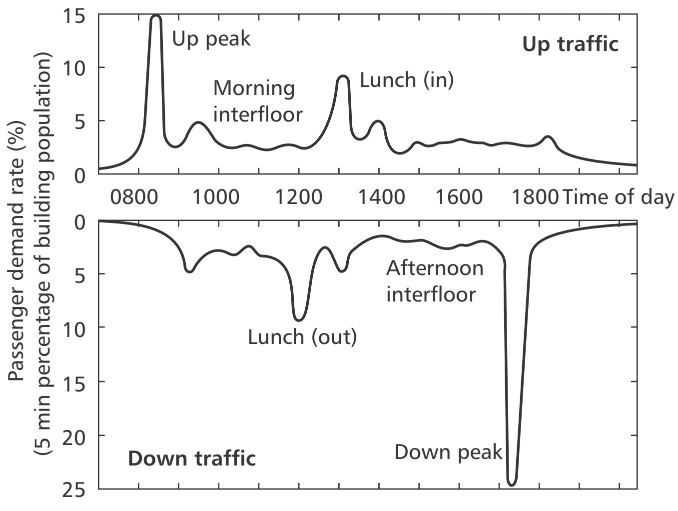

Figure 3.2 Passenger demand for an office building over a working day

intense and is often more demanding than either the up-peak or the down-peak, with strong patterns of simultaneous up and down traffic together with some interfloor traffic. This traffic condition may typically exist for one to two hours dependent on the arrangements for the mid-day break.

— During the rest of the day the numbers of up and down landing calls are much smaller than during the peak periods. They have similar up and down demand values and over a period of time they balance out. This traffic pattern is called interfloor traffic, sometimes qualified as balanced interfloor traffic. Interfloor traffic exists for most of the working day and is a very important traffic demand.

Generally, if the lift system, which uses a conventional landing call system (i.e. not hall call allocation signalling systems) is sized correctly for the up-peak traffic pattern, all other traffic patterns should be adequately served. There are exceptions to this comment. These include hotels, where meal times clash with check-in/check-out, hospitals at visiting times, buildings with trading floors (insurance and stock markets) that open at specified times, buildings where restaurants are high in the building and residential buildings.

3.5 Sizing an existing lift installation

See section 3.2 for definitions of symbols.

Figure 3.3 shows that a lift round trip is characterised by passengers arriving at the main terminal for transportation to the upper floors. The lift travels around the building making stops to allow passengers to alight, eventually reaching the highest requested floor at which time the lift reverses direction and then travels non-stop back to the main terminal floor.

3.5.1 The round trip time (RTT) equation

The calculation method, to size a given lift installation, requires the determination of the time, in seconds, that it takes for a single lift to make a round trip around a building during the up-peak traffic condition. This is called the round trip time (RTT). Figure 3.3 illustrates the spatial movements of a round trip.

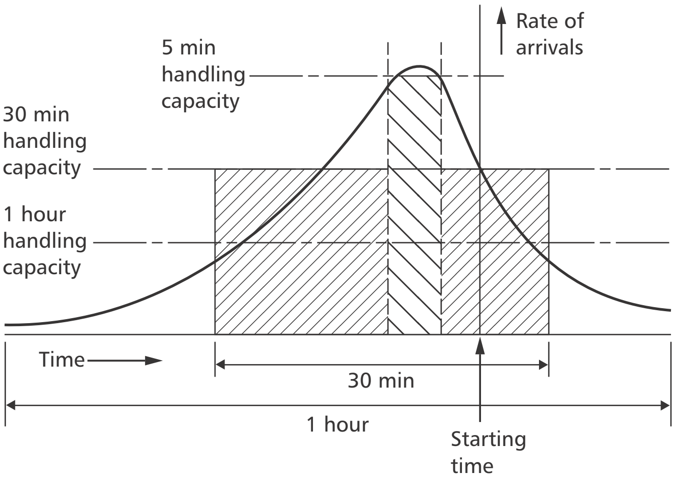

Figure 3.3 Components of a round trip for a single lift during peak up-peak traffic

The round trip time of a single lift during up-peak traffic (Barney and Dos Santos, 1975)[4] is given by:

$$\text{RTT} = 2\,H\,t_v + (S + 1)\,(T - t_v) + 2\,P\,t_p \qquad (3.1)$$

3.5.2 Evaluating up-peak interval,up-peak handling capacity and percentage population served

Using the value obtained for RTT the up-peak interval (UPPINT) can be calculated by dividing it by the number of lifts (L) in the installation. In a system of L cars the up-peak interval is given by equation 3.2:

$$\text{UPPINT} = \frac{\text{RTT}}{L} \qquad (3.2)$$

Note: in an installation of only one car, the up-peak interval (UPPINT) is equal to the round trip time (RTT).

The up-peak handling capacity (UPPHC) can be calculated using the average car occupancy of passengers (P). The up-peak handling capacity (UPPHC) is given by equation 3.3:

$$\text{UPPHC} = \frac{300\,P}{\text{UPPINT}} \qquad (3.3)$$

The percentage of building population that can be handled (%POP) is obtained by dividing the UPPHC value by the building's effective population (U). The percentage population (%POP) handled is given by equation 3.4:

$$\%\text{POP} = \frac{\text{UPPHC} \times 100}{\text{UPPINT}} \qquad (3.4)$$

To carry out a design the component parts of equation 3.1 need to be determined.

3.5.3 Values for average highest reversal floor (*H*) and average number of stops (*S*)

There are three variables: H, S and P; and three time values: t_v, T, t_p. The values for H (Schroeder, 1955)[13] and S (Basset Jones, 1923)[5] can be obtained from equations 3.5 and 3.6.

The evaluation of H and S requires values for the number of floors above the main terminal (N) and the average number of passengers in the car (P).

$$H = N - \sum_{i=1}^{N-1} \left(\frac{i}{N}\right)^P \qquad (3.5)$$

$$S = N\left(1-\left(1-\frac{1}{N}\right)^{P}\right) \quad (3.6)$$

Values for H and S have been tabulated in Appendix 3.A1 for a range of values for P.

3.5.4 Value for number of floors (N)

The number of floors above the main terminal is a known value. However, not all floors may be served and the value for N should be the number of served floors.

3.5.5 Value for average number of passengers (P)

For the calculation of RTT the average number of passengers in the car (P) should be taken as 80% of the maximum actual car capacity (AC).

$$P = 0.8 \times \text{AC} \quad (3.7)$$

For safety reasons, lifts are required by BS EN 81-1/2[7,8] to be sized to carry a rated load in kilograms. A safe nominal number of passengers that a lift can carry may be found by dividing the rated load by a figure representing the average weight of persons in the region where the lift is to be installed. In Europe this is taken in the standards as 75 kg.

Warning: this nominal value should not be used for traffic calculations as the physical size of the passengers (i.e. the volume occupied) often exceeds the space available.

Associated with the rated load is an available car area (for traction lifts see BS EN 81-1, Table 1.1, and for hydraulic lifts BS EN 81-2, Tables 1.1 and 1.1A). If a 75 kg person is assumed to occupy a floor area of 0.21 m^2 (see section 2.3.1) then the maximum (actual) passenger occupancy (AC) of a lift can be obtained. For European traffic designs see columns 3 and 4 of Table 3.1 for persons assumed to weigh 75 kg. Table 3.1 also shows the actual capacity and the design value for P for other assumed passenger weights. For example, 65 kg is often used in Singapore, 68 kg is often used in Australia and 80 kg is often used in Russia.

Note: average values of H, S and P are often not integer values.

3.5.6 Value for floor transit time (t_v)

To obtain a value for t_v, the average interfloor distance (d_f) and the rated speed (v) of the lift are required. The floor transit time is then given by equation 3.8:

$$t_v = \frac{d_f}{v} \quad (3.8)$$

The average interfloor distance can be obtained by dividing the total travel from the main terminal to the highest served floor (D_T) by the number of served floors:

$$d_f = \frac{D_T}{N} \quad (3.9)$$

Warning: the average interfloor distance may contain significantly different non-standard floor heights, e.g. main terminal, specialist floors etc. Where this is the case the value obtained for t_v may need overstated.

3.5.7 Value for rated speed (v)

This may be provided by the lift installer. If not then a generally accepted rule of thumb for offices is that a lift should be able to travel between terminal floors in 20 seconds for prestige class buildings or 30 seconds for speculative buildings.

For offices, Table 3.2 indicates maximum suggested travels for the ISO-specified range of rated speeds. Values for other building types are given in Table 3.3

Warning: the evaluation of the round trip time assumes that the rated speed is reached in the distance of a single

Table 3.1 Car capacity

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rated load (RL) (kg)	Max. area (CA) (m^2)	Passenger weight = 75 kg Occupancy = 0.21 m^2		Passenger weight = 65 kg Occupancy = 0.18 m^2		Passenger weight = 68 kg Occupancy = 0.19 m^2		Passenger weight = 80 kg Occupancy = 0.22 m^2	
		Actual capacity (AC) (persons)	Value for P for calcs.	Actual capacity (AC) (persons)	Value for P for calcs.	Actual capacity (AC) (persons)	Value for P for calcs.	Actual capacity (AC) (persons)	Value for P for calcs.
450	1.30	6.2	4.9	7.2	5.8	6.8	5.5	5.9	4.7
630	1.66	7.9	6.3	9.2	7.4	8.7	7.0	7.5	6.0
800	2.00	9.5	7.6	11.1	8.9	10.5	8.4	9.1	7.3
1000	2.40	11.4	9.1	13.3	10.7	12.6	10.1	10.9	8.7
1275	2.90	13.8	11.0	16.1	12.9	15.3	12.2	13.2	10.5
1600	3.56	16.9	13.6	19.8	15.8	18.7	15.0	16.2	12.9
1800	3.92	18.7	14.9	21.8	17.4	20.6	16.5	17.8	14.3
2000	4.20	20.0	16.0	23.3	18.7	22.1	17.7	19.1	15.3
2500	5.00	23.8	19.1	27.8	22.2	26.3	21.1	22.7	18.2

Notes: col. 1: rated load (RL) range taken from BS ISO 4190-1[9]; col 2: maximum car area (CA) values taken from BS EN 81-1/2[7,8], Table 1.1; cols. 3/5/7/9: actual capacity (AC) calculated by dividing car area (CA) by indicated passenger weight; cols. 4/6/8/10: value for P is 80% of AC for indicated passenger weight

Table 3.2 Maximum travel for various rated speeds

Rated speed (m/s)	Maximum travel (m) for 20 s travel time	Maximum travel (m) for 30 s travel time
1.00	20	30
1.60	32	48
2.50	50	75
4.00	80	120
5.00	100	150
6.00	120	180

Table 3.3 Total times for building types other than offices

Building type	Travel time (s)
Large hotels	20
Small hotels	30
Hospitals, nursing/residential homes, etc.	24
Residential buildings	20–30
Factories, warehouses, shops, etc.	24–40

floor jump. In approximate terms this is given by v^2 metres. Lifts with rated speeds over 1.6 m/s may not reach the rated speed over a typical floor height.

3.5.8 Value for performance time (T)

This time may be provided by the lift installer. The components of performance time (see equation 3.10) need to be carefully selected in order to achieve the correct handling capacity for the lift installation. At the tender stage, the lift maker should state contractual values for these times and the maintenance contractor should be required to keep them at the contract values throughout the life of the lift installation. Failure to do this can invalidate any traffic design.

Warning: some lift companies state the performance time (T) to be the time from the instant the doors start to close until the instant the doors start to open, even if the lift is still moving.

The performance time (T) is composed of a number of independent time values:

$$T = t_f(1) + t_{sd} + t_c + t_o - t_{ad} \tag{3.10}$$

Design tip: the variable T is made up of five terms. When any measurements are made on existing installations each term is subject to measurement error. Their subsequent summation can lead to significant inaccuracies. Although it is important to know their nominal values, a much more accurate value can be obtained by measuring T directly.

Design tip: of the three terms in the round trip time equation, the central term is the most influential and the saving of one second on the value of T can increase the handling capacity by about 5%.

3.5.9 Value for single floor flight time ($t_f(1)$)

This may be provided by the lift installer. The relationships between distance travelled, velocity, acceleration and jerk are complex and are given in detail in Appendix A2. Using the equations of motion given in Appendix A2, flight times can be obtained, by calculation or by using a spreadsheet, for any distance or number of floors travelled. Alternatively, Table 3.4 indicates some possible values for the assumed values of acceleration/deceleration, jerk and three average interfloor distances.

Table 3.4 Single floor flight times

Rated speed (m/s)	Acceleration (m/s^2)	Jerk (m/s^3)	Single floor flight time (s)		
			3.5 m	4.5 m	5.5 m
1.00	0.4-0.7	0.75	6.1	7.1	8.1
1.60	0.7-0.8	0.9	5.2	5.8	6.4
2.50	0.8-0.9	1.0	5.0	5.5	6.0
3.00	1.0	1.25	4.6	5.1	5.6
5.00	1.2	1.5	4.3	4.8	5.2
6.00	1.2	1.8	4.1	4.6	5.0

3.5.10 Value for start delay (t_{sd})

This time may be provided by the lift installer. Otherwise assume 0.5 seconds.

3.5.11 Values for door closing (t_c) and door opening (t_o) times

These times may be provided by the lift installer. Otherwise some typical values are shown in Table 3.5 and also Table 7.1 (see chapter 7).

Table 3.5 Door times

Door type	Door width (mm)			
	800	1100	800	1100
	Opening time (s)		Closing time (s)	
Side	3.0	4.0	2.5	3.0
Centre	2.0	3.0	2.0	2.5

3.5.12 Value for advance door opening time (t_{ad})

Also known as pre-opening time, this time may be provided by the lift installer. Otherwise assume 1.0 s.

3.5.13 Value for average one-way single passenger transfer time (t_p)

The passenger transfer time can vary considerably and is affected by the shape of the car, the size and type of car entrance, environment (i.e. commercial, institutional, residential), type of passenger (i.e. age, gender, agility, purpose), car loading.

General rules can be suggested. If the car door width is 1000 mm, or less, assume passengers enter or exit in single file. For door widths of 1100 mm and wider assume the first six passengers enter or exit in single file and the remainder in double file. For offices consider 1.2 s to be the one-way single passenger transfer time. Where passengers have no reason to rush or are elderly, the transfer times should be increased to about 2.0 s.

Warning: the value to be assigned to t_p is the average for all passengers that are transferring. For example a 2000 kg lift may load 16 passengers. Each passenger may have a transfer time of 1.2 s. But the first six passengers take $6 \times 1.2 = 7.2$ s, then the next 10 passengers exit in pairs, i.e. in 6.0 s. The total transfer time for all passengers is thus 13.2 s and the average transfer time is $13.2/16 = 0.83$ s. This is the figure is entered in equation 3.1.

See Table 3.6 for suggested passenger average transfer times (t_p) for offices, taking into account door width and car capacity. Note it has been observed that passengers often exit lift cars quicker than they enter. This effect can be accounted for by averaging.

Table 3.6 Passenger average transfer times (t_p) for offices

Rated load (kg)	t_p (s)
320–800	1.2
1000	1.0
1275	0.9
1600–2500	0.8

3.6 Round trip time equation: frequently asked questions

A number of assumptions are made in order to derive the round trip time equation (equation 3.1). These can place limits on the validity of the method. It is important for a designer to be aware of these limitations, especially when using computerised design methods, in order to ensure a correct design.

3.6.1 Do passengers arrive uniformly in time?

The derivation of the round trip time equation assumes that passengers arrived at a lift system for transportation, according to a rectangular probability distribution function (PDF). However, it is more likely that the arrival processes can be according to a Poisson PDF.

It has been shown[2a] that values for S and H derived using the Poisson PDF are always smaller than with a rectangular PDFs. Thus the use of formulae based on the rectangular PDF produces slightly conservative designs when compared to designs using formulae derived from other PDFs.

3.6.2 Are lifts loaded to an average load of 80%?

In the round trip time calculation the lifts are assumed to fill to 80% of the actual capacity (see Table 3.1). This has been shown[2b] to be a reasonable statistical assumption and allows some lifts to fill to capacity and others to lower values, giving an average of 80%. The number of passengers as a percentage of the actual capacity is called the percentage capacity factor (%CF), and is given by:

$$\%\text{CF} = \frac{P}{\text{AC}} \tag{3.11}$$

3.6.3 Are all floors are equally populated?

Generally the floors of a building are not equally populated. It is possible(2c) to derive quite complex formulae for S and H. If calculations are carried out for a building where most of the population occupies the higher floors then it is found that the value for H rises and the value for S falls. Conversely if most of a building's population occupies the lower floors of a building the value for H falls significantly and the value for S also falls. The effect in both cases compared to a building with each floor being equally populated is that the value for the round trip time falls. Therefore the effect of an unequal population is generally favourable to the conservative sizing of a lift system.

3.6.4 Is rated speed reached in a single floor jump and are interfloor heights equal?

These two assumptions are related. For lifts with speeds greater than 1.6 m/s the first assumption is not valid. Most buildings have irregular interfloor distances, e.g. main entrance floors, service floors, conference floors, making the second assumption invalid. It has been found(2d), that if the flight time to travel the average interfloor distance is determined and this time is used as tf(1) in the round trip time calculation, then an error in the calculation of only a few percent occurs.

3.6.5 What are landing and car call dwell times?

Some door control systems cause the lift doors to (dwell) open for a fixed length of time after a lift arrives at a floor. Passengers can then leave a lift (for a car call), or board a lift (for a landing call), without the doors closing on them.

Typical office building door dwell times are 2.0–3.0 seconds for a car call stop and 3.0–4.0 seconds for a landing call stop. The longer landing call dwell times allow waiting passengers to walk across a large lobby to the waiting lift. Where passenger detection systems are fitted to the car doors, these times can be automatically shortened to 0.5 seconds once the first passenger crosses the threshold. This is called differential door timing. The lift doors can then close only when the threshold is clear of passengers. Where disabled access is required the dwell time is set at 5.0 seconds minimum. In residential buildings it is common to set dwell times to 7.0 seconds to allow for prams and bicycles to be manoeuvred into and out of the lift. Good control systems should reduce the dwell times when a car call is registered or re-registered, or when the door close button is operated.

Where a door dwell time is longer than the calculated passenger transfer time the round trip time equation needs to be adjusted to account for this. This introduces the concept of a lift system cycle time (t_{cyc}). The cycle time can be applied to the round trip time equation by deleting the term ($2\,P\,t_p$) and adding the value of the dwell time to the value of the performance time (T).

Caution: where this is the case a simulation study may need to be carried out to verify the calculated design.

3.6.6 What are lobby loading times?

Many control systems operate a lobby loading time at the main terminal floor during up-peak. This prevents the lift closing its doors and moving away with only one passenger, once that passenger has entered and registered a car call. The lobby loading time should be set to be equal to the time for a reasonable number of passengers to board the car, this can be taken as 60% car loading. There may then be no effect on the round trip time calculation due to the lobby loading time.

Caution: if the lobby loading time does not reduce to standard dwell time values during off-peak periods, passenger service times may be increased.

3.6.7 Is the traffic controller ideal?

The traffic control system (dispatcher) is assumed to be ideal. On older scheduled (timed) systems, it is possible for the wrong control algorithm to be switched on for the prevailing traffic pattern; for example, the down-peak program during up-peak. Modern on-call traffic controllers utilise load and direction detection systems to determine the prevailing traffic pattern. Some designers add 5% or 10% (losses) to the round trip time to account for this inefficiency. This is not a recommended practice as the value used may not be known to all parties to a design.

Up-peak performance can be boosted by traffic control techniques[2e] such as up-peak zoning, up-peak sectoring, landing call allocation and landing call allocation with up-peak subzoning (see section 9.7). Formulae for H and S to be used in the calculation of the round trip time when a hall call allocation[2f] traffic control is employed are:

$$H = N - \sum_{i=1}^{N-1} \left(\frac{i}{N} \right)^{S} \tag{3.12}$$

$$S = \frac{N}{k} \left(1 - \left(\frac{N-1}{N} \right)^{kP} \right) \tag{3.13}$$

where k is the system look-ahead (usually a value of 2 or 3).

3.6.8 Footnote to up-peak round trip time calculations

The up-peak traffic pattern is defined absolutely, but real morning peak arrivals are never as precise. Often, there can be some down travelling and interfloor traffic during the up-peak period. Some designers attempt to include these in their calculations but, with such a variety of possible assumptions, no general benchmark condition can be defined. It is recommended that all up-peak calculations are 'pure' with no other traffic considered. Then the calculation can be used as a benchmark to compare different designs and competitive tenders.

The pure up-peak calculation gives a value for the underlying capability of the lift installation. It may be that a morning peak of only 10% of a building population is observed. However, there may be a further 5% of activity in the down direction and between floors. In this case a design for a 15% handling capacity would be justified.

Where better evaluations are required a simulation should be carried out (see chapter 4), but only after a thorough understanding of the design has been obtained by calculation.

3.6.9 Example 3.1

Example calculation using a spreadsheet, see Figure 3.4.

Requirements:

— %POP: 12%

— UPPINT: 30 s

Given data:

— Number of floors above main terminal (N): 10

— Rated load (Q): 1000 kg

— Number of lifts (L): 4

— Rated speed (v): 1.6 m/s

— Building population (POP): 750 persons

— Interfloor distance (d_f): 4.0 m

	A	B
11	INPUT DATA	Value
12	Number of floors	10
13	Rated load	1000
14	Actual car capacity	11.4
15	Number of passengers	8.8
16	Number of lifts	4
17	Rated speed	1.6
18	Building population	750
19	Interfloor distance	4
20	Express jump	0
21	Express additional time	0
22	Single floor flight time	5.5
23	Door close time	3
24	Door open time	2
25	Advance door opening	1
26	Start delay	0.5
27	Passenger transfer time	1
28		
29	RESULTS	Value
30	Number of passengers	8.8
31	Highest reversal floor	9.4
32	Number of stops	6.0
33	Performance time	10.0
34	Round trip time	117.5
35	Interval	29.4
36	Handling capacity	90
37	Percentage population	12.0
38	Capacity factor (%)	77
39	Uppeak average waiting time	23
40	Down peak handling capacity	145
41	Midday peak handling capacity	122

Figure 3.4 Example 3.1: spreadsheet output

— Single floor flight time ($t_f(1)$): 5.5 s
— Door close time (t_c): 3.0 s
— Door open time (t_o): 2.0 s
— Advance door opening (t_{ad}): 1.0 s
— Start delay (t_{sd}): 0.5 s
— Assumed one way passenger transfer time (t_p): 1.0 s

Procedure:

(1) Enter data into cells B12, B13.

(2) From Table 3.1 select actual car capacity (11.4) and the value for P (9.1) and enter into input cells B14, B15. Note that results cells B30–B32 (P, H, S) are updated.

(3) Enter data into cells B16–19, B22–B27. Note results cells B33–B38 (T, RTT, UPPINT, UPPHC, %POP, %CF) are updated.

(4) Set input cells B20–B21 as zero.

(5) Adjust value of P in input cell B15 from 9.1 to 8.8 to achieve a %POP served of 12% in results cell B37.

Derived data:

— %POP = 12.0% (cell B37)
— UPPINT = 117.5 / 4 = 29.4 s (cell B35)
— RTT = 117.5 s (cell B34)
— UPPHC = 90.0 persons/5-minutes (cell B36)

Note: percentage capacity factor by area (results cell B38) is 77%, which is slightly below the target of 80%.

Ignore results cells B39–B41, see sections 3.7.1, 3.9.1 and 3.9.2.

3.7 Passenger times during up-peak traffic demand

Figure 3.1 illustrates the relationships between the passenger times.

Caution: all the formulae below are based on a mathematical model. To determine more accurate time values a simulation study should be carried out, see chapter 4.

3.7.1 Passenger average waiting time (AWT)

An equation can be derived for the passenger average passenger waiting time[(2g)]. For passenger loads (P) from 50% to 80% of rated capacity (CC), AWT is given by:

$$\text{AWT} = [0.4 + (1.8\,P\,/\,\text{CC} - 0.77)^2]\ \text{INT} \qquad (3.14)$$

For car loads less than 50%, AWT is 40% of the interval (INT). Car loads above 80% are not considered.

On the spreadsheets for Examples 3.1 and 3.3 a value of AWT is presented in cell B39.

Caution: some lift companies state AWT as half the interval. Others state incorrectly that the time for the lift to respond to a first landing call registered, sometimes called system response time (SRT), is the passenger average waiting time. These times are often inaccurate as some lift companies cancel the call registration as much as eight seconds before the lift actually starts to open its doors at a landing.

3.7.2 Passenger average transit time (ATT)[(2h)]

An estimate of how long it takes the average passenger to reach their destination whilst in the car is obtained by calculating ATT to the midpoint of the local travel for any group of lifts. This implies travel for a distance of $H/2$ with the number of stops being $S/2$ and a transfer of P passengers boarding the lift and $P/2$ passengers alighting before the average passenger alights. The formula is:

$$\text{ATT} = 0.5\,H\,t_v + 0.5\,S\,t_s + 1.5\,P\,t_p \qquad (3.15)$$

3.7.3 Passenger average travel time to destination (ATTD)[(2i)]

The average time it would take for an average passenger to reach their destination floor is obtained by adding the primary physiological consideration of average passenger waiting time (AWT) to the secondary physiological consideration of average passenger transit time (ATT) to give a average passenger time to destination (ATTD). The formula is:

$$\text{ATT} = 0.5\,H\,t_v + 0.5\,S\,t_s + 1.5\,P\,t_p + \text{AWT} \qquad (3.16)$$

3.7.4 Passenger average journey time (AJT)

This is longer than the passenger average travel time to destination (ATTD) by the time required to open the lift doors and the passenger to cross the threshold.

3.7.5 Target passenger times and lift system response times

To achieve satisfactory passenger experiences the target times shown in Table 3.7 are recommended.

The times indicated in Table 3.7 can be calculated, but more reliable values may be obtained by simulation.

The grade of service provided by an installed lift system in an office building can be expressed as either the percentage of calls answered in specified time intervals, or the time to answer a specified percentage of calls.

Table 3.7 Target passenger average times for office buildings

Passenger time	Target	Poor
Average waiting time (AWT)	<25 s	>30 s
Average transit time (ATT)	<60 s	>70 s
Average journey time (AJT)	<80 s	> 90 s

Table 3.8 gives recommended target times for several grades of service, averaged over one hour of peak activity, in an office building using system response time as a quality indicator. Although system response times cannot be calculated they may be obtained by simulation. However, actual system response times can be measured using a stopwatch or data logger on an installed lift system.

Table 3.8 Average system response time performance in an office building

Quality of service	Percentage of calls (%) answered in stated time		Time to answer stated percentage of calls (s)	
	30 s	60 s	50%	90%
Excellent	>75	>98	20.0	45
Good	>70	>95	22.5	50
Fair	>65	>92	25.0	55
Poor/unacceptable	<65	<92	>25.0	>55

Note: an hour of peak activity is taken in order to obtain practical results

It should be possible to obtain the grades of service indicated in the table during the worst hour of activity. This might occur during the mid-day break rather than during the intense, but shorter, up-peak and down-peak periods at the beginning and end of the working day.

During a shorter period of activity of (say) fifteen minutes, e.g. during down-peak, the grade of service might fall to the next level.

During an even shorter period of activity of (say) five minutes, e.g. during up-peak, the grade of service might fall to the next level.

3.8 Sizing of office lifts to meet passenger demands

The method described below sizes a lift system to serve the demands of a building's occupants by matching the passenger demands for transportation with the handling capacity of the installed lift system for the worst 5-minute period during the morning up-peak traffic condition. The method provides the means of calculation and analysis for the planning and selection of lifts mainly for office buildings.

Warning: the building population may change over time.

Passenger demand is dependent on the population of a building. The size of the demand may be measured in terms of the arrival rate of either a specified number of persons/5-minutes (A_r) or a specified percentage of the building population (%POP) assumed to arrive in the peak 5-minutes. The traffic design should select a lift system to meet these 'quantity of service' criteria.

The round trip time equation (3.1) assumes that cars load to 80% of the actual capacity (AC). The value obtained for UPPHC relies on the same assumption. But this is only correct if the arrival rate (A_r) exactly equals UPPHC. If too few, or too many, passengers arrive the car load may not be 80% and the values for S, H, RTT and the interval may alter.

This is so for Example 3.1. Here the maximum actual car capacity is 11.4 persons (Table 3.1) giving the 80% value as 9.1 passengers. A calculation gives an interval of 29.8 s, a handling capacity of 92 persons/5-minutes, and a percentage population of 12.2%. However, the design only called for 12% arrival rate. Generally this can achieved with a lower car load of 8.8 persons, i.e. a 77% car loading.

Design tip: the use of an interactive program or spreadsheet exactly balances the lift's handling capacity to the arrival rate by an iterative calculation and then presents the percentage capacity factor by area (%CF). This should not exceed 80%.

3.8.1 Estimation of office building population

The size of the intended population should be obtained, either from the building owner, or from the proposed occupier. If the population value is available, go to section 3.8.4.

3.8.2 Estimating office building floor area

If the floor area is available, go to section 3.8.3. If the office population is not available, or the office building is a speculative one, then an estimation should be made using floor areas(6).

Most estimates start from a knowledge of the net usable area (NUA), i.e. the area which can be usefully occupied.

The NUA excludes circulation space (stairs, corridors, waiting areas, escape routes), structural intrusions (steelwork, space heating, architectural features, ductwork), and facilities (training rooms, smoking rooms, kitchens, toilets, cleaners' areas etc.).

The net internal area (NIA), sometimes called the 'rentable area', is larger than the usable area as it includes tenants' facilities such as kitchens and cleaners' cupboards and some of the circulation space.

The ratio of usable area (NUA) to rentable area (NIA) might be 80–85%.

3.8.3 Estimating office building population from floor area

If the expected density of occupation is known, go to section 3.8.4.

The number of people occupying the usable area can vary according to the quality of the accommodation (prestige, standard or speculative) and the type of occupancy (single, sector or mixed tenancy).

Buildings based on open plan layouts have higher populations than those with cellular offices.

For cellular offices, occupancy can range from 10 m^2 to 14 m^2 per person of NIA. As a starting point assume an occupancy of 12 m^2 per person. For prestige buildings, add

2 m^2 per person and for speculative buildings deduct 2 m^2 per person.

For open plan offices, occupancy can range from 8 m^2 to 12 m^2 of NIA. As a starting point assume an occupancy of 10 m^2 per person. For prestige buildings, add 2 m^2 per person and for speculative buildings deduct 2 m^2 per person.

For some task based activities (e.g. trading desks and call-centre workstations) the space per person may range from 4 m^2 to 6 m^2. Mixed arrangements would require separate consideration to obtain a total occupancy value.

Design tip: various studies have shown that in many buildings it is unlikely that all the total population is present on any one day. Where this is known to be the case the total building population can be reduced by 10–20% to account for persons working at home, on holiday, sick, away on company business, vacant posts, 'hot desking' etc.

3.8.4 Estimating passenger arrival rate

The passenger arrival rate should be obtained, either from the building owner, or from the proposed occupier. If the value for the passenger arrival rate is available, go to section 3.8.5.

The 5-minute up-peak arrival rate can vary depending on the type of building occupancy (different business interests or single tenant), the starting regime (unified or flexitime), and the distance to bulk transit facilities such as buses and trains.

The apparent morning arrival rate may appear to be low, but during the peak period the lifts are generally serving other interfloor and down travelling traffic. The design arrival rate might range from 11% to 15%. As a starting point assume an arrival rate of 12%. For mixed tenancy deduct 1%; for prestige buildings add 1%.

The value obtained for the passenger arrival rate should be used as the target handling capacity of the installed lift system.

3.8.5 Quality of service

The quality of service criterion is represented by the passenger average waiting time. For most office buildings this can range from 25 s to 30 s. For a wider range of quality values see Table 4.3. Unfortunately, passenger average waiting times cannot be easily measured, owing to the difficulty of determining the exact instant of arrival for each passenger. The time the lift system takes to respond to the landing call registered by the first arriving passenger can be measured. During up-peak traffic this time is called the interval, and is the average time between successive arrivals of the lift, or lifts, at the main terminal. Table 3.9 indicates a relationship between quality of service and interval. These values are similar to those given in BS 5655-6: 2002[10].

A target value for the average interval may be provided either by the building owner or the developer.

Table 3.9 Probable quality of service in office buildings

Interval (s)	Quality of service
<20	Excellent system
25	Very good system
30	Good system
40	Poor system
>50	Unsatisfactory system

Caution: when using the interval as a quality indicator, passenger waiting time depends on car occupancy, i.e. the number of passengers in the lift. In general, a passenger average waiting time of 85% of the calculated interval occurs when the average car occupancy is 80% of actual lift capacity. If cars are allowed to load above 80% then the passenger average waiting time increases substantially and it rapidly becomes unacceptable.

Simulation can be used to obtain more definitive values for passenger average waiting (see chapter 4).

Design tip: a useful rule of thumb for the general level of service provided by a single lift serving several floors is:

— *excellent service*: one lift per 3 floors
— *average service*: one lift per 4 floors
— *below average service*: one lift per 5 floors.

The performance time (T) has the most effect on the round trip time (equation 3.1). Reducing the value of T by one second can increase the handling capacity of a lift installation by about 5%. Quality of service may be judged by the value selected for T. Table 3.10 gives the values of T for an interfloor height of 3.5 m, which can indicate the probable performance of an installed lift system.

The above two rules of thumb may need to be ignored in order to achieve, for example, either a specified interval or a specified handling capacity.

Table 3.10 Performance time (T) as an indicator of quality of service

Value of T (s)	Comment
8.0–9.0	Excellent system
9.0–10.0	Good system
10.0–11.0	Average system
11.0–12.0	Poor system
>12.0	Consider system replacement

3.8.6 Example 3.2

It is required to design a suitable lift installation for a 10-floor office building with a net internal area of 6840 m^2 for a single speculative tenant with open plan accommodation.

Using section 3.8.3, assume 8 m^2 per person. Hence maximum population = 6840/8 = 855 persons.

Assume 10% absenteeism (section 3.8.3). Therefore actual population = 855 × 0.9 = 770 persons.

Using section 3.8.4, assume 13% arrival rate. Therefore arrival rate = 770 × 0.13 = 100 persons/5-minutes.

Using section 3.8.5, assume interval is 30 s (i.e. 'good' system).

What size of lift (rated load) should be considered?

In simple terms, there will be 10 trips in 5-minutes at an interval of 30 s. To transport 100 persons in 10 trips requires an average car occupancy of 10 persons. From Table 3.1 chose a 1000 kg lift. See Example 3.1 for the calculation of a suitable lift installation.

3.9 Traffic conditions other than up-peak

Formulae to calculate the other traffic conditions can be obtained in the similar way to that for up-peak. They can be used to estimate performance. However, a more accurate prediction of performance requires a study of all the circumstances by simulation (see chapter 4).

3.9.1 Down-peak traffic condition[2j]

The down-peak round trip time (RTT_d) can be obtained using:

$$\text{RTT}_d = N\, t_v + (0.5\, S + 1)\, t_s + 2\, P\, t_p \qquad (3.17)$$

The underlying down-peak handling capacity can then be calculated from the value of RTT_d.

The down-peak passenger average waiting time (DNPAWT) in terms of the up-peak interval (UPPINT), up-peak handling capacity (UPPHC) and the number of passengers arriving during the down-peak period (A_d) can be estimated using:

$$\text{DNPAWT} = 0.85\, A_d \frac{\text{UPPINT}}{\text{UPPHC}} \qquad (3.18)$$

On the spreadsheets for Examples 3.1 and 3.3, a value of DNPAWT is presented in cell B40.

3.9.2 Mid-day traffic condition[2k]

The mid-day round trip time (RTT_m) can be obtained using:

$$\text{RTT}_m = 2\, H\, t_v + 2\, S\, t_s + 4\, P\, t_p \qquad (3.19)$$

The underlying mid-day handling capacity (MIDHC) can then be calculated from the value of RTT_m.

On the spreadsheets for Examples 3.1 and 3.3 a value of MIDHC is presented in cell B41.

An estimate of the mid-day passenger average waiting time (MIDAWT) can be made from:

$$\text{MIDAWT} = 0.85\ \text{MIDINT} \qquad (3.20)$$

3.9.3 Interfloor traffic condition[2l]

The interfloor passenger average waiting time (IFAWT) in terms of the up-peak interval (UPPINT), up-peak handling capacity (UPPHC) and the number of passengers arriving during the interfloor period (A_i) can be obtained using:

$$\text{IFAWT} = \text{UPPINT}\left(0.22 + 1.78\,\frac{A_i}{\text{UPPHC}}\right) \qquad (3.21)$$

The passenger demands during off-peak traffic periods are modest. These can be equivalent to a 5-minute demand as low as 3% of the building's population, which is well within the underlying capability of a properly designed lift system.

3.9.4 General analysis

Alexandris et al. (1979)[1] analysed traffic patterns other than up-peak, but they made a large number of assumptions. Peters (1990)[12] developed the 'general analysis' (GA) method to overcome these problems. The mathematics is complex and has been reported in an earlier edition of this Guide[15].

General analysis allows round trip time calculations to be performed for any peak traffic flow. This overcomes most of the limitations associated with conventional up peak calculations. For example, GA allows assessment of:

— office buildings with car parks and basements

— hotel or residential buildings with two-way peak traffic

— shopping centres with heavy interfloor traffic

— offices with restaurants causing heavy peaks at lunch times

— double deck lifts.

The GA technique can be programmed into a computer. A full implementation of the GA method allows individual floor populations to be considered and for the specification of differing arrival rates at all floors.

It is important to note, however, that all RTT calculations are designed to analyse 'peak' traffic situations, where there are traffic flows to and/or from the main terminal floor. If the traffic levels are low relative to the underlying handling capacity of the system being considered, the mathematical basis of the RTT calculation may be no longer valid. Using the GA method may result in low or zero results being obtained. This is a limitation of all round trip time calculations as non-peak traffic can only be analysed using simulation techniques.

General analysis can be used to analyse up-peak, down-peak and mid-day traffic as these are heavy traffic conditions. The method can provide improved results compared to the classical method described in this chapter.

3.10 Equipment selection with respect to lift function

3.10.1 Double deck lifts

There are some 600 double-deck lifts installed world wide, mostly in the USA, with about 30 in Europe. They are used mainly in very tall buildings and comprise two passenger cabs, one above the other, connected to a single suspension/drive system. The upper and lower cabs can serve two adjacent floors simultaneously. During peak periods the cabs are arranged to serve even and odd floors respectively with passengers guided into the appropriate cab for their destination. Special arrangements are made at the lobby for passengers to walk up/down a half flight of stairs/escalators to reach the lower or upper main lobby.

The advantage for double-deck lifts is that the shaft handling capacity is improved as, effectively, there are two lifts in each shaft. The disadvantage is for the passengers during off-peak periods, when one cab may stop for a call with no call registered for the other cab. Special control systems are available, such as only using one deck during off-peak periods. The round trip time for double deck system can be obtained using[(2m)]:

$$\text{RTT} = 2Ht_v + \left(S\left(2 - \frac{S}{N}\right) + 1\right)(T - t_v) + P\,t_p + P\left(2 - \frac{S}{N}\right)t_p \tag{3.22}$$

The use of double-deck lifts is rare in the UK and their traffic design is a specialised procedure requiring the use of simulation software (see chapter 4).

3.10.2 Firefighting lifts

Firefighting lifts are discussed in detail in chapter 6 and are usually single lifts situated around the floor plate. Their rated load is often only 630 kg and their rated speed sufficient only to reach the highest occupied floor in 60 s. Therefore their handling capacity is low. They do provide a small, but useful addition to the vertical transportation services of a building, especially those with large floor plates. Where a firefighting lift is part of a group, extra precautions are made to protect it, i.e. fire-protected stairways, through-car doors etc. These precautions may affect the traffic handling of these lifts and this should be taken into account when calculating the handling capacity of such a group.

3.10.3 Goods lifts

The need for goods lifts has increased substantially in recent years. Despite the computer revolution the amount of paper in and scrap paper out has increased. Also it is quite common to find in any type of building one or more floors under refurbishment, with the requirement to bring in equipment and to remove rubbish and debris. All buildings should be served by an adequate number of goods lifts of a suitable size. This should ensure that the passenger lifts are used for their designed purpose and not used as goods transporters to the detriment of the passenger service.

It is recommended that all office buildings contain at least one dedicated goods lift for usable floor areas up to 10 000 m^2. For larger buildings, an additional goods lift should be provided for each additional 20 000 m^2 gross floor area. Dedicated goods lifts should have a minimum rated capacity of 1600 kg. Consideration should be given to providing goods lifts with rated loads up to 2500 kg. Where passenger lifts are used as goods lifts, either generally, or in an emergency, the interiors should always be protected by suitable drapes.

3.10.4 Observation (glass/scenic) lifts

Observation lifts are often installed in hotels and shopping complexes to provide a feature or visual impact. They may attract a large percentage of pleasure riders. They contribute to the vertical transportation system of a building. Generally they have longer flight and door times, which reduces their traffic handling performance. Also the car interiors are shaped for aesthetic and viewing purposes rather than easy circulation in the car. They should be considered to be occupied at a reduced occupancy of (say) 60% in comparison to the 80% used for a conventional lift.

3.10.5 Shuttle lifts

Shuttle lifts generally serve two stops, such as at a railway station, underground station or in a tall building, which are divided into zones with service direct from the main lobby to an upper lobby. Calculation of their traffic performance is simple, as they only serve two floors, and is given by:

$$\text{RTT} = 2\,T + 2\,P\,t_p \tag{3.23}$$

When installed in tall or very tall buildings, shuttle lifts are usually quite large and fast and are an important transportation facility. Here their traffic design is a specialised procedure as they often transport passengers to/from a sky lobby, where further groups of lifts serve another section of the building.

3.10.6 Lifts sharing a common well (shaft)

Here two independent lifts are installed in the same shaft. Usually the upper cab runs at a higher rated speed than the lower cab. Special precautions have to be adopted to ensure the two cabs do not collide. They are installed with the intention to reduce the number of shafts penetrating the total height of the building and thus release rentable space. For instance a 4-car group serving a low zone and a 4-car group serving a high zone can be reduced to four pairs in four shafts. The size of the wells is larger throughout the building and it may be found necessary to install an additional pair in a fifth shaft to achieve an equivalent performance, thus reducing the 'saved' space.

This type of installation is not easily analysed mathematically and traffic design needs to be carried out using simulation, see chapter 4.

3.11 Equipment selection with respect to building form

3.11.1 Basement service and floors served by only part of a lift group[(2n)]

Buildings are sometimes designed with car parks or with a service facility, such as restaurant or leisure area, below the main terminal at basement levels. Often not all floors below the main terminal floor are served by all lifts in a group. While this saves capital expenditure, it is not recommended as it violates the general rule that all lifts in a group should serve the same floors. Passengers may experience difficulty in selecting the correct lifts out of a group, which serve a basement, unless special signalling arrangements are made. In the event that only one lift out of a group serves all floors, the waiting time that passengers experience may be long. It may then be better to provide basement service to the main terminal floor by a separate lift or lifts. This solution can avoid seriously affecting the traffic handling capabilities of the main lift group.

Serving floors below the main terminal has an effect on the up-peak, down-peak and mid-day traffic patterns. One effect of service to the basement area is that during up-peak cars arrive at the main terminal already partly full, causing confusion. The time penalty to be added to the round trip time can be between 15 s to 30 s or more, depending on the number of basement stops. Designers should take account of these factors, when sizing an installation with served levels below the main terminal.

A calculation of the basement probable stops (S_M) and basement reversal floor (H_M) can be carried out in a similar way to the upward service. The resulting additional time can then be added to the normal round trip time. The round trip, equation 3.1, is modified to:

$$\text{RTT} = 2\,H\,t_v + (S + 1)\,(T - t_v) + 2\,P\,t_p + 2\,H_M + S_M\,(T_M - t_{vM}) \quad (3.24)$$

where transit time t_{vM} and the performance time T_M are evaluated for the basement interfloor distance.

3.11.2 Entrance bias

Some buildings have more than one main entrance (at a common level) and each entrance may be served by its own group of lifts. Or there may be a large lobby area with two groups of lifts on either side serving the same floors. The difficulty here is deciding whether or not the building population use these entrances (and their associated group of lifts) on a 50/50 basis. In the absence of any guidance designers should assume an entrance bias of 60/60 and size the lift groups to meet this demand.

3.11.3 Stairs

The provision of well signed and easily accessible stairs can considerably lessen the demands made on the lifts. Table 3.11 provides guidance to the division of passenger demand between lifts and stairs. Designers should take the stair usage factor into account.

Table 3.11 Stair usage

Floors travelled	Usage up (%)	Usage down (%)
1	10	15
2	5	10

3.11.4 Attractive building facilities

There may be facilities in buildings which can distort traffic movements. Examples are restaurants (positioned at the top of the building, in the basement, even half way up the building); drinks and sandwich machines; leisure club facilities (swimming pools, gymnasia), facilities floors (bank, travel agent, shops), toilet facilities; post rooms; trading floors etc. These floors may provide a powerful attraction at different times of the day and should be considered in the traffic design.

The effect of 'magnet' floors on lift performance can be studied using simulation, see chapter 4.

3.11.5 Lobby design

Lobby design (see section 2.6.4) can have an effect on the round trip equation. If lifts are served from large lobbies then the lobby door dwell time may need to be increased. Alternatively, an increase in the passenger transfer time (t_p) used in equation 3.1 by 10% may be considered to account for any loading inefficiency. In severe situations some designers add 10% to the round trip time.

3.11.6 Tall buildings

Examination of Table 3.A1.1 (Appendix 3.A1) indicates that for a specified size of car the number of stops (S) increases as the number of served floors (N) increases. As the round trip time in equation 3.1 is dominated by the central term, which includes S, the effect is to increase the round trip time, which in turn increases the up-peak interval, the passenger waiting time and the passenger journey time. A similar deterioration of performance occurs for the other traffic conditions. The solution is to limit the number of floors served by the lifts. A rule of thumb is to serve a maximum of 15–16 floors with a lift or a group of lifts. This introduces the concept of zoning, whereby a building is divided so that a lift or group of lifts is constrained to serve a designated set of floors. There are two forms of zoning:

— *Interleaved zoning*: an interleaved zone is where the whole building is served by lifts, which serve, either even floors, or odd floors. This arrangement is not recommended today

— *Stacked zoning*: where a tall building is divided into horizontal layers. This in effect stacks several buildings on top of each other, with a common footprint, in order to save ground level space. It is a common and recommended practice for office and institutional buildings. Each zone can be treated differently with regard to shared or separate lobby arrangements, grade of service etc.

Where it is required that each zone receives the same grade of service, either the number of floors or the number of lifts in each zone can be adjusted to achieve this. It is usually easier to adjust the number of floors per zone than the number of lifts per zone.

The number of floors in a zone, the number of lifts serving a zone and the length of the express jump all affect the round trip time. The round trip time equation can be adjusted by adding a time equal to the time (t_e) taken to pass the 'un-served' floors in both directions.

$$\text{RTT} = 2\,H\,t_v + (S+1)\,(T - t_v) + 2\,P\,t_p + 2\,(t_e - t_f(1)) \tag{3.25}$$

where t_e is the flight time from the main terminal to the express zone terminal ('sky lobby').

The design procedure is illustrated in Example 3.3, below.

3.11.7 Very tall buildings

Very few very tall buildings (i.e. those over 40 stories high) are built in the UK at the moment. It is not proposed to discuss the traffic design of such buildings, the use of sky lobbies, shuttle lifts, top/down service and double deck lifts etc., as this is a very specialised procedure.

	A	B
11	INPUT DATA	Value
12	Number of floors	10
13	Rated load	1275
14	Actual car capacity	13.8
15	Number of passengers	10.1
16	Number of lifts	4
17	Rated speed	5
18	Building population	750
19	Interfloor distance	4
20	Express jump	60
21	Express additional time	18
22	Single floor flight time	4.7
23	Door close time	3
24	Door open time	2
25	Advance door opening	1
26	Start delay	0.5
27	Passenger transfer time	1
28		
29	RESULTS	Value
30	Number of passengers	10.1
31	Highest reversal floor	9.5
32	Number of stops	6.5
33	Performance time	9.2
34	Round trip time	134.8
35	Interval	33.7
36	Handling capacity	90
37	Percentage population	12.0
38	Capacity factor (%)	73
39	Up-peak average waiting time	24
40	down-peak handling capacity	121
41	Midday peak handling capacity	120

Figure 3.5 Example 3.3: spreadsheet output

3.11.8 Example 3.3

See Figure 3.5. Suppose the lift system defined in Example 3.1 is positioned to serve floors 16–25 of an upper building zone. The express jump distance from the main terminal floor to Floor 16 is 60 m (cell B20).

The total travel is now 100 m. The rated speed should be increased to 5.0 m/s. The flight time then becomes 4.7 s and the time to travel the express zone of 60 m is 18.0 s (cell B21).

To achieve the specified 12% handling capacity the car size is increased to 1275 kg giving a maximum actual capacity of 13.8 persons (80% = 11.0). The car occupancy (cell B15) becomes 10.1 persons to match the %POP of 12% (cell B37). The capacity factor is 73% (cell 38).

Note: the interval has deteriorated to 33.7 s. This could be remedied by using a 5-car group, which might not be acceptable. However, the predicted passenger average waiting time is given as 24 s, which would be acceptable. A simulation study should be carried out to confirm this figure.

3.12 Equipment selection with respect to building function

Note: this section is concerned with the selection of equipment for twelve different types of buildings. Reference to the corresponding sub-sections of chapter 2, which deals with the circulation of people, and those sub-sections of section 5.2.2 that deal with the application of different types of lifts should also be consulted.

3.12.1 Airports

The movement of baggage carts/trolleys from one level to another is a significant demand. A solution is to install moving ramps and this greatly improves circulation. Lifts, however, are the main means of vertical movement.

Generally each baggage trolley might be attended by two persons plus their baggage. A trolley may weigh (including its own weight) some 75 kg, but occupy the space taken by three or four persons. Thus the total weight of two passengers and their trolley might be some 225 kg and occupy the space of some five people. This occupancy and loading requirement should be taken into account. In these circumstances lifts are very unlikely to become overloaded.

There are no changes required to equation 3.1, but care may need to be taken in the assumptions of lift car occupancy levels.

3.12.2 Car parks

Car parks can be attached to shopping centres, offices, airports, railway stations etc. They are often multi-storey, although those at out-of-town shopping centres and railway stations may be at a single level. The pedestrian demand on the lifts is more likely to be constrained by the entry and exit ramp vehicle movement capacities. A factor is the vehicle occupancy, which can be considered to be 1.2 persons per car for office car parks and two persons per car elsewhere.

For offices the peak demand is often in the evening, when building occupants are attempting to reach their cars. The office lifts, which may not necessarily serve the car parking levels, can bring large numbers of people to the lobby. Those persons with cars can then make a significant demand on any lifts serving the car park levels. The demand on the car park lifts is similar to that experienced by the main lifts during the morning peak period, but this demand is downwards and to fewer floors.

The traffic design should use equation 3.1, if the car park lifts are separate to the main lifts, and equation 3.19, if the lifts are part of a basement service.

3.12.3 Department stores

This category applies to large departmental and chain stores. These stores can have many entrances, some of which may open to a main street whilst others may open into shopping mall areas. The opportunity therefore exists for 'leakage' into and out of the shopping centre. Many stores own the lifts and escalators inside their occupancies. These facilities may be used by shopping centre pedestrians to move between mall levels.

3.12.4 Entertainment centres, cinemas, theatres, sports centres, stadia and concert halls

Buildings providing these functions can specialise in one of the activities or many of them. Many sports centres are low-rise and do not require lifts, unless for disabled access. Town centre buildings such as cinema complexes, concert halls and theatres can be of higher rise. Such complexes generally use escalators as the main vertical transportation element. Lifts provided in these circumstances do not have to meet a large demand and may only have to satisfy the requirements of persons with limited mobility and for firefighting.

There are no changes required to equation 3.1.

3.12.5 Hospitals

The building form is important, i.e. whether the building has a small footprint and is tall (US practice) or has a large footprint and is low (UK practice). In the former case, where lifts are used as a primary circulation element, their proper operation is vital, particularly when dealing with operating theatre emergencies. In Britain most hospitals are designed on a 2–3 storey low-rise principle, although many city hospitals have high-rise elements. Lifts are provided in UK low-rise hospitals mainly as a means of moving bed-bound patients and for service activities from floor to floor as staff and visitors use the stairs.

The traffic designer should understand the *modus operandi* of the hospital before finalising a design. Factors to be considered include numbers of staff and shift patterns; numbers of visitors and visiting hours; location of theatres, X-ray department etc.; distribution and deliveries of food, beverages, housekeeping supplies; waste disposal; patient emergency evacuation; porters etc. For infection control purposes it may be necessary that patient bed lifts are separate from the visitor and staff lifts.

Demand estimation can be made by multiplying the number of beds by three to allow for staff, visitors etc. A suitable arrival rate can be taken as 8–10% with an interval of 30–50 seconds. Health Technical Memorandum 08-02: 2009[(11)] gives more specialised guidance.

There are no changes required to equation 3.1.

3.12.6 Hotels

Lifts play an important part in the circulation of guests and service staff in a hotel. Escalators should be employed for short range movements, e.g. to connect function levels with the lobby.

The average room occupancy is dependent on the type of hotel. For business hotels assume one person; for transit hotels, 1.5 persons; and for holiday hotels, two persons. These figures can be used to determine the likely demand.

The traffic patterns in hotels are complex, and are not comparable to the morning and afternoon peaks in an office building. The most demanding times are at check-out (08:00 to 10:00) and check-in (17:00 to 19:00). At these times heavy two-way traffic occurs with guests going to and from rooms and restaurants, and in and out of the hotel. The arrival rate might change according to the star rating of the hotel. Assume an arrival rate in the range of 10% (1-star) to 15% (5-star) and an interval range of 30 seconds (5-star) to 50 seconds (1-star).

Calculations should be made assuming equal numbers of up and down stops at these times.

At most other times lifts are unlikely to load to fill to more than 50%. However, the lift sizes should be at least 1275 kg, in order to accommodate luggage and provide guests with uncrowded and comfortable travel conditions.

As a rule of thumb assume one lift for every 90–100 keys and there should be one passenger/goods lift for every two passenger lifts.

This rule should be used with care as it would not be suitable for a low-rise hotel with 30% of its rooms at the entrance level. Neither would it be suitable for a high-rise hotel with a small footprint. There are also differences between the operational needs of 'transit' hotels near to airports etc., where guests stay one night, and hotels used by longer term and holiday guests.

There are no changes required to equation 3.1.

3.12.7 Offices

Much of this chapter has been concerned with lifts in commercial office buildings.

3.12.8 Railway stations

Railway stations may be served mainly by stairs and pedestrian ramps although some, particularly the deeper underground stations, use escalators. Generally railway stations, whether above or below ground, have poor provision of lifts. This may change as the requirements to assist persons with limited mobility are applied.

Passengers wishing to move from one level to another with hand baggage may find this difficult. When baggage trolleys are used these difficulties increase. As with shopping centres (section 3.12.11) a solution to this problem is to install moving ramps. This also greatly improves circulation.

There are no changes required to equation 3.1.

3.12.9 Residential buildings

The estimation of the population in a residential building is usually based on the number of bedrooms and the occupancy per bedroom. Suitable rules of thumb for the number of persons occupying a flat (apartment) are given in Table 3.12.

The commonly used design period for a residential building is the afternoon, 5-minute, two-way traffic condition, which is considered the most demanding traffic period. During this period, people enter and leave the building. The lifts load passengers at the main lobby, distribute these passengers to various upper floors, reverse direction at the uppermost hall call, stopping in the down direction for additional passengers and transporting them to the main lobby. In low income housing (e.g. housing association), where many children and adults are leaving for school and work at the same time, the morning down-peak may also be very heavy. Table 3.13 gives guidance.

In residential and low income flats one passenger lift should be large enough (say 1600 kg) to allow furniture movement, accommodate stretchers and to handle other service needs. Luxury flats may include a separate goods lift for furniture, trades-people and domestic help. These goods lifts should have rated loads of at least 2000 kg.

Each flat should have access to an alternative lift during maintenance or out of service conditions.

Penthouse apartments may require special considerations regarding occupancy and lift provision.

There are no changes required to equation 3.1.

Table 3.12 Occupancy factors for residential buildings

Type	Luxury	Normal	Low income
Studio	1.0	1.5	2.0
1-bedroom	1.5	1.8	2.0
2-bedroom	2.0	3.0	4.0
3-bedroom	3.0	4.0	6.0

Table 3.13 Design criteria: residential buildings (5-minute, two-way)

Type	Luxury	Normal	Low income
Interval (s)	45–50	50–60	50–70
Two-way handling capacity	8%	6–8%	5–7%

Note: the value suggested for interval is nominal and should be calculated for an 80% occupied car.

3.12.10 Residential care homes and nursing homes

Homes generally have a low traffic requirement, which can be catered for by a single lift or lifting platform. Larger homes might acquire a second lift giving security of service in the event of break down or maintenance.

3.12.11 Shopping centres

Shopping centres are often built with two or three levels of retail and several levels of car parking above or below. Lifts do not play a major part in the pedestrian transportation arrangements, which are usually centred on escalators. Lifts should always be located in pairs and not singly in order to provide a reasonable interval of 40-60 s and security of service during breakdowns and maintenance. Often scenic lifts are provided not only for transportation, but as an enjoyable experience.

In multi-level shopping complexes provision should be made for the movement of shopping trolleys, push chairs and persons with mobility problems from one level to another. A commonly applied solution to this problem is to install moving ramps. Where lifts are used it is unlikely that they fill to more than 50%.

The demand on lifts to access car parks is determined mainly by the maximum rate of entry/exit of vehicles and the average occupancy of each vehicle. These values may be determined from an associated (road) traffic study.

3.12.12 Universities and other education buildings

A university campus can have a collection of office-type buildings, halls of residence, catering services and factory-like units containing teaching and research equipments. Some buildings are mixed function: lecture rooms, laboratory and offices. Some buildings may specialise as lecture blocks only.

Where universities occupy city sites many have tall buildings (10–20 stories) and even those on out-of-town sites follow suit in order to reduce land use and achieve a compact campus.

There may be hourly cycles of 10 minutes of demand before and after each 50 minute lecture, tutorial or seminar session. These peaks can range from 15–25% with an interval of from 30–50 seconds. It is unlikely that an economic solution can be found to accommodate such high peaks requirements and heavy stair use can be expected. In between the peaks the activity levels are very low.

The office-type buildings can be treated as detailed elsewhere in this chapter.

The halls of residence can be treated as hotels, although perhaps at lower levels of demand and performance.

The catering services can be attached to either the office type buildings or halls of residence and should be treated similarly to those provided in office facilities or hotel facilities.

The research buildings can be low rise and be subject to special movement provisions associated with the equipment installed.

3.13 Review of all traffic conditions(2p)

The primary traffic condition for design is pure up-peak. It is analytic and formulae can be easily derived. The pure down-peak and mixed mode, mid-day traffic patterns are usually satisfied by the correct sizing carried out for the up-peak traffic pattern. Both of these patterns are analytic if assumptions are made. The interfloor traffic pattern can be analysed mathematically, but it is a very complex procedure. Fortunately interfloor demands are very modest compared to the other three traffic patterns. See Table 3.14 for a review of the equations developed.

The up-peak design method provides a measure of the underlying handling capacity of a lift system. This in turn sets the performance of the three other major traffic conditions of down-peak, interfloor and mid-day traffic. With the up-peak traffic condition considered to be unity, the underlying handling capacity ratios for the other conditions can be taken as:

— up-peak: 1.0
— down-peak: 1.6
— mid-day: 1.3
— interfloor: 1.4

For example, if a lift group has an up-peak handling capacity of 12% then it has a handling capacity of 19.2% during a down-peak traffic demand.

Note that the underlying interfloor handling capacity is never utilised, as the typical demand is about one fifth of the up-peak demand.

It is important to obtain the correct up-peak sizing if the other traffic patterns are to be satisfactory. If, for example, an installation is sized for up-peak using an up-peak booster, such as hall call allocation (see chapter 9) then the underlying handling capacity may be too small to meet the midday and down-peak demands.

3.14 Finally

All the calculations in this chapter are based on average values derived from mathematical models of experimental data. There can never be an average system and therefore the results may not represent the performance gained from an actual installation. The calculations provide a suitable traffic design in 90–95% of cases.

For unusual arrangements and a more accurate indication of performance, simulation techniques as described in chapter 4 can be used. Simulation can deal with such items as non standard floor heights (3.5.6), target rated speeds (3.5.7), dwell times (3.6.5), non-mathematical models (3.8 and 3.10) etc.

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Table 3.14 Review of equations for different traffic patterns

Traffic pattern	Round trip time equation	Handling capacity equation	Passenger average waiting time equation
Up-peak	$\text{RTT} = 2\,H\,t_v + (S+1)(T - t_v) + 2\,P\,t_p$ (equation 3.1	$\text{UPPNC} = 300\,P/\text{UPPINT}$ (equation 3.3)	$\text{AWT} = [0.4 + (1.8\,P/\text{CC} - 0.77)^2]\ \text{INT}$ (equation 3.14)
Down-peak	$\text{RTT}_d = N\,t_v + (0.5\,S + 1) + 2\,P\,t_p$ (equation 3.17)	$\text{DNPHC} = 300\,P/\text{DNPINT}$	$\text{DNPINT} = 0.85\,A_d\,(\text{UPPINT}/\text{UPPHC})$ (equation 3.18)
Interfloor	No equation available	No equation available	$\text{IFAWT} = \text{UPPINT}\,(0.22 + 1.78\,A_i/\text{UPPHC})$ (equation 3.21)
Mid-day	$\text{RTT}_m = 2\,H\,t_v + 2\,S\,t_s + 4\,P\,t_p$ (equation 3.19)	$\text{MIDHC} = 300 \times 2\,P/\text{MIDINT}$	$\text{MIDAWT} = 0.85\ \text{MIDINT}$ (equation 3.20)

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Appendix 3.A1: Table of values of *H* and *S*

Table 3.A1.1 Values of *H* and *S* with respect to number of passengers carried in car (*P*) (it may be necessary to use interpolation between given values of *P*)

(*a*) For 5 to 12 passengers per trip

Number of served floors, *N*, above MT	*H* and *S* values for stated average number of passengers per trip (*P*): 5		6		7		8		9		10		11		12	
	H	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*
5	4.6	3.4	4.7	3.7	4.8	4.0	4.8	4.2	4.9	4.3	4.9	4.5	4.9	4.6	4.9	4.7
6	5.4	3.6	5.6	4.0	5.7	4.3	5.7	4.6	5.8	4.8	5.8	5.0	5.9	5.2	5.9	5.3
7	6.3	3.8	6.4	4.2	6.5	4.6	6.6	5.0	6.7	5.3	6.7	5.5	6.8	5.7	6.8	5.9
8	7.1	3.9	7.3	4.4	7.4	4.9	7.5	5.3	7.6	5.6	7.7	5.9	7.7	6.2	7.8	6.4
9	8.0	4.0	8.2	4.6	8.3	5.1	8.4	5.5	8.5	5.9	8.6	6.2	8.7	6.5	8.7	6.8
10	8.8	4.1	9.0	4.7	9.2	5.2	9.3	5.7	9.4	6.1	9.5	6.5	9.6	6.9	9.6	7.2
11	9.6	4.2	9.9	4.8	10.1	5.4	10.2	5.9	10.3	6.3	10.4	6.8	10.5	7.1	10.6	7.5
12	10.5	4.2	10.7	4.9	11.0	5.5	11.1	6.0	11.2	6.5	11.3	7.0	11.4	7.4	11.5	7.8
13	11.3	4.3	11.6	5.0	11.8	5.6	12.0	6.1	12.1	6.7	12.3	7.2	12.3	7.6	12.4	8.0
14	12.1	4.3	12.5	5.0	12.7	5.7	12.9	6.3	13.0	6.8	13.2	7.3	13.3	7.8	13.4	8.2
15	13.0	4.4	13.3	5.1	13.6	5.7	13.8	6.4	14.0	6.9	14.1	7.5	14.2	8.0	14.3	8.4
16	13.8	4.4	14.2	5.1	14.5	5.8	14.7	6.5	14.9	7.0	15.0	7.6	15.1	8.1	15.2	8.6
17	14.6	4.4	15.0	5.2	15.3	5.9	15.6	6.5	15.8	7.1	15.9	7.7	16.0	8.3	16.1	8.8
18	15.5	4.5	15.9	5.2	16.2	5.9	16.5	6.6	16.7	7.2	16.8	7.8	16.9	8.4	17.1	8.9
19	16.3	4.5	16.8	5.3	17.1	6.0	17.4	6.7	17.6	7.3	17.7	7.9	17.9	8.5	18.0	9.1
20	17.1	4.5	17.6	5.3	18.0	6.0	18.2	6.7	18.5	7.4	18.6	8.0	18.8	8.6	18.9	9.2
21	18.0	4.5	18.5	5.3	18.8	6.1	19.1	6.8	19.4	7.5	19.6	8.1	19.7	8.7	19.8	9.3
22	18.8	4.6	19.3	5.4	19.7	6.1	20.0	6.8	20.3	7.5	20.5	8.2	20.6	8.8	20.8	9.4
23	19.6	4.6	20.2	5.4	20.6	6.2	20.9	6.9	21.2	7.6	21.4	8.3	21.5	8.9	21.7	9.5
24	20.5	4.6	21.1	5.4	21.5	6.2	21.8	6.9	22.1	7.6	22.3	8.3	22.5	9.0	22.6	9.6

(*b*) For 13 to 20 passengers per trip

Number of served floors, *N*, above MT	*H* and *S* values for stated average number of passengers per trip (*P*): 13		14		15		16		17		18		19		20	
	H	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*	*H*	*S*
5	4.9	4.7	5.0	4.8	5.0	4.8	5.0	4.9	5.0	4.9	5.0	4.9	5.0	4.9	5.0	4.9
6	5.9	5.4	5.9	5.5	5.9	5.6	5.9	5.7	6.0	5.7	6.0	5.8	6.0	5.8	6.0	5.8
7	6.9	6.1	6.9	6.2	6.9	6.3	6.9	6.4	6.9	6.5	6.9	6.6	6.9	6.6	7.0	6.7
8	7.8	6.6	7.8	6.8	7.9	6.9	7.9	7.1	7.9	7.2	7.9	7.3	7.9	7.4	7.9	7.4
9	8.7	7.1	8.8	7.3	8.8	7.5	8.8	7.6	8.8	7.8	8.9	7.9	8.9	8.0	8.9	8.1
10	9.7	7.5	9.7	7.7	9.8	7.9	9.8	8.1	9.8	8.3	9.8	8.5	9.8	8.6	9.9	8.8
11	10.6	7.8	10.7	8.1	10.7	8.4	10.7	8.6	10.8	8.8	10.8	9.0	10.8	9.2	10.8	9.4
12	11.6	8.1	11.6	8.5	11.6	8.7	11.7	9.0	11.7	9.3	11.7	9.5	11.8	9.7	11.8	9.9
13	12.5	8.4	12.5	8.8	12.6	9.1	12.6	9.4	12.7	9.7	12.7	9.9	12.7	10.2	12.8	10.4
14	13.4	8.7	13.5	9.0	13.5	9.4	13.6	9.7	13.6	10.0	13.7	10.3	13.7	10.6	13.7	10.8
15	14.4	8.9	14.4	9.3	14.5	9.7	14.5	10.0	14.6	10.4	14.6	10.7	14.6	11.0	14.7	11.2
16	15.3	9.1	15.4	9.5	15.4	9.9	15.5	10.3	15.5	10.7	15.6	11.0	15.6	11.3	15.6	11.6
17	16.2	9.3	16.3	9.7	16.4	10.2	16.4	10.6	16.5	10.9	16.5	11.3	16.6	11.6	16.6	11.9
18	17.2	9.4	17.2	9.9	17.3	10.4	17.4	10.8	17.4	11.2	17.5	11.6	17.5	11.9	17.6	12.3
19	18.1	9.6	18.2	10.1	18.2	10.6	18.3	11.0	18.4	11.4	18.4	11.8	18.5	12.2	18.5	12.6
20	19.0	9.7	19.1	10.2	19.2	10.7	19.3	11.2	19.3	11.6	19.4	12.1	19.4	12.5	19.5	12.8
21	19.9	9.9	20.0	10.4	20.1	10.9	20.2	11.4	20.3	11.8	20.3	12.3	20.4	12.7	20.4	13.1
22	20.9	10.0	21.0	10.5	21.1	11.1	21.1	11.5	21.2	12.0	21.3	12.5	21.3	12.9	21.4	13.3
23	21.8	10.1	21.9	10.7	22.0	11.2	22.1	11.7	22.2	12.2	22.2	12.7	22.3	13.1	22.3	13.5
24	22.7	10.2	22.9	10.8	22.9	11.3	23.0	11.9	23.1	12.4	23.2	12.8	23.2	13.3	23.3	13.8

4 Advanced planning techniques and computer programs

Principal author

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4 Advanced planning techniques and computer programs

4.1 Introduction

Chapter 3 indicated the procedure to carry out a manual calculation of lift traffic performance. Some of the assumptions made in order to derive the round trip time calculation (see section 3.6) can be addressed in software as the complexity of the mathematics is of no concern to the user. The complete up-peak calculation recommended for implementation in software is given in Appendix 4.A1. The same or similar calculations are implemented in a number of programs available from consultants and lift manufacturers.

In simulation the whole process of passengers arriving at the landings, registering their landing calls, boarding the lifts when they arrive, registering their car calls and then alighting at their destination is modelled. Lift simulation is a very powerful tool. However, it is good practice to start all design exercises with a round trip time calculation for the following reasons:

— Historically, lift installations sized correctly with round trip time calculations have proved successful. If a round trip analysis is done prior to a simulation analysis then any major differences between the two can be investigated and understood. If the simulation was done without the round trip analysis, any discrepancies would not be noticed and explored.

— Simulation is complex and it is easy for less experienced practitioners to make mistakes; a round trip calculation may alert the practitioner.

— Round trip time calculations are much faster than simulation. Using round trip time calculations it is possible to establish very quickly which solutions are worth testing by simulation.

The use of computer methods greatly reduces the possibility of errors compared to manual methods. However, with any computer program, it is important that the input data and the output data are checked by experienced designers and not simply accepted without question. The method of calculation should also be examined very carefully if results differ significantly from those that would be obtained applying the calculation procedures discussed in this Guide.

4.2 Simulation

Simulation has a number of advantages over round trip time calculations:

(1) Round trip time calculations (see chapter 3) simplify the analysis exercise in order to be able to formulate the problem in mathematical terms. Results are extrapolated from an 'average' round trip of a single lift. With simulation, every lift trip is modelled, thereby avoiding the need to work with average trips.

(2) Round trip time calculations give results in terms of the system 'interval', which is the average time between successive lift departures from the main terminal floor. Quality of service is better measured in terms of passenger waiting and transit times, which can be calculated by simulation. Although interval is often used as a quality metric that gives some indication of passenger waiting time, it is not directly analogous to passenger waiting time.

(3) Simulation is visibly closer to 'real life' and therefore more intuitive. For example, an overloaded system in simulation can show queues forming at landings.

(4) Simulation can model the traffic control system. Simulation programs normally have a range of control systems available and sometimes have an option for users to add their own or a specified manufacturer's traffic control algorithms. The choice of control system can significantly affect the results.

(5) System features such as dwell times and lobby times can be modelled.

(6) The output results can be displayed in a wide range of tables and graphs.

Simulation can be used to model scenarios that cannot normally be analysed with the round trip time calculations, including:

— light (non-peak) traffic

— changing levels of traffic, e.g. the increasing levels of traffic as the work start time approaches in an office building

— mixed types of traffic, e.g. goods and passenger traffic using the same lifts

— lifts in the same group with different speeds and sizes.

Simulation is not always appropriate. If a designer's brief is to select a lift installation for an office building using the traditional design benchmarks (see section 3.8), e.g. 12% up-peak handling capacity and 30 seconds up-peak interval, then the preferred approach would be to use a round trip time calculation. Introducing simulation can otherwise complicate a simple exercise.

However, as stated in section 3.6.8, simulation is capable of better evaluations. This is most true when the actual traffic flow is known, or can be estimated with some certainty. Otherwise, a range of simulations with different traffic patterns may be performed to demonstrate to the client that the way in which the building is used and how densely it is populated will affect recommended lift configurations. Note that usage can change during the life of a building.

4.3 Describing traffic

4.3.1 Preface

In order to apply advanced planning techniques such as simulation and General Analysis (see section 3.9.4), an enhanced understanding of traffic in buildings is required.

4.3.2 Mixed traffic

Simple traffic is defined in terms of the percentage of the building population transported upwards or downwards in five minutes. Mixed traffic includes an element of people travelling to and from the main terminal floor, plus an element of interfloor traffic. This can be described by specifying a total demand as a percentage of the building population over 5-minute periods. This total can then be divided into three parts as follows:

— *Percentage incoming*: the part of the total demand that corresponds to passengers arriving at the main terminal and travelling up the building (or down to any floors below the main terminal floor). Sometimes called entrance traffic[1].

— *Percentage outgoing*: the part of the total demand that corresponds to passengers arriving at floors above (or below) the main terminal floor, and travelling to the main terminal floor. Sometimes called exit traffic[1].

— *Percentage interfloor*: the part of the total demand that corresponds to passengers travelling between floors other than the main terminal floor.

Table 4.1 Example entrance level bias table

Floor	Entrance level bias / %
Car park 3	10%
Car park 2	20%
Car park 1	20%
Ground	50%

This approach is particularly useful for defining heavy traffic at lunchtime. For example, the traffic in an office building may peak at 13% of the building population arriving over five minutes, with a split of 45% incoming, 45% outgoing and 10% interfloor.

For buildings with multiple entrances, an entrance level bias should also be defined. For example, in an office building with three car park levels and one main entrance, there may be an entrance level bias as shown in Table 4.1.

The entrance level bias in Table 4.1 would be determined by making an assessment of the number of car park spaces and expected persons per car, in proportion to the number of people who occupy the building. Note that the entrance level bias may be different at different times of the day. For example, if people drive to work, but not to lunch, the car parks can have a higher bias at the beginning and end of each day.

Restaurant and other utility floors introduce further considerations. Figure 4.1 shows the results of a traffic survey in an office building with a restaurant. Passenger demand can be presented as 'stacked area' graph, highlighting the contribution of each traffic component: incoming, outgoing, interfloor, restaurant arrivals and restaurant departures. The total peak demand (from all traffic types) at lunchtime is approximately 13% of the observed building population per 5 minutes.

The simplest way to model this building is to assume that the restaurant itself is an entrance floor, with an entrance bias.

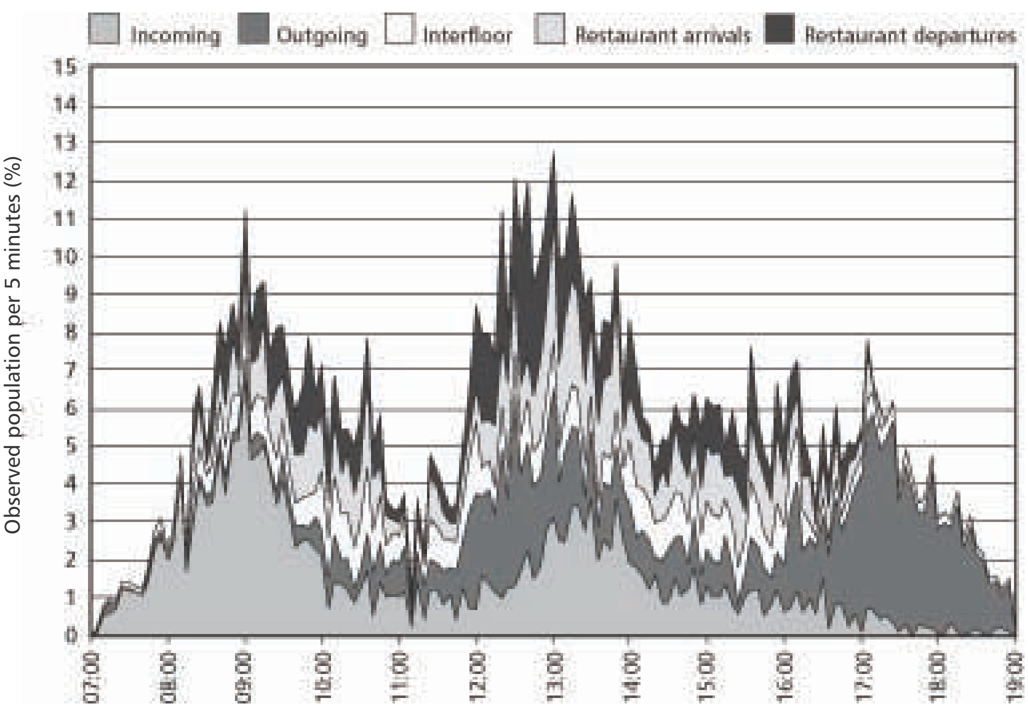

Figure 4.1 Example of mixed traffic in an office building with a restaurant at an upper level

If the restaurant in this building were removed, and it was assumed that people not eating in the restaurant would eat locally outside the building, the restaurant arrivals traffic would be added to the outgoing traffic component. Similarly, the restaurant departures traffic would be added to the incoming traffic component. This approach provides consistency when comparing results with offices without a restaurant or other utility floor. This is the assumption used in the presentation of survey results in section 4.6.

Some entrance floors are populated, which introduces further complexity. For example, in some buildings people enter at a car park level and then take the lifts to their offices on the ground floor. If traffic arising from people whose offices are on entrance floors is likely to be significant, specialist advice should be sought.

4.3.3 Complex traffic

For traffic flows that cannot be described in terms of mixed traffic, a more sophisticated measure is needed. Two terms are required:

— the passenger arrival rate at floor *i* (defined for each floor at which passengers may arrive)

— the probability of the destination floor of passengers from floor *i* being the floor *j* (defined for all possible values of *i* and *j*).

Table 4.2 provides an example of traffic presented in this form. In this presentation of traffic, the demand is no longer simplified to be a function of the population.

4.4 Measuring traffic

4.4.1 Need for traffic surveys

All traffic analysis and simulation studies rely on an estimate of traffic demand.

There is increasing recognition that, although up-peak calculations work, this is not because the assumed demand (see sections 3.9 and 3.14) is realised, but because the combination of assumptions work together to provide a good 'rule of thumb'.

The up-peak round trip calculation is accepted globally. However, if its application and assumptions are extended too far, errors can occur. For complex situations, more sophisticated models are required. However, without reliable estimates of passenger demand, results may still be questionable.

4.4.2 Manual passenger traffic surveys

In manual surveys, observers count passengers in and out of the lifts. A manual survey requires at least one person at each main terminal floor and a person in at least one car. Peters and Evans[(2)] provide a detailed discussion of how to undertake a survey. Figure 4.2 shows survey results from a single tenancy building in London. In this passenger demand plot, traffic up the building is shown in the top section, traffic down the building is shown in the lower section; this style of presentation mimics the classical plot in Figure 3.2. Interfloor traffic is included in the up and down plots.

In Figure 4.2, the % population per five minutes axis is based on the observed population on the day of the survey. This scales the results so that the passenger demand measured in different buildings can be compared. Figure 4.3 shows that a maximum observed population of over 1400 people was reached during late morning. The occupancy of the building dropped over lunchtime; in this instance, not everyone returned to the office after lunch. The observed population is often less than the nominal building population as many buildings are not fully occupied, and some occupants will be absent (see section 3.8.3).

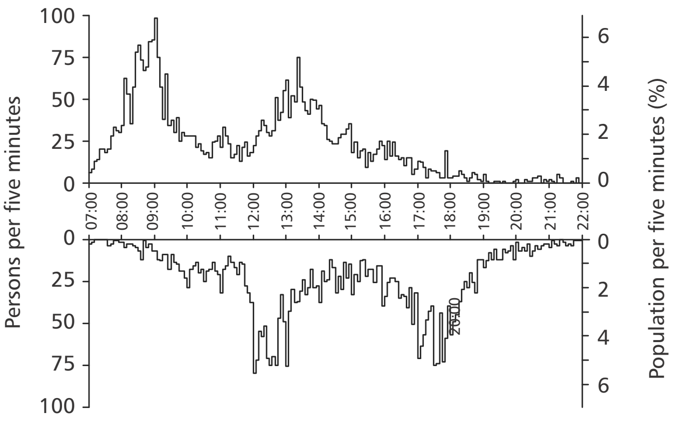

Figure 4.2 Passenger demand for sample traffic survey

Table 4.2 Example arrival rate and destination probability table

From/to	Arrival rate (persons per 5-minutes)	Destination probability / %							
		Ground	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Ground	25.2	0.0	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Level 1	2.4	50.0	0.0	8.3	8.3	8.3	8.3	8.3	8.3
Level 2	2.4	50.0	8.3	0.0	8.3	8.3	8.3	8.3	8.3
Level 3	2.4	50.0	8.3	8.3	0.0	8.3	8.3	8.3	8.3
Level 4	2.4	50.0	8.3	8.3	8.3	0.0	8.3	8.3	8.3
Level 5	2.4	50.0	8.3	8.3	8.3	8.3	0.0	8.3	8.3
Level 6	2.4	50.0	8.3	8.3	8.3	8.3	8.3	0.0	8.3
Level 7	2.4	50.0	8.3	8.3	8.3	8.3	8.3	8.3	0.0
Total:	42								

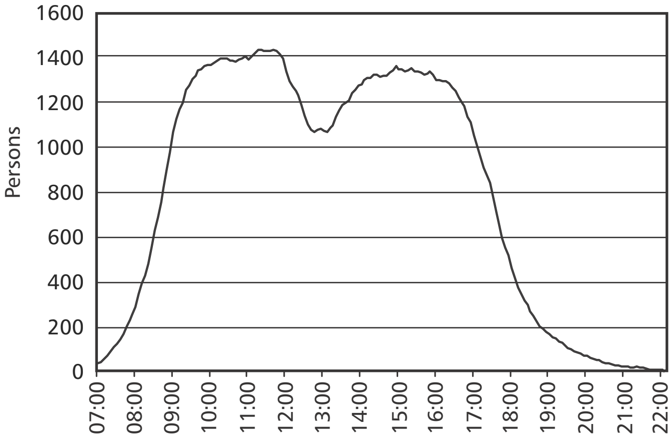

Figure 4.3 Observed building occupancy for sample traffic survey

For surveys to be credible a person experienced in lift systems and research should supervise them. Ideally the survey team should include someone who is able to identify faults and limitations in the existing system, for example:

- Wasted stops due to the absence or failure of the load bypass system.
- Unnecessary stops due to more than one hall call riser in the system — people register hall calls on both sets of buttons, resulting in two cars being sent to serve one person.
- Wasted car trips due to over active zoning systems continuously re-parking idle cars.
- Failure of systems to switch into an up-peak mode when there is predominant traffic from the main terminal floor. This can result in one or more cars being idle at upper floors, while at the same time there are queues forming at the main terminal.
- Failure of systems to switch into a down-peak mode. This can result in lower floors in the building receiving no or very poor service during down peaks.

Major faults can affect the observed passenger demand as sometimes people choose to travel at non-peak times or to use the stairs rather than to endure long waiting times. Performance metrics, e.g. average waiting time, will be negatively influenced.

4.4.3 Automated traffic analysers

Simple traffic analysers may be linked to the lift control system, and record the time every landing and car call is made and cleared. They analyse the data and provide a range of performance results and graphs. Modern control systems incorporate similar functionality. A range of traffic and performance measures can be determined, for example:

- average response time to landing calls by time of day
- distribution of response times
- distribution of car calls by floor.

These traffic analysers can give an indication of a lift system's performance, but very limited information about the actual passenger traffic flow. In general, except when destination control (hall call allocation) is in use, the number of people associated with a given lift signal, e.g. a car or hall calls, is unknown.

For the building presented in Figure 4.2, the up and down hall calls counted by the control system are presented in Figure 4.4. The hall call information gives no indication of the up-peak in the morning or at the beginning of lunch measured by observers counting people. This is because in up-peak traffic, a single hall call at the entrance level could correspond to a large group of passengers. At the same time, a down call at upper floors may correspond to a single passenger. For this reason, it is generally unreliable to use simple traffic analyser results to assess the demand on an existing system, or to evaluate the benefits of modernisation.

Instead, a count or estimate of the number of people transported should be made.

Some manufacturers have improved the estimate of actual demand by using information from passenger detection systems (light beams) and load weighing. Siikonen[3]

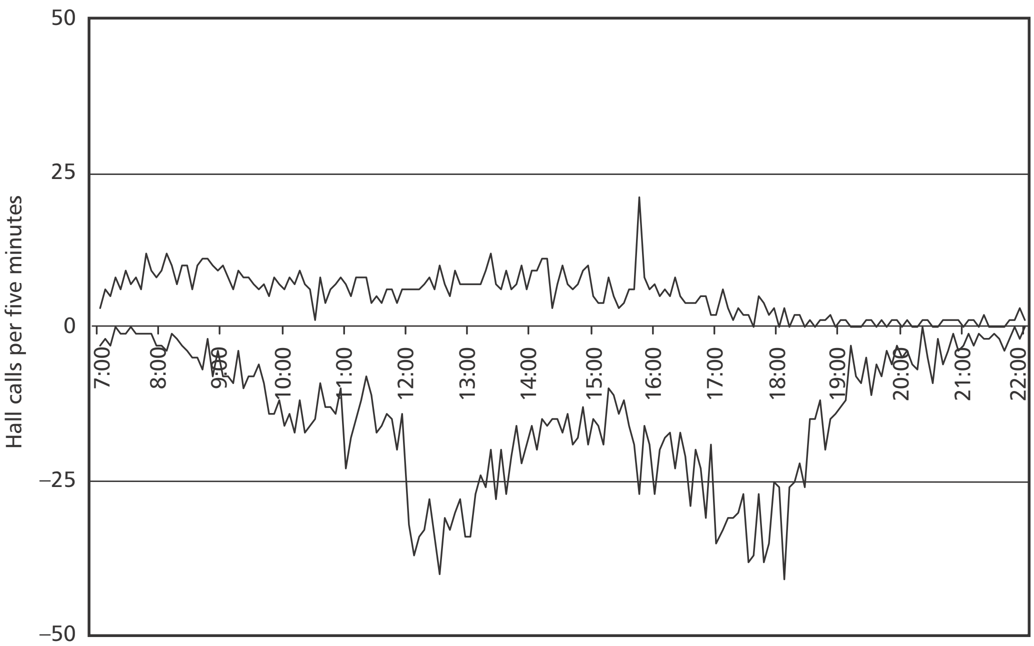

Figure 4.4 Plot of up and down hall calls per 5 minutes

presents an example of this for a multi-tenant office building in Paris. The survey results measured and stored by the group control system are reproduced in Figure 4.5. Passenger demand is presented as a 'stacked area' graph, similar to Figure 4.1. It should be noted that these traffic data have been collected in 15-minute (as opposed to 5-minute) intervals and that results are averages based on daily statistics. On a single day during the busiest five minutes, measured peaks could be higher.

The increased application of destination control (hall call allocation) makes automatic data collection more straightforward as each passenger is required to register their own call for the system to operate optimally. This allows the origin and destination of the passenger for every call to be identified. Smith and Peters[(4)] provide examples of data collected from an installation using destination control. Figure 4.6 plots the data of five working days in the same building. Plotting data for a whole week demonstrates a high level of consistency in passenger demand. Each installation has a recognisable passenger demand pattern or 'signature'. The assumption is made that one destination call corresponds to one person. This is reasonably reliable. Overestimates occur when waiting time is long and impatient passengers re-register their calls. Underestimates occur when passengers travelling together only register one call for the group.

4.5 Theoretical simulation templates

Since widespread introduction of simulation tools, one of the challenges for the lift industry internationally has been trying to reach a consensus on how to apply simulation. In preparation for this edition of CIBSE Guide D, extensive consultation has been undertaken, both with the designers and users of simulation tools. The most widely used current, and proposed, design templates are presented in sections 4.5 and 4.6.

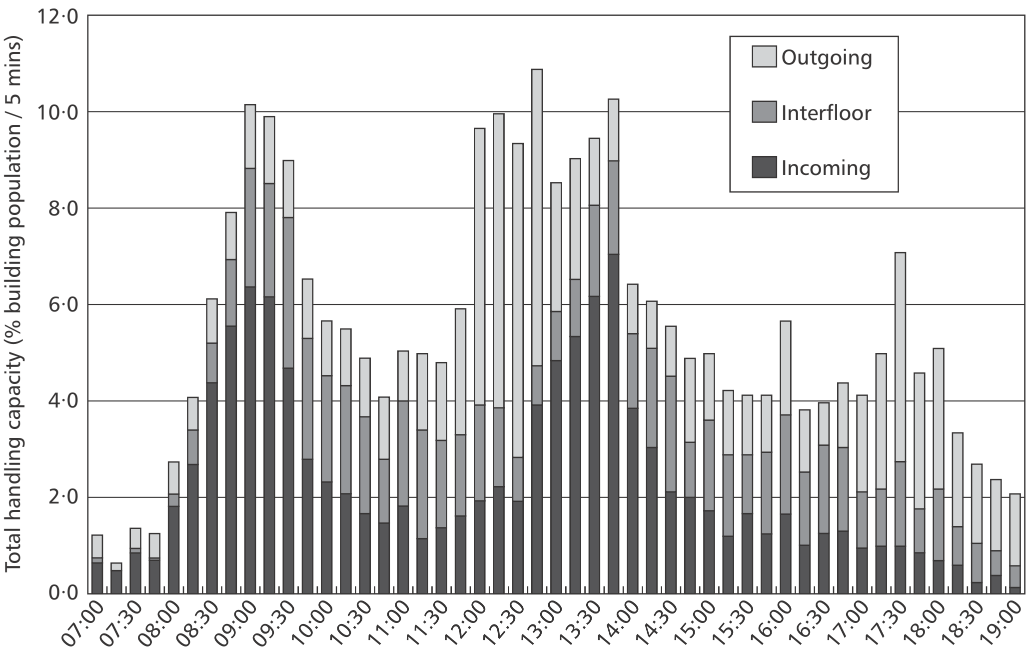

Figure 4.5 Example automatic traffic measurements for a multi-tenant office building

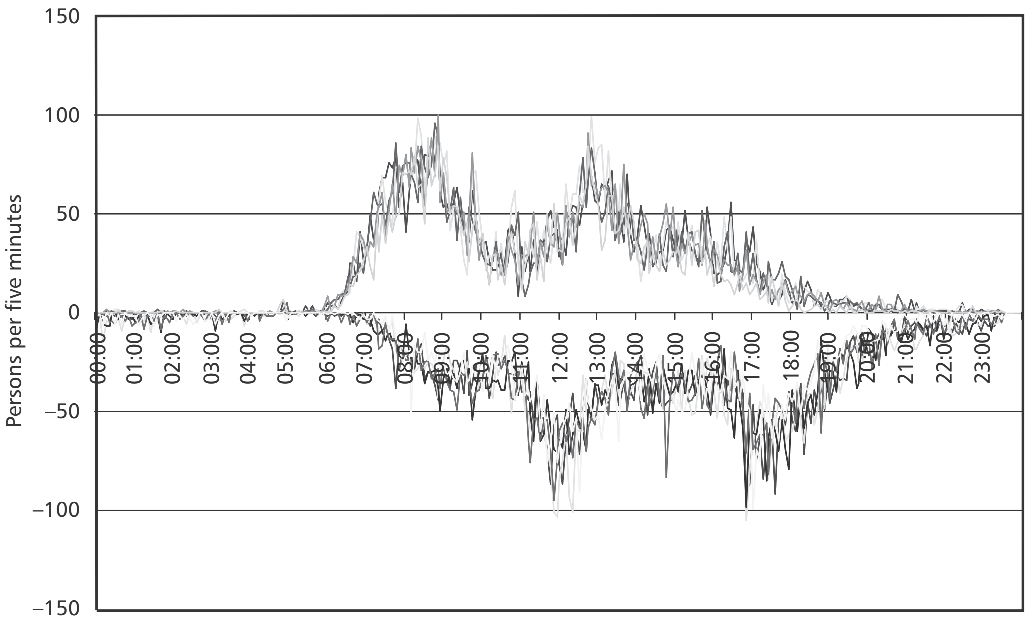

Figure 4.6 Traffic signature

4.5.1 CIBSE classic office up-peak template

This template shown in Figure 4.7 and proposed by Barney[5] represents the classic morning up-peak. Like the up-peak round trip time calculation described in chapter 3, it does not consider outgoing or interfloor traffic. The template represents one hour in twelve 5-minute periods. It shows a rise in passenger arrivals from a low background level to a peak and then a fall-back to the background level. The profile represents the arrival of 80% of the effective building population. The value of the peak can be adjusted to meet the design value.

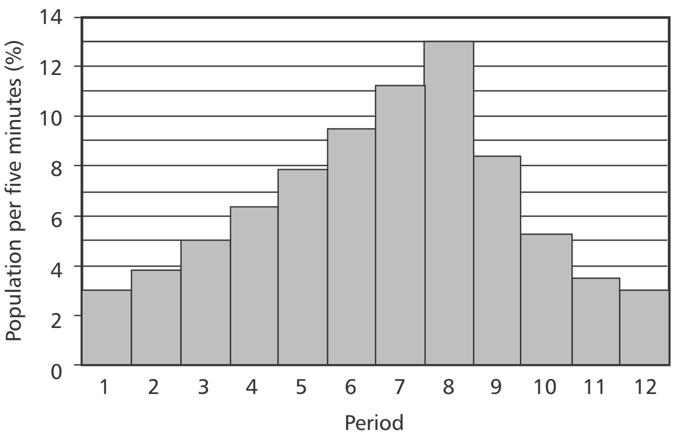

Figure 4.7 CIBSE classic office up-peak templates

Some designers use a similar profile, but require 100% of the population to arrive over the hour. This is an arbitrary requirement without any known basis, and inconsistent with published traffic surveys.

The *BCO Guide to Specification*[6] calls for the application of an up-peak template and plots, and provides an example.

For consistency, users of the CIBSE classic office up-peak template may apply the algorithm provided by Peters[7] to generate the template.

When using the CIBSE classic office up-peak template, results for waiting time, transit time, and loading should be quoted for the peak 5-minute period, and not averaged over the whole hour, which can give a false impression of performance at the peak time. See chapter 3, Table 3.7 for target passenger times.

4.5.2 Step profile

This template, shown in Figure 4.8, starts with a low demand and increases continuously or in increments of 1% every five minutes. The demand can be pure up-peak, or any combination of mixed traffic. The premise of this approach is that the system's performance is tested across a range of traffic intensities.

The waiting time, loading (and other parameters) can be presented for each level of demand, both graphically, and in tabular form.

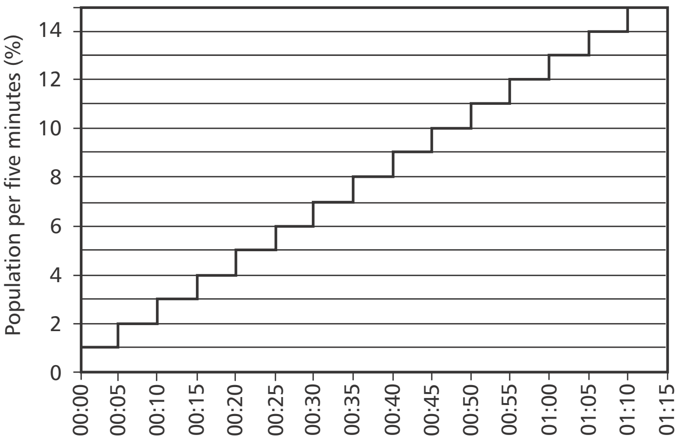

Figure 4.8 Passenger demand for step profile increasing by 1% every 5 minutes

This presentation is useful as it highlights to the customer that the waiting time, loading and other parameters are dependent on demand. A system that manages 13% of the design population in five minutes may be sufficient in most buildings. However, if it can transport a greater demand without saturating, it is more likely to manage, for example, if the building population exceeds the design population.

The presentation is also very useful to compare control systems, which do not necessarily perform consistently across a range of traffic intensities. For example, at the design handling capacity, a conventional system could have a better waiting time than the equivalent system with destination control (hall call allocation). However, if demand increases and the conventional system saturates, destination control may have better waiting times.

A step profile plot shows the demand introduced to the system but does not show the actual amount of people handled in each of those five minute periods. If the passenger demand exceeds the handling capacity, the 'spillover' of people from one period to the next will get larger and larger; the system saturates. This is apparent in plots of queue lengths and passenger transfer (count of people loading and unloading the lifts).

There are several variations on this template:

- The step duration is extended, e.g. 30 minutes on the basis that it helps establish if the system can sustain each level of handling capacity. Passengers who arrive in the first and last five minutes of each step of the simulation are discarded from the analysis.
- The simulation is started with a level of passenger demand at which the system is expected to saturate. The demand is stepped down until the system can manage the traffic; this is then the reported handling capacity.
- The step is substituted with a ramp where the demand is slowly increasing over two hours, rather than in steps. Results are presented for a selected 15-minute window.

None of the above variations are incorrect as they are system tests, not intended to mimic reality. However, it is not possible to compare the results between the alternative approaches.

If the simulation rises up to, or down, from a point where the system is saturated, these methods can be used to estimate the maximum handling capacity of the system.

The step profile with a 1% traffic increase every five minutes is the closest to real traffic (see Figure 4.10). So, for consistency, this approach is recommended. The simulation should continue to at least 1% beyond the design value for passenger demand. If the maximum handling capacity is of interest, the simulation may be continued up to the point where the system saturates.

4.5.3 Constant traffic

This template is based on a demand that is constant for an extended period of time. The premise is that if a system has a handling capacity of x%, it can sustain that demand indefinitely. This is directly analogous with the round trip time calculation.

If the lifts cannot cope with the traffic defined, the longer the simulation runs, the longer the passenger waiting times can become. Increasing queue lengths may develop as the simulation progresses.

The simulated handling capacity (SHC) is defined as the maximum traffic demand that an installation can sustain indefinitely. This is expressed as a percentage of the population per five minutes. It should be quoted together with traffic bias in terms of incoming, outgoing and interfloor traffic.

The simulated handling capacity may be marginally less than the handling capacity calculated with round trip time calculations, as discussed in section 4.10.

There is no consensus as to how long a constant traffic template should be run. Some designers disregard the contribution to the results of passengers arriving during the beginning and end of the simulation. A short simulation (e.g. five minutes) gives an unrealistic advantage because the simulation starts with the lifts empty. The recommended approach is to simulate for 30 minutes, and then to disregard passengers arriving during the first and last five minutes when calculating results.

4.6 Simulation templates derived from traffic survey

4.6.1 Preamble

The templates in the previous section are not intended to represent actual passenger demand in buildings; they are tools to assist designers to establish an appropriate design. Each is valuable when applied by experienced practitioners. However, the most authoritative position is to design by applying evidence-based research.

4.6.2 Traffic research

Siikonen[3], Strakosch[8], Barney[9] and Powell[10] have proposed templates, which are intended to represent real traffic in actual buildings.

Peters Research Ltd. has undertaken case studies of a range of office buildings between 2007 and 2009[11]. Figure 4.9 shows a plot of average demand normalised against observed population.

Caution: traffic designs should not be based on average passenger demand. Some buildings have lower demand peaks than indicated in Figure 4.9, other buildings have higher peaks.

Figure 4.10 shows how the demand, on average, is split between incoming, outgoing and interfloor components. For example, during the early morning, the interfloor traffic comprises a smaller percentage of the total traffic than it does later in the day.

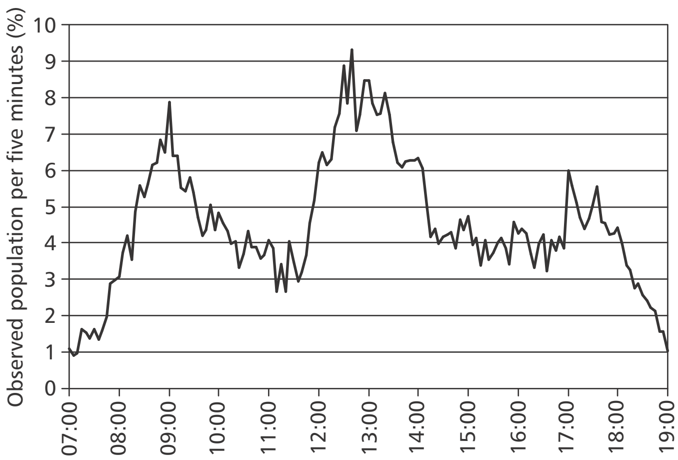

Figure 4.9 Average passenger demand based on survey

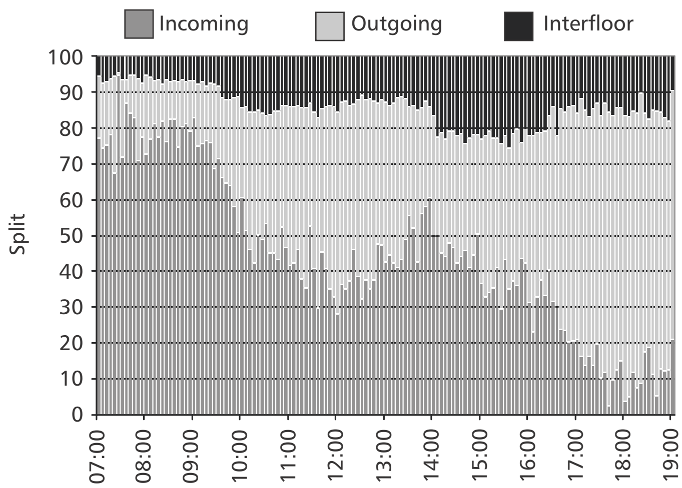

Figure 4.10 Stacked column graph demonstrating the relative contribution of incoming, outgoing and interfloor traffic

4.6.3 Observations

Some general observations can be made about modern office buildings:

- total passenger demand is normally (but not always) greater at lunchtime than it is during the morning up-peak
- morning up-peak traffic is now more widely spread than the classic up-peak design suggests
- major down-peaks are rarely seen
- traffic is mixed throughout the whole day, including incoming, outgoing and interfloor components.

In one building the peak demand exceeded 18%. This is characteristic of buildings with low population. In this survey, the population served by the lifts was approximately 200 people. Thus 1% of the population equates to two people. With a larger sample size, for example, if the survey were repeated on multiple days, one could expect the average peak to be lower. It is not necessary to design to these high peaks as they do not occur in larger buildings, and in smaller buildings they represent a small number of people. Queues can be cleared in a short time because the high demand is not sustained.

Figure 4.11 shows the range of passenger demand that has been measured in major office buildings (observed populations greater than 1000 people).

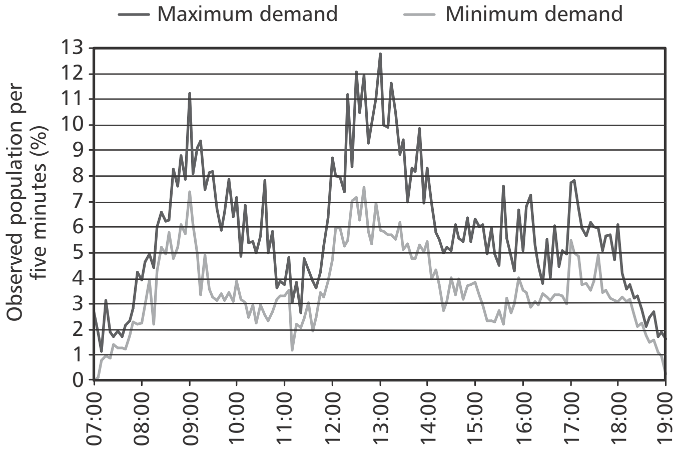

Figure 4.11 Passenger demand range for major office buildings based on surveys of occupied buildings

4.6.4 Design templates

Peters has suggested new design templates to reflect the traffic in modern office buildings, see Figures 4.12 and 4.13. Each template represents one hour in twelve 5-minute periods. Quality of service criteria are given in Table 4.3.

Table 4.3 CIBSE modern office template quality of service criteria (*Note*: capacity factor is given in terms of area, not rated load (cf. Table 3.1))

Quality of service rating	Up-peak			Lunch-peak		
	Average waiting time (s)	Average transit time (s)	Capacity factor by area (%)	Average waiting time (s)	Average transit time (s)	Capacity factor by area (%)
7-star	10	40	70	15	40	70
6-star	15	60	75	22.5	60	75
5-star	20	80	80	30	80	80
4-star	25	100	85	37.5	100	85
3-star	30	120	90	45	120	90
2-star	35	140	95	52.5	140	95
1-star	40	160	100	60	160	100
Unclassified	Not meeting 1-star criteria			Not meeting 1-star criteria		

Notes: (1) These criteria apply only to the CIBSE modern office templates. (2) The target performance for a prestige city office is 5-star. (3) To achieve a quality of service rating, both up-peak and lunch-peak criteria must be met. (4) Tabulated values refer to the worst result for any 5-minute period in the simulation. The waiting time is measured across all floors, not just the main terminal. (5) Capacity factor by area is to be monitored both on arrival and departure from the main terminal floor. (6) Where a car passes through an express zone, the time to travel through the express zone at full speed can be added to the transit time criterion.

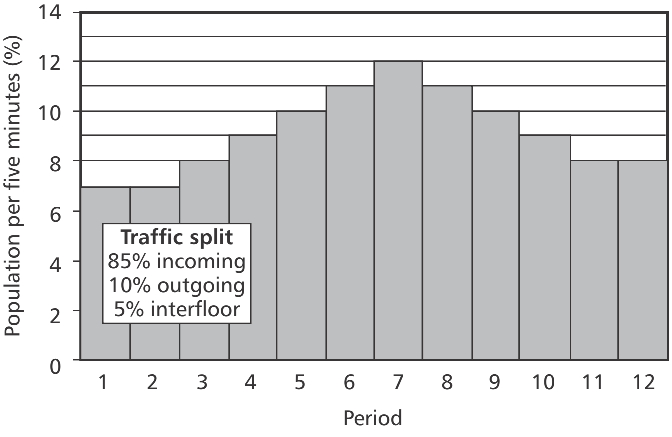

Figure 4.12 CIBSE modern office up-peak traffic templates

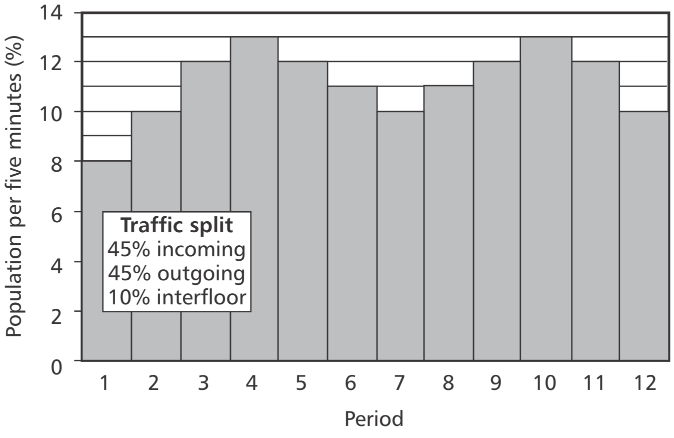

Figure 4.13 CIBSE modern office lunch-peak traffic template

These templates should be applied when comparing the relative performance of competing proposals during a detailed design. They allow a better assessment to be made of the benefit of enhanced equipment and traffic control systems. For example, destination control (hall call allocation) boosts up-peak handling capacity. If comparing conventional and destination control, applying a classic up-peak profile (Figure 4.8) can exaggerate the benefits of destination control; this is because destination control performs best when traffic is purely up peak, yet in reality traffic normally includes down and interfloor components.

The templates are appropriate for a single tenancy building. Some designers may want to account for multiple tenancy buildings with a reduced demand (see section 3.8.4). However, caution should be applied. Some buildings have lift installations that are insufficient because they were designed for multiple tenancies, and are then subsequently occupied by single tenants.

The traffic split between incoming, outgoing and interfloor traffic varies over the simulation period, particularly during lunch time. For simplicity, the lunch peak split has time is based on an average over the lunch hour.

Warning: it is common for lifts not to perform as well as has been assumed in design calculations and simulations.

Warning: traffic designs based on realistic traffic estimates are the best way to predict actual performance. However, all equipment assumptions should be verified with the lift supplier. It is not unusual for different suppliers to claim a higher rating for equipment with nominally the same specification. For this reason, lift selection should normally be based on generic equipment, and not rely on the enhanced performance claims of one supplier.

Furthermore, it is not uncommon for one or more lifts in a group to be out of service, even in prestige buildings with new lifts. For this reason, designs should also be tested with one lift out of service, and the results reported to the client for their consideration. The contribution to performance made by high quality equipment together with good installation and maintenance cannot be overstated. When it is critical to provide a consistent quality of service, a monitoring system with daily reporting of lift availability and lift performance should be specified.

4.7 Other considerations

4.7.1 Running multiple simulations

For a simulation to give the same results each time an analysis is run, it must generate the same list of passengers for the same input data. This is achieved by generating passengers according to a random number sequence. This sequence starts at a certain initial value, which can be changed by a process called 'seeding'. When multiple runs are carried out, with different seeds, different results are obtained. It is as if Monday, Tuesday, Wednesday etc. simulations are being run. The results can then be averaged for all the simulations.

Without multiple simulations, the chance element in simulation means that changing a parameter, such as speed or door operating times can sometimes lead to performance results getting worse when it would be expected for them to improve (or vice versa). Running multiple simulations is the best way to avoid counter-intuitive results.

Design tip: start by using one simulation, then increase the number of simulations to at least five for final results when an appropriate lift configuration has been selected.

4.7.2 Start and end effects

When some simulations begin, the lifts are empty and have no calls. The lifts effectively have a 'head start'. It is possible to provide some 'conditioning' traffic prior to the analysis period; for example, by running the simulation for an extra five minutes and ignoring the results for the first 5-minute period. Similarly, the final five minutes may also be ignored as the final passengers to be served may have their calls answered in a period when there is new demand. If the simulation is run for a sufficient length of time, e.g. one hour, start and end effects are usually negligible.

4.8 Design examples

4.8.1 Example 4.1

Apply a computer program based on the formula given in Appendix 4.A1 to select a lift configuration for the following parameters.

Requirements and assumptions:

- Number of office floors above ground: 14
- Population: 1120 (80 persons per floor)
- Interfloor distance: 3.8 m
- Round trip time losses: 5%
- Up-peak passenger handling capacity: 12% of population per 5 minutes
- Maximum interval: 30 s
- Loading time per passenger: 1.2 s
- Unloading time per passenger: 1.2 s
- Maximum capacity factor by mass: 80%
- Passenger mass: 75 kg
- Maximum capacity factor by area: 80%
- Passenger area: 0.21 m^2

To determine the maximum practical loading of the car, consider both area and mass. As discussed in section 3.5.5, the nominal passenger carrying capacity of lifts presented in safety standards should not be used for planning.

Designers used to requiring a higher up-peak handling capacity should note that the limiting factor on handling capacity in this calculation is capacity factor by area (see Appendix 4.A1). With more optimistic requirements and assumptions, the selected configuration could be demonstrated to achieve 15% handling capacity with 80%

capacity factor by mass. The recommendation of this Guide is that designers use lower, more realistic requirements for handling capacity in combination with more realistic assumptions about passenger behaviour and lift performance.

Selected configuration:

- Number of cars: 6
- Rated load: 1600 kg
- Car area: 3.56 m^2
- Rated (actual) capacity: 21 (16) persons
- Rated speed (v): 2.5 m/s
- Acceleration (a): 0.8 m/s^2
- Jerk (j): 1.0 m/s^3
- Start delay time: 0.5 s
- Door open time: 1.8 s
- Door close time: 2.9 s

Calculation results:

- Interval: 27.1 s
- Capacity factor by mass: 57.8%
- Capacity factor by area: 71.6%
- Average number of passengers in car departing home floor: 12.1
- Average number of stops above home floor: 8.3
- Average highest reversal floor above home floor: 13.4

4.8.2 Example 4.2

Repeat analysis of selected configuration in Example 4.1 using the General Analysis round trip time calculation (see section 3.9.4).

Calculation results:

- Interval: 26.4 s
- Capacity factor by mass: 56.2%
- Capacity factor by area: 69.6%
- Average number of passengers in car departing home floor: 11.8
- Average number of stops including home floor: 9.0
- Average highest reversal floor (where 1 is lowest floor): 14.2

Designers comparing different calculation programs and manual methods should not be unduly concerned when the results are not precisely the same.

The up-peak and General Analysis results are very similar, except for numbers of stops and highest reversal floor where the calculations are using different definitions. This inconsistency with the traditional up-peak calculation is necessary because the General Analysis can be used to analyse buildings with multiple entrance floors. The General Analysis can also be used to assess buildings with mixed traffic.

4.8.3 Example 4.3

Run a simulation for the selected configuration using the CIBSE modern up-peak and lunch peak template. Repeat the analysis with a car out of service.

Additional assumptions:

- Passengers may not load beyond the actual car capacity determined by area (16 persons).
- A generic dispatching algorithm (dynamic sectoring operating an up-peak mode, see section 9.4.1.4).
- 10 simulations runs.
- An allowance for door dwell times after passenger transfer is complete (3 s if beam is not broken until car doors close, 2 s if beams have been broken and have been re-established).
- Doors are allowed to re-open for late arriving passengers if the car has not left the floor.

Results are summarised in Table 4.4. Figures 4.14 to 4.18 show typical results plotted by a simulation package for the analysis with all cars in service.

Table 4.4 Example 4.3: summary of results

Lift configuration	Up-peak			Lunch-peak			Quality of service rating
	Average waiting time (s)	Average transit time (s)	Capacity factor by area (%)	Average waiting time (s)	Average transit time (s)	Capacity factor by area (%)	
6 × 1600 kg cars at 2.5 m/s	29	91	74	35	81	52	3-star
5 × 1600 kg cars at 2.5 m/s	134	98	91	76	97	75	Unclassified

Table 4.5 Example 4.4: summary of results

Lift configuration	Up-peak			Lunch-peak			Quality of service rating
	Average waiting time (s)	Average transit time (s)	Capacity factor by area (%)	Average waiting time (s)	Average transit time (s)	Capacity factor by area (%)	
6 × 1600 kg cars at 2.5 m/s	18	76	48	26	67	34	5-star
5 × 1600 kg cars at 2.5 m/s	60	88	85	46	82	63	Unclassified

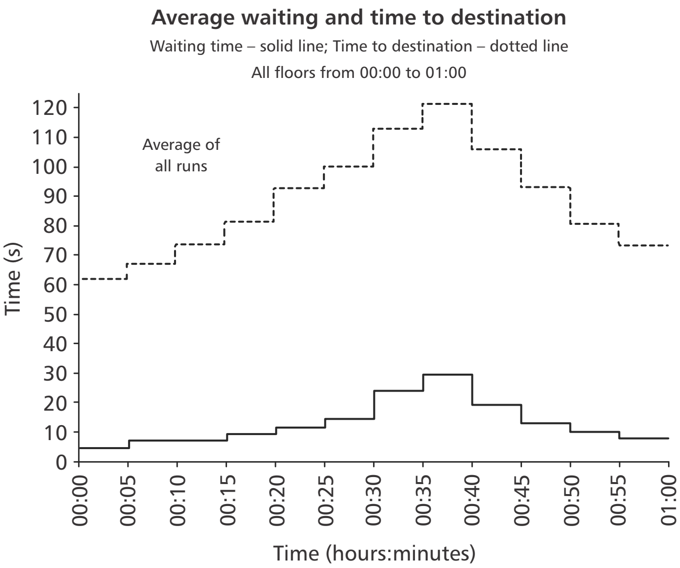

Figure 4.14 Example 4.3: average waiting time and time to destination during up-peak,

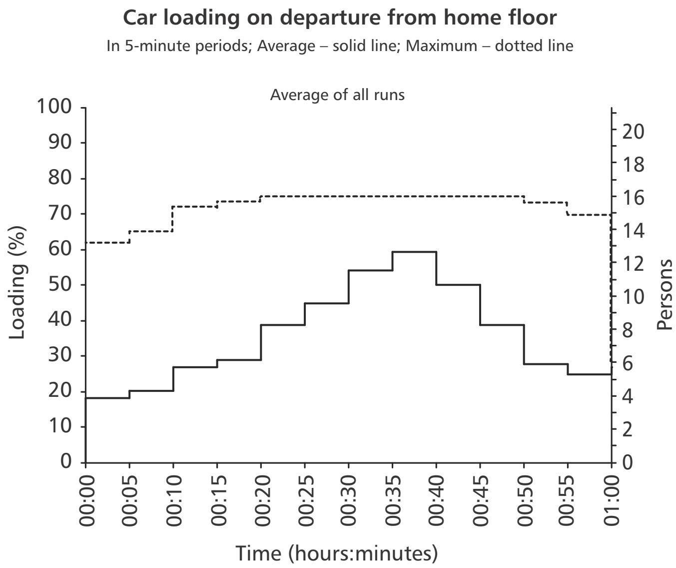

Figure 4.15 Example 4.3: car loading on departure from home floor during up-peak

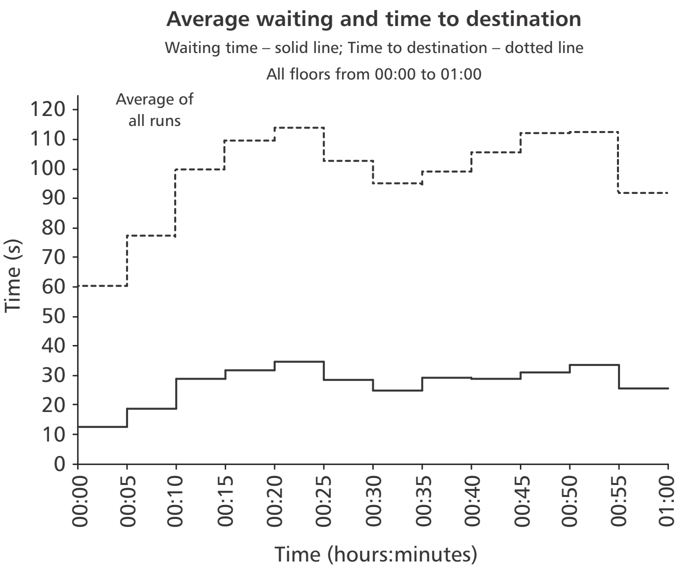

Figure 4.16 Example 4.3: average waiting time and time to destination during lunch peak

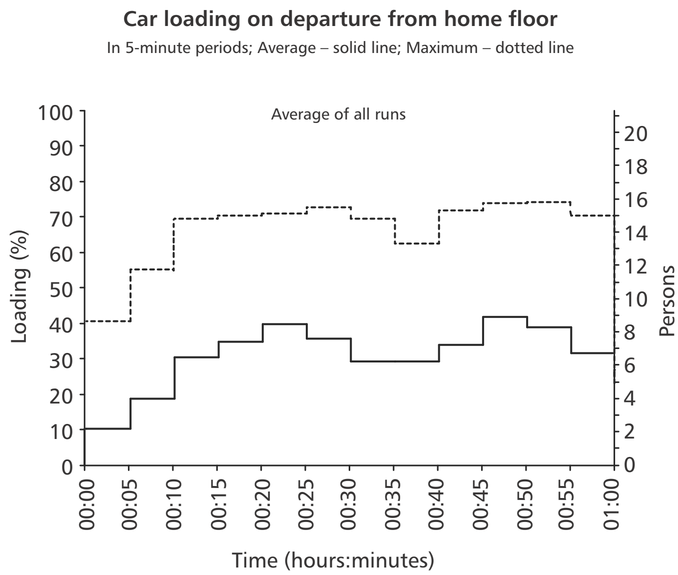

Figure 4.17 Example 4.3: car loading on departure from home floor during lunch peak

4.8.4 Example 4.4

Repeat Example 4.3; improve the system with advanced door opening of 0.7 s and reduce the average door dwell time by 1.0 s based on the application of differential door timing (see section 3.7.5).

The results are presented in Table 4.5

4.8.5 Discussion of examples

In Example 4.3, the simulation suggests a 3-star rating for the solution proposed based on a round trip time calculation. However, a relatively minor improvement to the performance time (e.g. the addition of advanced door opening) yields 5-star performance. With a car out of service, the performance is very poor. Two options worth considering would be:

— more but smaller cars

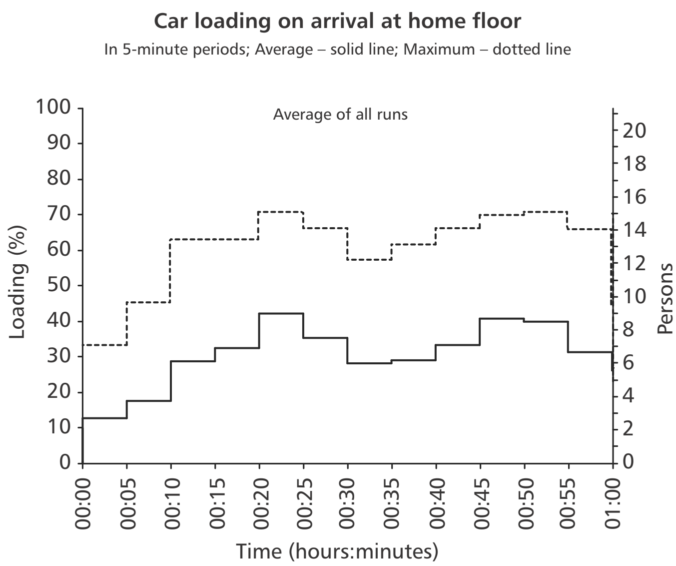

Figure 4.18 Example 4.3: car loading on arrival at home floor during lunch peak

— the application of destination control (hall call allocation).

The impact of performance time on the quality of service is noteworthy. See Appendix A2, section A2.5 for a discussion of measurements taken in actual buildings.

Caution should be applied if relying on a lift control solution that boosts up-peak handling capacity such as destination control (hall call allocation). These systems are less effective when the traffic is mixed. In particular, waiting times during lunchtime peaks can be high if the number of lifts is reduced.

In such cases, attempts to reduce the number of lifts based on up-peak performance improvements should be resisted unless assessment of the lunchtime peak period demonstrates no significant reduction in performance for the destination control solution over a conventional solution.

Whilst a reduction in lift numbers is unlikely to be justified by using destination control, the increased up-peak handling capacity, combined with the lower car loading required during lunch time peaks, can often allow a reduction in lift car size without compromising the overall system performance.

4.9 Simulation applied to modernisation

Simulation is a particularly valuable modernisation tool, as actual lift performance and passenger traffic can be measured and modelled. This allows the benefits of modernisation to be assessed more realistically.

A pre-modernisation design exercise in a major building should always begin with a traffic survey. All other input parameters to a calculation, or simulation, should also be measured on site. Simulation allows designers to answer 'what if ?' questions such as:

— What might the performance be like during the modernisation when one or more cars are out of service?

— What benefit can increasing rated speed, door times, etc. have on waiting and transit times?

— Can improvement to the traffic control algorithm have any significant benefits?

— If practical, what is the effect of installing additional cars?

Simulation programs that allow for third parties to add their own dispatching algorithms can be applied to demonstrate faults in existing systems, and to justify performance claims by suppliers.

In interpreting results, note:

— any differences between pre- and post-modernisation building populations

— that modernisation may lead to a marginally increased demand on the system, as people are more likely to take the lifts if the service is improved.

4.10 Comparing simulation with round trip time calculation results

A constant traffic template should be applied in this exercise (see section 4.5.3). When comparing round trip time calculations with simulations, it is important to note that:

— most designers using round trip time calculation do not consider door dwell times (although an allowance is possible, see section 3.6.5)

— round trip time calculations are based on averages and may be based on the assumption a car is loaded with, say, 9.9 persons; a simulation with multiple runs also yields an average, but in each simulation the maximum car load is an integer number of persons

— unless a round trip time inefficiency (%LOSS in Appendix 4.A1, equation 4.12) is used, round trip time calculations assume an ideal system with, for example, no bunching, door re-openings or other 'real life' delays.

To demonstrate consistency, it may therefore be necessary to marginally adjust variables in either the calculation or the simulation. It is normally possible to show a close correlation between the interval and the car loading calculated using a round trip time calculation (see section 3.7.1).

As stated in chapter 3, section 3.7, the calculation of waiting time and other passenger-based measures using round trip time calculations is based on a mathematical model. This is another level of mathematical extrapolation beyond the calculation of interval. Thus the values calculated with simulation may differ significantly for individual cases. Round trip time calculations are normally carried out to establish the maximum handling capacity of a system. Thus, in simulation, the modelling can be near or at the saturation point. When a simulation reaches saturation, long queues may form, with excessive waiting times, as may be seen in a real system. Small variations in demand can change waiting time significantly.

Some simulations are designed to match the results of round trip time calculations as closely as possible. This is not an unreasonable approach to demonstrate consistency provided that all assumptions are declared. However this performance reported does not reflect the performance that can be seen in real buildings.

4.11 Traffic analysis and simulation software

4.11.1 Evaluating analysis software

Modern lift traffic analysis software packages provide engineers and designers with a powerful tool for determining the number of lifts required, their speed and the size of the cars. Programs available range from crude and very limited to sophisticated and complex. Thus, it is important that a software evaluation exercise is carried out prior to making a purchase. It is recommended that answers to the following questions should be obtained as part of any software evaluation exercise:

— Can the program run on the computer and operating systems intended to be used? (*Note*: some programs require a particular version of a particular operating system, others may not run using that operating system.)

— Is additional software needed to run the program, such as BASIC interpreter or spreadsheet program?

— Does the program use round trip time formulae, simulation, or both?

— Does the program use an iterative process to find the solutions for a level of passenger demand, e.g. 12% up-peak handling capacity, specified by the designer?

— What traffic flows can the program analyse (e.g. up-peak, down-peak, etc.)?

— Can the program analyse single and/or double deck lifts?

— What are the inputs and outputs to the program? (Compare these inputs and outputs with those discussed in chapters 3 and 4 of this Guide. If the program omits some inputs, it is important that the user is aware of, and satisfied with, the values used and/or assumptions made by the program. If the program omits some outputs, the user must be satisfied that these are not required.)

— Does the program provide spreadsheet and graphical output?

— Does the program use a rigorous pseudorandom binary sequence (PRBS)?

— Does the PRBS sequence provide a choice of probability distribution functions?

— Does the program have an adequate random number generator to emulate floor demands?

— Who are the developers?

— What quality control procedures are in place to test the results are correct?

— Is the program generally available?

— What are the initial and on-going costs?

— Is a detailed manual provided?

— Is technical support available and, if so, from whom and at what cost?

— Is the program copy-protected? If so, what form of protection is used?

— Is user-training available and, if so, at what cost?

— Is the source code available for review?

— Are there future plans for upgrades, enhancements etc?

4.11.2 Comparing results between different simulation programs

When comparing the results of different simulation programs, note that there must be consistency between:

— input parameters including traffic templates

— definition of results.

It should be possible to demonstrate consistency between lift simulation programs when 'like-for-like' analyses are being compared. Some benefits can be demonstrated by applying enhanced dispatching algorithms. However, dramatic discrepancies should be examined closely and treated with caution. Competition between suppliers to demonstrate best performance with proprietary simulation software is of limited value if the assumptions applied by the simulation are not fully documented.

Barney (2003)[12] has examined two commercially available simulation programs, one of which dates back to the early 1970s and the other to the 1990s.

4.12 Epilogue

The CIBSE Lifts Group (http://www.cibseliftsgroup.org) encourages co-operation between consultants, suppliers and researchers as a means of improving the industry's understanding of lift traffic demand and lift system performance.

To this end, readers of this guide are invited to submit their traffic survey results to the CIBSE Lifts Group to assist in improving future editions of this Guide. Guidance can be offered for those prepared to share their survey results.

The templates in this section of the guide may be revised, updated, and extended to other building types in future editions of this Guide.

The CIBSE Lifts Group is also pleased to participate in peer review of enhanced performance claims where a supplier claims that their system requires fewer lifts than other suppliers. Genuine enhancements will be acknowledged and reported on the Group's website.

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Appendix 4.A1: Symbols and formulae

4.A1.1 List of symbols

a Acceleration (m/s^2)
A_c Car area (m^2)
A_p Area per person (m^2)
CC Car rated (contract) capacity (persons)
%CFM Capacity factor by mass (%)
%CFA Capacity factor by area (%)
d Travel distance (m)
d_H Distance to reach reversal floor H excluding express zone (m)
d_x Total height of un-served floors in express zone (m)
H Average highest reversal floor
h_i Height of floor i (m)
j Jerk (m/s^3)
L Number of lifts
%LOSS Round-trip time losses (%)
m Average passenger mass (kg)
N Number of floors served above the main terminal
P Average number of passengers in car (persons)
%POP Percentage population served in up-peak five minutes (%)
RL Rated load (kg)
RTT Average round-trip time (s)
S Average number of stops above main terminal
T Performance time (s)
t_{ad} Advanced door opening time (s)
t_c Door closing time (s)
$t_f(d)$ Flight time for travel distance(s)
t_l Passenger loading time per person (s)
t_o Door opening time (s)
t_p Passenger average transfer time (entry or exit) (s)
t_{sd} Start delay time (s)
t_u Passenger unloading time per person (s)
U Effective building population (persons)
U_i Population of floor i (persons)
UPPHC Up-peak handling capacity (persons/5-min)
UPPINT Average up-peak interval with 80% car load (s)
v Rated (contract) speed (m/s)

4.A1.2 Formulae

In a manual lift calculation, it is normally assumed that the lift fills with a fixed number of passengers in the car (P), see 3.5.5. This enables the up-peak handling capacity (UPPHC) to be determined. In software, the calculation is often performed iteratively. If the calculated UPPHC is greater than passenger demand, the capacity factor by mass (CFM) has to be reduced using an iterative procedure until the UPPHC is equal to the required passenger demand.

Rated capacity (CC):

$$\mathrm{CC} = \mathit{floor}\left(\frac{\mathrm{RL}}{m}\right) \qquad (4.1)$$

where *floor* is a function meaning round down to the nearest whole number.

CC is the rated capacity in persons based on BS/EN standards. It is not the actual capacity, see section 3.5.5. To determine the maximum practical loading of the car, consider both area and mass. As discussed in section 3.5.5, the nominal passenger carrying capacity of lifts presented in safety standards should not be used for planning.

Number of passengers (P) in the lift:

$$P = \left(\frac{\%\text{CFA}}{100}\right)\text{CC} \quad (4.2)$$

Capacity factor by area (CFA):

$$\text{CFA} = 100 \times P\,(A_p/A_c) \quad (4.3)$$

Effective building population (U):

$$U = \sum_{i=1}^{N} U_i \quad (4.4)$$

Highest reversal floor (H):

$$H = N - \sum_{j=1}^{N-1}\left(\sum_{i=1}^{j}\frac{U_i}{U}\right)^P \quad (4.5)$$

See also equation 3.5. Equation 4.5 allows for unequal floor populations.

Probable number of stops (S):

$$S = N - \sum_{i=1}^{N}\left(1 - \frac{U_i}{U}\right)^P \quad (4.6)$$

See also equation 3.6. Equation 4.6 allows for unequal floor populations.

Passenger average transfer time (t_p):

$$t_p = \frac{t_l + t_u}{2} \quad (4.7)$$

Travel distance to highest reversal floor (d_H):

$$d_H = \left(\sum_{i=0}^{\text{floor}(H-1)} h_i\right) + \left(H - \text{floor}(H)\right) h_{\text{floor}(H)} \quad (4.8)$$

Travel time function:

In a manual calculation, most designers use a table to determine the time it takes for a lift to travel between floors. Some typical values are given in section 3.5.9, Table 3.4. This table is based on fixed interfloor heights, and the stated values of speed, acceleration and jerk (rate of change of acceleration).

In software it is possible to write a program that accepts the dynamic parameters (speed, acceleration and jerk) and then calculates the travel time for any lift trip distance.

If: $d \geq \dfrac{a^2 v + v^2 j}{j\,a}$ then: $t_f(d) = \dfrac{d}{v} + \dfrac{a}{j} + \dfrac{v}{a}$ (4.9)

If: $\dfrac{2\,a^3}{j^2} \leq d < \dfrac{a^2 v + v^2 j}{j\,a}$ then: $t_f(d) = \dfrac{a}{j} + \sqrt{\dfrac{4d}{a} + \left(\dfrac{a}{j}\right)^2}$ (4.10)

If: $d < \dfrac{2\,a^3}{j^2}$ then: $t_f(d) = \left(\dfrac{32\,d}{j}\right)^{\frac{1}{3}}$ (4.11)

For more information about lift kinematics, refer to Appendix A2.

Round trip time (RTT):

$$\text{RTT} = \left(\frac{2\,d_H}{v} + (S+1)\left(T^{*} - \frac{d_H}{v\,S}\right) + 2\,P\,t_p + \frac{2\,d_x}{v}\right)\left(1 + \frac{\%\text{LOSS}}{100}\right) \quad (4.12)$$

where:

$$T^{*} = t_f(d) + t_c + t_o + t_{sd} - t_{ad} \quad (4.13)$$

See also equation 3.1. The conventional RTT equations assume that the lift reaches rated speed in the distance of a single floor jump and that there are no irregularities in floor heights (see section 3.5.6). This is not always the case. Peters (1997)[(13)] has provided formulae for the 'corrections' recommended in the 1993 edition of this Guide. The resulting mathematics associated with these corrections are reflected in equations 4.12 and 4.13. This approach may be applied to all calculations, not just those requiring correction.

For completeness, express zones are included equation 4.12. An assumption of this equation is that the lift reaches full speed in its travel through the express zone (note the $2\,d_x/v$ term). If this is not the case, the RTT calculation may be optimistic. A better approach would be to determine the actual flight time through the express zone, or to use simulation.

The assumption that traffic control not ideal (see section 3.6.7) is allowed for by including the term (%LOSS) such as 5–10%.

Up-peak interval (UPPINT):

$$\text{UPPINT} = \frac{\text{RTT}}{L} \quad (4.14)$$

See also equation 3.2.

Up-peak handling capacity (UPPHC):

$$\text{UPPHC} = \frac{300\,P}{\text{UPPINT}} \quad (4.15)$$

See also equation 3.3.

Handling capacity expressed as percentage of building population (%POP):

$$\%\text{POP} = \frac{\text{UPPHC}}{U} \times 100 \quad (4.16)$$

See also equation 3.4.

5 Types of transportation systems

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Chapter contents

5 Types of transportation systems

5.1 Introduction

In the modern building, vertical transportation takes on an increasingly important role to ensure the efficient movement of all potential occupants is achieved by providing passenger lifts with adequate capacity and performance as well as additional lifts to provide goods service, firefighting and evacuation and other building servicing functions. Chapter 2 indicates the circulation requirements and chapters 3 and 4 detail how the correct number and size of lifts are established for a building. This chapter looks at the different types of lifting systems and provides advice on the planning and design of each type.

Within the UK, lifts are typically provided for passenger service by using either an electric traction (geared or gearless) or hydraulic drive arrangement (see Figures 5.1 and 5.2). Rack and pinion drives offer an alternative, worthy of consideration, for some very large goods lifts or where the use of hydraulic or electric traction lifts are otherwise not practical.

Paternoster systems, consisting of a number of open cars (without doors) moving continuously in a single well, are now obsolete. A few systems are still operating in the UK but no new systems have been installed for many years and the relevant British Standard has been withdrawn. For these reasons, paternoster systems are not considered in this Guide.

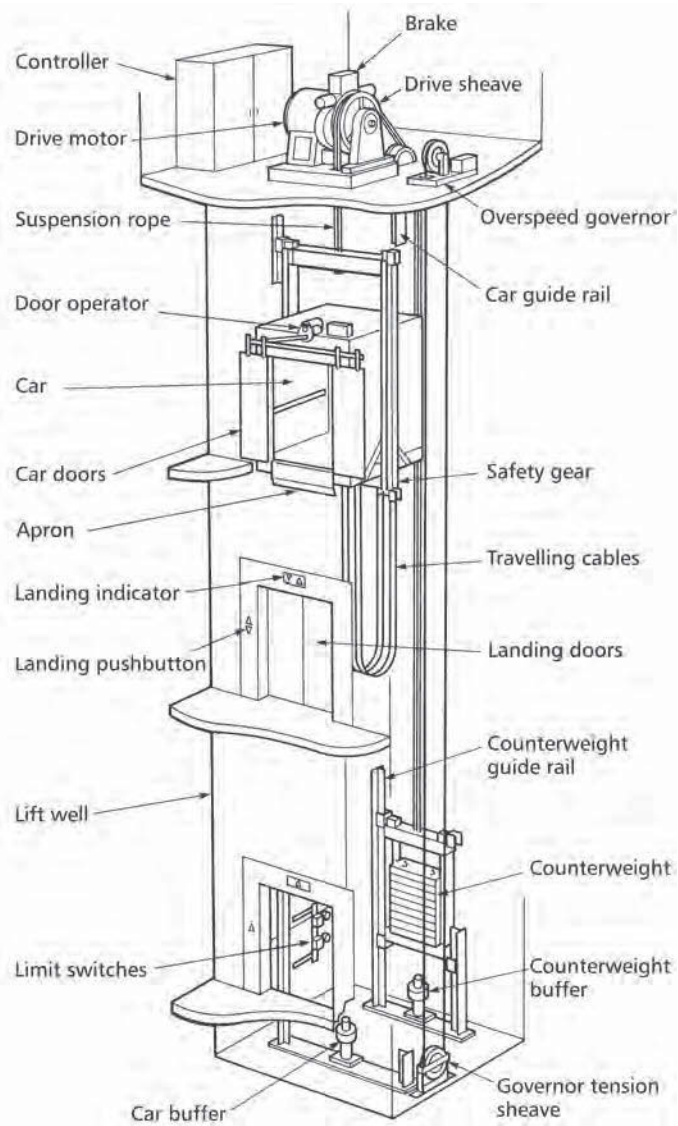

Figure 5.1 General arrangement of an electric traction passenger lift

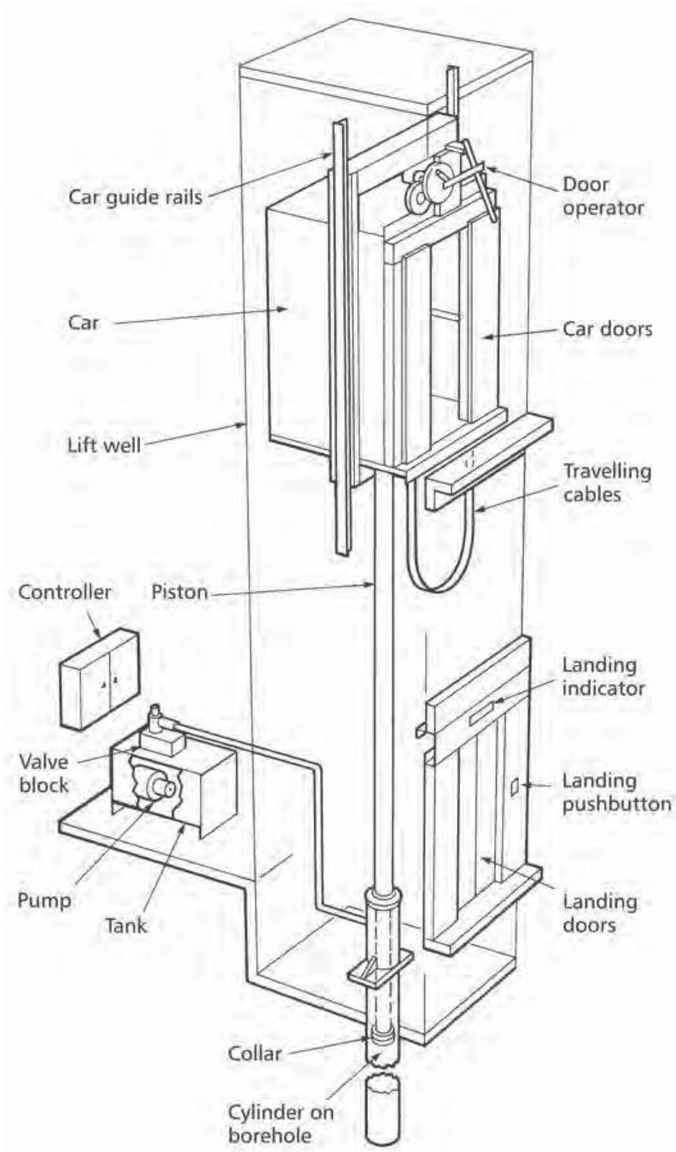

Figure 5.2 General arrangement of a hydraulic passenger lift

All new passenger lift systems installed within the UK must satisfy the Essential Health and Safety Requirements (EHSRs) laid down in the Lifts Regulations 1997[1] to ensure the installation provides the necessary levels of safety. The EHSRs can be met by designing and installing the lift, either in accordance with harmonised standards such as BS EN 81-1[2] or BS EN 81-2[3], or by obtaining approval from a Notified Body for any parts of the design or installation that do not comply with these standards.

As well as the BS EN 81 series of harmonised European standards, some British Standards remain current (see Appendix A3 and should be applied as necessary to installations in the UK. In particular, Code of Practice BS 5655: Part 6[4] provides useful guidance to the selection and installation of new lifts and BS 7255[5] is the primary standard for safe working on lifts.

The economic life cycle for the types of system depends upon the original design duty and the standard of maintenance employed. Typically, a 20–25 year life span can be anticipated for traditionally engineered lift systems, whilst life spans of less than 15 years might be more realistic for packaged lifts that are mass produced using lightweight materials to keep cost down. During the normal life cycle of all types of lift systems, oil seals, suspension ropes, bearings and other components subject to wear will require maintenance and possibly replacement as part of a planned maintenance regime.

In addition, components such as push buttons, indicators, drive and control systems might be replaced as part of an ongoing modernisation programme to benefit from technological advances (see chapter 16).

The type, speed, load and layout of the lift system all contribute to the user's perception of the service provided. The lift car finishes need to suit the particular application to project the required impression, be it the strength and durability of a goods lift or various levels of refinement for passenger lifts. The design, however, should be practical from the users' point of view and pushbuttons and fixtures, for example, should be selected not only on the basis of appearance but also their practicality. Compliance with any relevant disabled access codes such as BS EN 81-70[6], BS 8300[7] and Building Regulations Approved Document M[8] to ensure compliance with the Disability Discrimination Act[9,10] should be considered from both the functional and aesthetic point of view, see chapter 11.

BS ISO 4190-1[11] for passenger lifts and BS ISO 4190-2[12] for goods lifts set out the recommended dimensions of cars and wells for lifts of various standard capacities and dimensional configurations. These sizes may be fine-tuned in negotiation with the lift supplier to suit the particular circumstances. Most manufacturers now offer lift cars with variable dimensions at no extra cost, to satisfy non-standard lift configurations, however some manufacturers may apply additional design and production costs for non-standard lift dimensions and these should therefore be avoided unless there are good reasons for deviating from BS ISO 4190 dimensions.

The range of applications for which 'machine room-less' lifts (MRLs) are available, continues to increase and MRL lifts are readily available for passenger applications up to 2000 kg (33-passenger) capacity with speeds up to 2.5 m/s. MRL goods lifts are now available up to 5000 kg from some suppliers at speeds up to 0.5 m/s and some suppliers now have solutions for MRL vehicle lifts.

Care should be taken when designing for MRL lifts as the accommodation of drives and control equipment within the lift well sometimes means the lift well dimensions need to be larger than those recommended by BS ISO 4190, whilst other dimensions may be smaller.

The modern passenger lift appears, or should appear, to be a simple means of transport within a building. This apparent simplicity belies a complex and sophisticated mechanical, electrical and microelectronic system. Passengers and owners expect safe, comfortable, transportation, which is always in service.

— *Safety*: the motion of the doors should be smooth and safety devices should be provided to ensure that passengers entering or leaving the lift car will not be injured if the doors start to close. The levelling of the car to the landing floor should not constitute a tripping hazard and should allow easy movement of any wheeled objects such as trolleys, wheelchairs or pushchairs etc.

— *Comfort*: the ride between floors should have acceptable levels of acceleration and jerk (i.e. rate of change in acceleration) and vibration should be kept to a minimum. Quiet operation of the doors and noise levels during travel are important factors in overall passenger comfort. Noise levels emitted on to landings should also be kept to a minimum since some buildings do not have lift lobbies, see section 12.13.

— *Service*: passengers regard waiting time as the appropriate measure of quality of service for a lift system. Despite this, lift designs are generally based on round trip time calculations to quantify performance levels in terms of a theoretical interval time, related to handling capacity. However, new guidance in chapter 4 of this edition of Guide D provides details of ongoing research based on traffic surveys in buildings and details how this can be used to allow lift design to be based on simulation techniques. See chapters 3 and 4.

Safety must be ensured at all times and this applies equally to passengers and to persons working on a lift, e.g. service personnel, surveyors, consultants, inspectors etc. It is also important that any goods transported are safe from damage and that the lift does not degrade the environment in which it operates. Any alterations to suit particular or special circumstances should not jeopardise the provision of good, safe access to equipment after installation, since it will be necessary to carry out in-service maintenance and repairs to the equipment during the life of the installation. The final equipment layout should also take into account the space requirements for possible replacement of major components in the future. This is particularly important with MRL equipment where maintenance operations that would previously have occurred in a protected and normally spacious machine room are carried out within the confines of the car top or even from inside the car. In addition more activities may be required from landing levels, where control, or emergency operating equipment, may be located.

The type of building and the potential traffic demand will determine the choice of control for the lift system. After consideration of any special client requirements or traffic patterns, the vertical transportation designer should select a suitable control system (e.g. single button, down collective, full collective or group control). In addition, the use of hall call allocation (HCA) systems (also known as destination control) is becoming more widespread and these too can be considered for non-public installations, see section 9.4.2.3.

The following sections offer guidance to the selection of the type of lift most suitable for the application being considered. Reference should be made to chapter 7, which describes individual components in detail.

5.2 Passenger lifts

5.2.1 General

Lift suppliers offer ranges of products from 'pre-engineered' lifts to one-off systems designed and manufactured to individual requirements. Pre-engineered lifts offer a limited choice of options of styling and function but the production line methods used in manufacture help to reduce costs. Custom-tailored systems are appropriate for more complex applications such as observation lifts where a more sophisticated design is required. In between these two extremes, and particularly on larger lifts with larger drive machines, MRL lifts are available with enhanced finishes that may accommodate stone floors, glass and mirrors but mass limitations will vary between manufacturers and should be checked prior to their appointment to ensure the project requirements can be met with the proposed products. With custom or one-off designs, the price reflects the higher design and production costs and longer manufacturing and delivery times will be required.

The lift drive, door control and group control should be correctly specified to ensure that the required quality of lift service and safety is provided for the customer and the passenger and that the equipment installed is suitable for the environment in which it will operate.

The main applicable standards for passenger lifts are BS EN 81-1[2] for electric traction lifts and BS EN 81-2[3] for hydraulic lifts. Passenger lifts are designed to carry passengers and although they may occasionally carry goods and be considered as a shared goods passenger lift, this is not their primary purpose. Goods passenger lifts transport both passengers and goods and if used mainly for passenger service they may have fixings for drapes to protect the car interior when used for goods, or they may be more robustly fitted out. Goods passenger lifts are covered in more detail in section 5.3 and lifts intended to be used for goods only, which are not designed to carry passengers at all, are covered in section 5.4.

This section deals with lifts intended primarily for the transportation of passengers.

5.2.2 Applications of passenger lifts

Within the UK there are twelve main types of buildings, each with differing requirements for passenger lifts (see also sections 2.5 and 3.12). These are listed alphabetically for easy reference and thus the order does not represent the relative number of lifts installed in a particular building type.

Where reference is made to disability requirements, readers should refer to BS EN 81-70[6], the Disabilities Discrimination Act[9,10] and Part M of the Building Regulations[8]. Where reference is made to vandal resistant lift features, readers should refer to BS EN 81-71[13].

5.2.2.1 Airports

See also sections 2.5.1 and 3.12.1.

Airports are generally low-rise structures with the arrivals and departure facilities on separate levels. Escalators are typically used as the primary means of passenger transfer between levels and moving walks are commonly provided to assist passengers needing to cover long walking distances to and from the boarding gates.

The design of airports should minimise the need to move trolleys vertically wherever possible, but inevitably the provision of lifts will be required to accommodate passengers with trolleys as well those with baggage and persons with disabilities. Passenger lifts should be as large as possible to accommodate large family groups with baggage and also trolleys where these can or need to be moved vertically. In these cases, lifts that can accommodate one or two baggage trolleys are not suitable and the recommended minimum size for a passenger lift is 2000 kg, which will easily provide compliance with the recommendations of BS EN 81-70[6] for wheelchair access.

The major operational difference is likely to be in the control of the lift doors. These should have a door-open period (dwell time) sufficiently long to ensure that the doors do not close before passengers can manoeuvre a trolley to the lift. As is common with nearly all modern passenger lifts, full height, electronic, non-contact safety edges should be provided to ensure the doors do not close on passengers or their baggage during loading or unloading. The requirement for longer door dwell times will detract from the efficiency of the lift system and needs to be considered in determining the number, size and speed of the lifts.

As many of the people who visit an airport will be unfamiliar with the layout of the building, suitable signage should be provided, giving clear directions to the lifts and the stairs at all levels.

5.2.2.2 Car parks

See also sections 2.5.2 and 3.12.2.

Of all passenger lift types, car park lifts are probably subjected to the greatest misuse. Unlimited public access, combined with limited supervision, means that vandal resistant fixtures are essential. BS EN 81-71[13] provides design guidance and advice on vandal resistant lifts identifying the need for durable finishes, controls and indicators etc.

Visible fixings on landing and car operating panels should be avoided and key switch control of car lighting and fans or surface mounted fixtures should not be provided as these can attract unwanted attention from vandals and be easily tampered with.

Consideration should be given to incorporating additional security such as anti-'surfing' devices that sound an alarm and prevent the movement of the lift, in the event of intruders accessing the lift car roof or the pit area.

The biggest deterrent to vandalism is an increased level of observation of lift users and the incorporation of closed circuit television (CCTV) monitoring within lift cars and glazed panels on car and landing doors, to provide a visual link between the car and the landings, aid passenger security and are common requirements of modern car park operators.

All new lifts in public car parks should provide facilities for disabled persons.

Protection against vandalism or potential vandalism is also a consideration in the improvement of existing lifts. Refer also to section 16.10.

5.2.2.3 Department stores

See also sections 2.5.3 and 3.12.3.

Department stores may be situated in high streets, where they must make independent provision, or in retail developments where they may rely on the lift provision of the shopping centre. The lifts will be used by people carrying shopping or pushing trolleys and also by people with pushchairs or wheelchairs. They should therefore be sized to carry a minimum of 17 persons (1275 kg) to provide space for wheelchair passengers to turn around in the car if necessary, although some department stores may have their own design standards requiring larger passenger lifts capable of carrying up to 26 persons (2000 kg). The design recommendations made in BS EN 81-70[6] and BS 8300[7] to facilitate use by disabled persons should also be considered.

The finishes should provide a pleasant environment in keeping with the general surroundings whilst providing the necessary contrasting details to offer maximum usability to passengers with any visual impairment. The doors should be electronically controlled to ensure that the lifts are accessible to people with trolleys, pushchairs and wheelchairs and incorporate full height, electronic, non-contact safety edges.

Larger department stores will incorporate a combination of goods and passenger lifts as well as escalators to provide an efficient transportation system.

5.2.2.4 Entertainment centres, cinemas, theatres, sports centres, stadia and concert halls

See also sections 2.5.4 and 3.12.4.

With the exception of stadia, this application generally makes little demand for passenger lift provision with lifts provided primarily to cater for disabled access.

Modern stadia, however, often incorporate extensive conference, banqueting and corporate entertaining facilities as well as large media centres. These facilities are often spread over a number of floors and lifts will be required to provide access from the entrance level for guests and visitors.

The nature of the events hosted within stadia involves heavy traffic flows as people arrive and leave after events. Lifts should be supplemented with easily accessible stairs and consideration can be given to escalators to deal with the high volumes of people.

5.2.2.5 Hospitals

See also sections 2.5.5 and 3.12.5.

The passenger lifts in hospitals serve two distinct functions: the transportation of patients (including those being moved on beds and trolleys) and the transportation of the staff and visitors. The provision of dedicated lifts for each function is often not possible due to financial constraints and therefore a dual role can be achieved by incorporating special control features which allow the staff to call lifts out of normal passenger service to serve as bed lifts (priority control). Such features will improve the response times for lifts during emergency situations.

The transportation of patients requires lifts that provide a smooth ride and, therefore, the acceleration and jerk (rate of change of acceleration) should be kept low. The operation of the doors should allow for the potentially slow movement of passengers into and out of the lift car. The lift door safety edges should be of the full height, electronic, non-contact type, since any contact with an infirm or elderly patient should be avoided. These considerations will affect the performance of these lifts and should be considered when determining the quantity, size and speed of lifts required for any particular project. The lift groups should be able to perform efficiently during visiting times where, depending on hospital visiting policy, the building population may double within a very short period of time.

For the general public, the car interior should have clear and concise indication of floor and ward locations. Lift cars should also be designed to be easy to clean and vandal resistant, and incorporate the relevant recommendations of BS EN 81-70[6] for compliance with the Disability Discrimination Act[9,10]. Lifts in hospitals should have suitable lobbies that are recessed from any walkways, corridors or streets, to ensure that waiting passengers do not impede other traffic flows through the hospital.

Other lifts, in addition to the passenger lifts, will be required to service catering and housekeeping activities and general goods service. In some designs, infection control requirements may dictate a need for 'clean' and 'dirty' service paths resulting in additional lifts dedicated to either clean or dirty goods.

In addition to BS ISO 4190-1/2[11,12], further information on lift car dimensions to suit the movement of beds and trolleys is available in Health Building Note HBN 00-04[14] and additional design information specific to lifts in hospitals is available in Health Technical Memorandum HTM 08-02[15].

5.2.2.6 Hotels

See also sections 2.5.6 and 3.12.6.

The requirements of passenger lifts and shared goods passenger lifts (used by guests with luggage and staff for service) for a hotel are different to those for offices, and the company or hotel brand will generally be reflected in the quality and design of the lifts.

The major operational difference is likely to be in the control of the lift doors. These may have a longer door-open period (dwell time) than other public lifts to allow passengers with luggage time to enter the lifts before the doors begin to close, thereby giving the use of the lift a more relaxed image. The slower door systems will detract from the efficiency of the lift system and need to be considered in determining the number, size and speed of the lifts. Lift doors should have full height, electronic, non-contact safety edges to hold the doors open while passengers enter and leave the lifts.

In hotels, the level of service with regard to interval and waiting time is not expected to be as high as that in commercial buildings but the sizing of guest lifts should be generous to cater for passengers with luggage and to afford the necessary comfort levels for guests. The minimum recommended car size for a hotel passenger lift is 1275 kg, which will also provide compliance with the recommendations of BS EN81-70 for wheelchair access, although many hotel operators may have their own design standards requiring larger lift cars.

Since many of the people who visit a hotel will be unfamiliar with the layout of the building, suitable signage should be provided, giving clear directions to the lifts and the stairs at all levels.

5.2.2.7 Offices

See also sections 2.5.7 and 3.12.7.

The prime objective when providing lifts in a commercial office is to transport passengers quickly and efficiently to their places of work. The quality of service in terms of the lift interval and passenger waiting time should be high. The psychological effects of long waiting times on the user can be significant. Long waiting times will result when large queues build up during peak periods which reflect badly on the building and can affect the marketability of the premises.

The number of lifts, car size, type, speed, type of drive, drive control and door control will all affect the efficiency of the lift system.

The aesthetic aspects of the lift system, e.g. call buttons, car and landing indicators, car interiors and the ride comfort, reflect the company's image and in larger buildings will often be detailed by the architect to complement the building architecture, meaning standard lift manufacturer finishes are often not appropriate. The design should also consider passengers with special needs in accordance with the recommendations of BS EN 81-70[6] for compliance with the Disability Discrimination Act[9,10].

5.2.2.8 Railway stations

See also sections 2.5.8 and 3.12.8.

Surface railway stations are generally low rise buildings and usually stairs or escalators are provided as the primary means of transfer between levels and lifts are provided to allow access for persons with disabilities. In addition to the primary lift safety standards, train operating companies (TOCs) in the UK adopt special codes published by Network Rail which are designed to provide equipment with a minimum life span of 25 years and it will be found that standard model lifts are generally not suitable for use in railway environments.

Older underground stations can be very deep and passenger lift provision may be poor to non-existent with only recently constructed stations offering passenger lifts as a matter of course. New stations should incorporate lifts to provide compliance with BS EN 81-70[6], the Disabilities Discrimination Act[9,10] and Part M of the Building Regulations[8].

The underground environment of stations is very dusty and the confined conditions introduce additional risks in terms of safety and reliability. Underground train operators such as London Underground Limited in London and the New York City Transit Authority address the special requirements with prescriptive codes and standards developed to minimise fire hazards with special protection to the controllers and wiring. Again, standard model lifts will not normally be suitable or accepted for such applications.

The poor lift provision within many existing underground stations means that consideration is necessary to introducing new lifts in order to assist the elderly and persons with disabilities, as required by the requirements of the Disabilities Discrimination Act[9,10], however structural limitations will make this very difficult and will limit the level of compliance that can be achieved.

5.2.2.9 Residential buildings

See also sections 2.5.9 and 3.12.9.

Modern architectural and design concepts demand careful consideration of the needs of the people using a building. This is particularly true for residential buildings, which should provide a pleasant and safe environment for the occupants.

A well-designed residential building ensures that its inhabitants can easily and safely move within the building. Parents with children and shopping, the elderly and especially those with special needs should be provided with a convenient and reliable means of transport.

The requirements of the Disability Discrimination Act[9,10] mean that reasonable provision must be made to enable all people to be able to access residential premises. All new multi-storey residential developments should incorporate lifts or some other suitable means of access to upper storeys.

Therefore where a single lift may provide the necessary performance for the population levels and size of a particular residential building, consideration should be given to the height of the building and demographics of potential residents to ensure that in the event of the only lift failing, residents could be reasonably expected to walk up to their respective accommodation levels. For this reason a single lift should only be considered in buildings with four or five levels above the entry level. Beyond this it may be considered unreasonable to expect all passengers to be able to walk up stairs in the event of a lift failure and two lifts should be considered in residential buildings above five storeys.

Where the design of a building allows for separate lifts, perhaps at each end of a long block, consideration should be given to linking these with a public corridor to provide redundancy in the event of lift failures.

The required performance and aesthetic appeal of lifts will vary according to the nature of the accommodation, e.g. luxury apartments or local authority housing.

If the access to the lifts is not restricted, as in the case of many local authority buildings, the car fixtures and fittings should be robust in design and vandal resistant with no visible fixings or surface mounted fixtures and the provision of monitored CCTV cameras should be considered to increase security for lift passengers.

To provide the necessary security and privacy for residents many modern residential buildings have electronic access control systems requiring swipe cards or proximity devices to gain access. Where these systems are provided, it is becoming common to incorporate interfaces between the lifts, the access control system and the apartments. In this way, access to the building or parts of the building can be restricted to people with authorised access cards.

Consideration should also be given, to incorporating additional security such as 'anti-surfing' devices that sound an alarm and prevent movement of the lift, in the event of intruders accessing the lift car roof or the pit area.

5.2.2.10 Residential care homes and nursing homes

See also sections 2.5.10 and 3.12.10.

The passenger lift requirements for care and nursing homes will vary greatly depending on the type of premises. Many homes are large, old properties, converted from domestic housing stock, that are unsuitable for accommodating conventional lifts. In such cases, vertical transportation may be provided by lifting platforms and stairlifts.

Modern purpose-built care homes should be designed with conventional lifts where necessary and consideration should be given to providing lifts capable of accommodating stretchers or beds.

Due to the likelihood of elderly and infirm passengers, designers should consider fitting folding seats and low level alarm pushes for passengers who may be prone to falling. In many homes, the alarm system within the lift car will be arranged to link into the emergency nurse call system normally provided in care and nursing homes.

5.2.2.11 Shopping centres

See also sections 2.5.11 and 3.12.11.

With the recent trend for large urban and suburban retail developments, there is a growing demand for lift installations in shopping centres. Often, modern shopping centres incorporate a combination of lifts and escalators to provide an efficient transportation system and the lifts will often be a mixture of conventional passenger lifts with observation lifts in large atria, to enhance the overall aesthetics of the centre. See also section 2.5.

Lifts in public shopping areas will be used by people carrying shopping or pushing trolleys and also by people with pushchairs or wheelchairs. They should therefore be sized to carry a minimum of 17 persons (1275 kg) in order to provide adequate capacity for unattended wheelchair access in accordance with BS EN 81-70[6]. The design recommendations made in BS EN 81-70 and BS 8300[7] to facilitate use by disabled persons should also be considered.

Careful consideration should be given at the design stage to the finishes, which should be durable, and the fixtures and fittings, which need to be robust and vandal resistant. The finishes should also provide a pleasant environment in keeping with the general surroundings whilst providing the necessary contrasting details to offer maximum usability to passengers with any visual impairment.

The doors should be electronically controlled to ensure that the lifts are accessible to people with trolleys, pushchairs and wheel chairs and incorporate full height, electronic, non-contact safety edges.

5.2.2.12 Universities and other education buildings

See also sections 2.5.12 and 3.12.12.

Universities have a variety of building types from low-rise to tower blocks. The use of these building types varies from residential accommodation (halls of residence), conference facilities with hotel style accommodation, bars, restaurants, lecture blocks, laboratory areas and office accommodation. The need for passenger lifts should be assessed based on the building types considered in the previous sections.

Consideration should be given however to the student demographic with additional attention to increased risk of misuse and abuse which may require the installation of monitored CCTV and vandal resistant fixings for car and landing control panels as well as durable finishes.

5.2.3 Car size and payloads

BS EN 81-1/2[2,3] requires that all lift cars display a notice detailing the carrying capacity of the lift in terms of the number of passengers and the rated load in kilograms.

These European standards assume each passenger has a mass of 75 kg for this purpose and tables are provided in the standards to ensure lift cars are rated according to the available floor area. However the relationship between the internal car area and the rated load is not linear and means that lift cars tend to have passenger ratings in excess of the physical capacity that can be accommodated within the internal area.

BS ISO 4190-1[11] provides internationally recognised standard dimensions and standard lift configurations for passenger lifts and entrances for rated loads between 630 kg (8-person) and 2500 kg (33-person) capacities.

BS EN 81-70[6] specifies the minimum size of lift car, suitable to accommodate a manual wheelchair only, as a 450 kg lift with internal dimensions of 1000 mm wide and 1250 mm deep. To accommodate a manual wheelchair with an accompanying person the minimum size required is the 630 kg (8-person) car with internal dimensions of 1100 mm wide by 1400 mm deep. The minimum size of lift to accommodate a stretcher is the 1000 kg (13-person) car. Where full manoeuvrability of the wheelchair is required, a lift with a rated load of 1275 kg (17-person) car is required. See also section 5.9.3 and chapter 11.

BS ISO 4190-1[11] recognises a lift rated at 320 kg for residential use. This is unsuitable for use in a commercial or public environment since it would not provide sufficient room to accommodate a wheelchair and is below the minimum dimensions for compliance with the Disability Discrimination Act[9,10]. This car size is not recommended for any public or commercial applications.

Even where an 8-person lift provides adequate capacity to achieve the required traffic handling performance (see chapter 3), there may be operational reasons for adopting larger cars such as the need to move furniture or stretchers in residential buildings, or the need to provide capacity and comfort for passengers with baggage in commercial or hotel environments.

5.2.4 Entrances, car fittings and finishes

Landing entrances are perhaps the most important aspect of a lift to the user, since they offer the first impression to a prospective passenger of the quality of the installation. For passenger lifts, entrances doors should be automatically operated and incorporate edge protection by way of full height, non-contact electronic safety edges. The use of single beam detectors has reduced dramatically in recent years as technological advances and competition has made full height curtain protection the norm for all but the very cheapest of model lift packages.

Automatic doors for passenger lifts are available in either centre opening or side opening configurations. Centre opening doors offer improved operating (opening and closing) times and better aesthetics so are often preferred on higher quality installations such as those in commercial offices, hotels, shopping centres or luxury residential environments.

Side opening doors can be accommodated in smaller lift wells than the equivalent sized centre opening doors, however due to the reduced performance (longer opening and closing times) and the poorer aesthetics, side opening doors tend to be used on residential buildings where the usage is not intensive or in hospitals where larger opening widths can be achieved to provide access for beds and stretchers.

BS ISO 4190-1[11] provides internationally recognised standard dimensions for entrance sizes, as shown in Table 5.1.

Table 5.1 BS ISO 4190-1[11] entrance sizes

Class	Usage	Entrance sizes / mm
I	Residential	700, (A) 800, (B) 900
I	General purpose	(A) 800, (B) 900, (C) 1100
III	Health care	1100, 1300, 1400
VI	Intensive duty	1100, 1200

For residential lifts, there are two series (A and B) with 800 mm and 900 mm wide entrances respectively and, for small residential lifts, a 700 mm wide entrance is also indicated. However, the 700 mm wide entrance would not provide access for passengers with wheelchairs or push-chairs and should not be considered for general usage or anything other than a private residence.

The three different series (A, B and C) are intended to cover the different entrance requirements of national regulations and localised markets around the world for general purpose passenger lifts. For intensive duty passenger lifts the entrance widths should be larger at 1100 mm or 1200 mm.

Larger entrance widths of 1100 mm, 1300 mm or 1400 mm are typical for hospital and health care applications and are common on larger lifts specifically designed to transport beds and stretchers and also on passenger goods lifts.

Generally, all the configurations given above are available within the UK from most manufacturers standard product ranges.

5.2.5 Types of drive and operating speeds

For passenger lifts, electric traction and hydraulic drives can both be considered suitable (see chapter 8). Each has its own advantages and the final choice is likely to be determined by the specific application. An alternative drive exists in the form of rack and pinion (see section 5.8) although this is generally only used where a hydraulic or electric traction lift cannot be used.

5.2.5.1 Traditional electric traction drive

Traditional electric traction drives are suitable for passenger lifts of any capacity, and there are no significant travel or speed limitations. In general, long travel distances are avoided with passengers transferring at sky lobbies (see section 3.11.7). Rated speeds can be as low as 0.25 m/s and the current maximum speed in service is 17 m/s. The commonly used range is from 1.0 m/s to

6.0 m/s. Accurate levelling is achieved by modern solid state control and feedback position monitoring equipment. Single and 2-speed and, to a lesser extent, variable speed AC power systems and DC converter systems, are now technologically obsolete and should not generally be considered for new passenger lifts. Variable voltage variable frequency (VVVF) drives are now almost exclusively specified and provide good energy efficiency and speed control.

Re-levelling should be provided since the loading or unloading of lift cars can cause the lift to drop below, or rise above the floor level, particularly with longer travel or larger capacity lifts.

The limitations of conventional electric traction drives are mainly concerned with the location of the machine room, available headroom and the possibility of high loads being applied to the building structure.

5.2.5.2 Hydraulic drive

Hydraulic drives are generally available for lifts up to a rated speed of 0.63 m/s and some manufacturers offer speeds of 1.0 m/s. The realistic maximum travel distance for a hydraulic lift is around 18 m.

Up to 1275 kg rated load, hydraulic drives can use a single side-acting cylinder unit supporting a cantilevered car. This imposes a horizontal load to the supporting wall that must be considered during building design. Above 1275 kg capacity, the most common configuration is twin rams, located with one each side of the car (see section 7.3.2.3). This reduces the horizontal loading to a minimum.

The energy efficiency of hydraulic lifts is relatively poor since they typically have no balance weight. This is reflected in higher heat outputs from the drive unit and relatively low maximum duty cycles of around 45 starts per hour before additional cooling becomes necessary. The use of hydraulic lifts therefore tends to be limited to installations with low traffic and light usage or where the structural advantages of a hydraulic lift are necessary and the limited duty cycles and heat issues can be accommodated (see section 7.3).

More recently hydraulic systems have become available with variable voltage variable frequency drives and hydraulic accumulator systems that act as a hydraulic counterweight. These are able to offer much improved energy efficiency, lower heat outputs and increased duty cycles without the need for additional cooling and can be considered for more intensive use, but are unlikely to be selected in preference to electric traction lifts, unless there are other reasons for selecting a hydraulic lift, such as structural or aesthetic requirements

Starting currents will generally be higher than those for electric traction lifts and it is recommended that star-delta starting or an alternative means be used in order to limit the starting currents on hydraulic lifts. This may be critical if the capacity of the mains supply to the building is limited or where the lift may require powering from a standby generator and therefore should be considered early in the design process.

5.2.5.3 Machine room-less electric traction drive

Standard machine room-less (MRL) passenger lifts are available with rated loads between 630 kg and 2000 kg at rated speeds of between 0.5 m/s and 2.5 m/s. Travel distances are much improved with modern machine room-less lifts capable of travel distances up to 80 m while some manufacturers can now achieve travel distances up to 100 m. At these travel heights however, the speed limitations of 2.5 m/s may make it preferable to consider traditional traction lifts with a machine room capable of higher speeds.

The mounting of the drive machine in the lift well is achieved in different ways by the various manufacturers. Some mount the drive machine directly on the guide rails so that most of the vertical loads are transferred via the guide rails to the pit floor, in a way similar to that for hydraulic lifts. Others adopt a bedplate arrangement built into the structure for which adequate provision must be made in the construction design.

5.2.5.4 Counterweight-less electric traction drive

A recent development that has been brought to the market is a machine room-less lift that has no counterweight. The system employs suspension ropes anchored at the top of the well passing over a series of diverter sheaves in the well and on the car before being anchored again in the lift pit. This results in a multiple roping ratio of either 6:1 or 10:1 which reduces the required motor size. The rate of acceleration and deceleration is varied depending on the load in the car to ensure that traction between the suspension ropes and the traction sheave is not broken.

Counterweight-less lifts are currently available for rated loads between 240 kg and 800 kg at rated speeds up to 1.0 m/s and a travel up to 30 m.

The major benefit of these lifts is the reduced well dimensions, achieved by omitting the counterweight. The systems are intended for use primarily in buildings where existing lifts can be replaced by a lift with significantly increased car dimensions, or where they can be installed in restricted areas with a smaller well than conventional MRL lifts.

5.2.6 Well

The construction of the lift well should comply with national construction standards, which in England and Wales are governed by Building Regulations. In addition BS EN 81-1/2[2,3] provides guidance on the construction of lift wells that require minimum safety clearances within the pit, the headroom and the lift well, in order to provide a safe lift installation and safe working conditions for maintenance and service personal. These clearances are required by the Lifts Regulations 1997[1] to allow the CE-marking to be applied to an installation.

BS ISO 4190-1[11] provides guidance on the minimum pit depth and headroom, but since the requirements may vary between different manufacturers and drive types, headroom and lift pit dimensions should be checked with lift manufacturers at an early stage of the design process.

Guidance on well sizes is provided in BS ISO 4190-1, although this standard only deals with lifts using automatic doors and does not consider the different configurations offered by manufacturers for MRL lifts. Well dimensions for any given application will vary depending on the door type and configuration, the lift car size, the rated speed, the rated load and the type of drive. Thus, the space requirements should also be established with a lift manufacturer, particularly for non-standard lift sizes and arrangements, such as manual doors.

Appendix 5.A1 to this chapter is a summary table[16] of the BS ISO 4190-1[11] requirements. Further extensive guidance regarding wells can be found in BS 5655-6[4].

5.2.7 Machine room

The machine room or machine space should comply with BS EN 81-1/2[2,3]. All machine room doors and any personnel access doors must be lockable and able to be unlocked from the inside without a key. They should always open outwards.

All machine rooms should be heated and ventilated to control the temperature and remove smoke (see section 12.10) and lighting is required to a minimum of 200 lux at floor level.

Appendix 5.A1 to this chapter provides guidance on suitable machine room sizes.

5.2.7.1 Traditional electric traction lifts

Guidance on the size of the machine room is given in BS ISO 4190-1[11]. The sizes appear to be generous compared to those required by modern equipment and smaller machine rooms may therefore be achievable but this should be checked with lift manufacturer. Depending on machine size, machine room heights providing a clear height of at least 2000 mm to any structural elements of the ceiling or lifting beams will be required. For large lift systems, higher rooms will be required to accommodate the drive machines.

For electric traction drives, the machine room is ideally located directly above the lift well (see section 7.2.7). Bottom and side drives are sometimes used, but can be costly, requiring special engineering for machine mountings and increased maintenance costs for reduced rope life caused by multiple and reverse bends introduced in potentially complicated roping arrangements (see section 7.15).

In all cases access should be considered for the possible replacement of machine room equipment in the future. With top-drive lifts, suitable lifting facilities by way of beams or eyes should be installed overhead to allow lifting of the equipment from the trap door to the approximate operating position. Access to machine rooms of bottom drive electric traction lifts must be sufficient for the passage of lift equipment and should be checked carefully, particularly when equipment is located in basements. The use of access hatches, whilst acceptable for equipment, is totally unsuitable for personnel access.

With bottom or side drive, an overhead pulley room is required which should be the plan size of the lift well with a minimum internal height of 1500 mm. A separate pulley room may not be required if an underslung car arrangement is employed (see section 7.15.1). Basement machine rooms must be adjacent to the lift well with a plan size to suit the equipment and to provide an adequate safe working area for maintenance. In such installations, the designer should refer to the lift supplier for guidance.

5.2.7.2 Hydraulic lifts

For hydraulic drives, the machine room is ideally located adjacent to the lift at the bottom level. However, if necessary, the machine room can be located remote from the well but the distance between the machine and the hydraulic jack should not be greater than 6 metres. In these circumstances, the lift supplier should be consulted.

Guidance on the size of the machine room is given in BS ISO 4190-2[12], which recommends a minimum machine room size of the lift well width (or depth) by 2000 mm and at least 2000 mm high. This is usually adequate, except for very large capacity lifts requiring more than one tank unit. In such a case, if the machine room is on the short side of the well, it may be necessary to increase the 2000 mm dimension and advice should be sought from a manufacturer. The machine room height will need to be increased if a lifting beam is required. Access to machine rooms for hydraulic lifts must be provided for the passage of lift equipment.

Temperature control in hydraulic machine rooms can be a major issue due to the higher heat outputs of this type of lift. Oil coolers are often fitted to increase the lift duty cycle (typically quoted as the rated number of motor starts a lift can make in one hour) and maintain adequate performance during peak operating periods. However, the cooler is often located in the machine room and therefore the output from the cooler has to be dissipated or ventilated away to prevent excessive temperatures in the machine room which will restrict the effectiveness of the cooler. In many cases, it is necessary to install cooling equipment by way of air conditioning units to maintain suitable ambient temperatures in hydraulic machine rooms.

Where direct acoustic communication between the lift well and the machine room is not possible, a maintenance intercom should be fitted between the machine room and the lift car.

5.2.7.3 Machine room-less lifts

The concept of MRL lifts is that all equipment is located within the lift well. The pit depth and over-runs on MRL lifts tend to be less than those for conventional lift installations and therefore additional space is not usually required external to the lift well for MRL lifts.

Solutions for accommodating drive machine or drive unit and controller equipment within the lift well have been achieved in a variety of ways. For electric traction lifts, arrangements are available with the drive machine located within the lift pit, the headroom of the well and in some cases even on the lift car itself (refer to section 7.2.8). For hydraulic MRL lifts the drive unit may be placed in the pit area or in a purpose-built cabinet built into the lift well wall.

A control system for MRL lifts is often split between a maintenance panel commonly located at either the top or bottom lift landing within the front wall and accessed from the landing for normal maintenance and emergency release procedures. The larger components such as the drive unit and resistor banks etc. are located within the lift well.

The high efficiencies of modern traction gearless machines used for MRL lifts means that additional ventilation is rarely required . However advice should be taken from the lift manufacturer on any additional requirements for ventilating the lift well to maintain suitable ambient temperatures around the control and drive equipment.

5.3 Goods passenger lifts

5.3.1 General

This section deals with lifts design to carry goods and passengers that must comply with the Lifts Regulations 1997[1], either by the use of the harmonised standards BS EN 81-1[2] for electric traction lifts and BS EN 81-2[3] for hydraulic lifts, or by certification by a Notified Body. Some lifts designed for the movement of goods are not intended to be used to transport passengers, these are covered in section 5.4.

The width, depth and height of a goods passenger lift is often a function of the nature of the goods carried and the way in which they are moved (e.g. on pallets of a known size or in containers). Where possible, the designer should select one of the standardised lift sizes given in BS ISO 4190-2[12] since lifts manufactured to these sizes are likely to be cheaper than ‘one-off’ designs.

Consideration should also be given to the transportation of items other than those for which the lift is normally used. For example, the goods passenger lift may be the only means of transporting items such as office furniture and partitions between floors. Standard access doors are not always wide or high enough for such items.

For safe loading and easy access, goods passenger lifts should be located in a position that provides adequate free space in front of the entrance. If wheeled trolleys or fork-lift trucks are to be used, adequate space to manoeuvre these should be provided, with clear access to the loading area. Consideration should also be given to the effect of loading on the lift car sills and flooring. The installation of trolley ‘bump rails’ should be considered in all goods passenger lifts.

5.3.2 Applications for goods passenger lifts

5.3.2.1 Airports

Airports contain many facilities including offices, car parks, restaurants and shops; all of which may require goods service. Dedicated goods passenger lifts should be provided to avoid the use of airport passenger lifts for goods service. Their specification will depend on their main purpose, as described elsewhere in section 5.3.2.

5.3.2.2 Car parks

The requirement for goods passenger lifts in a car park is unlikely.

5.3.2.3 Department stores

Single goods passenger lifts may be provided in smaller department stores, but it is recommended where the goods passenger lift is crucial to ongoing retail operations that at least two units be provided to allow for peak periods and lift breakdowns.

Goods passenger lifts are usually placed adjacent to vehicle loading/unloading bays or lay-bys and care should be taken to ensure sufficient units are provided. The rated load will depend on the nature of the stores business, but should be at least 2000 kg, except where specialised goods are being transported, when smaller rated loads might be appropriate.

5.3.2.4 Entertainment centres, cinemas, theatres, sports centres, stadia and concert halls

A variety of activities can be found in this application area including offices, restaurants, bars, changing rooms, washrooms etc., all of which will require goods service. Dedicated goods passenger lifts may not be necessary, provided one or more/passenger lifts are made available and can be used for goods handling without compromising the passenger lift performance or the patron’s experience of a venue.

Where catering facilities need to be serviced via a lift, dedicated goods passenger lifts are recommended to avoid the use of passenger lifts for food deliveries and waste movements which can create dirty and untidy lift interiors. Service lifts (see section 5.6) may also be required to serve bars, restaurants and kitchens.

5.3.2.5 Hospitals

In addition to passenger lifts, hospitals require lifts to support the facilities management (FM) teams who regularly need to move trolleys of food, linen, goods and clinical equipment around the hospital. These lifts may be located on dedicated FM routes, although current trends for hospital design around a hospital street make this less common. Hospital planning should try to minimise the number and intensity of these journeys by arranging deliveries and collections of different load types so they do not coincide.

In addition to BS ISO 4190-2[12], which provides recommended lift car and well sizes for hospital lifts, information specifically related to hospital trolley dimensions is available in Health Building Note HBN 00-04[14] and additional design information specific to hospitals is available in Health Technical Memorandum HTM 08-02[15].

5.3.2.6 Hotels

Generally, service (goods) activities such as baggage transfers, room service, housekeeping etc. should be separated from the guest access routes and use of guest lifts for such functions should be avoided. Designers of lift systems for hotels should carefully consider the operational requirements of the hotel and incorporate dedicated goods passenger lifts (and service lifts, see section 5.6) for the use of staff servicing the guest rooms where the use of passenger lifts by cleaning or laundry staff will detract from the lift service available to guests.

Goods passenger lifts should be located in an area not normally accessible to guests (i.e. 'back of house') and will need to be sized to cater for any cleaning or laundry trolleys that may be used. Since such lifts will be used for transporting large amounts of goods and refuse, they should have durable finishes and a minimum load of 1600 kg.

Special requirements may also be necessary for large lifts to service exhibition and conference facilities. These lifts may be required to accommodate large goods such as exhibition displays and possibly even vehicles.

5.3.2.7 Offices

See section 3.12.7.

5.3.2.8 Railway stations

The requirement for goods passenger lifts at railway stations is generally small, as most surface stations are single level and underground stations make other arrangements. Many stations where the platforms are above or below the access road employ ramps for passenger use and these can be used for the movement of goods. Where they are provided, passenger lifts can be used to transport goods provided passengers take priority and the cars are suitably protected.

One exception to this though is in terminal stations where trains are prepared for journeys. Such preparation will usually involve the charging of water tanks, restocking of catering facilities and cleaning of the trains and therefore terminal stations may have a need for goods passenger lifts. Some goods passenger lifts may be of a special size to accept baggage trolleys or water tugs and will require early consultation with the station operators to establish the correct requirements.

5.3.2.9 Residential buildings

Most residential buildings are designed with passenger lifts designated for shared goods usage, provided with protective curtains and suitable finishes, and designed and intended to contribute to the required passenger handling capacity of the lift system during periods of peak traffic. However, in some high quality prestigious developments, it may be necessary to incorporate dedicated goods passenger lifts that are intended to be available at all times for handling goods and furniture and are not considered to contribute to the required passenger handling capacity. Dedicated goods passenger lifts should also be considered in large tower blocks where the number of apartments will generate a high volume of residents moving furniture into or out of the building. In this case, the regular use of one of the main passenger lifts for goods movements will reduce the availability of lifts for other residents and result in poor performance. In addition, the regular presence of goods and furniture in the main lobby can prove inconvenient and frustrating to other residents.

Dedicated goods passenger lifts should be sized to accommodate large furniture items and any refuse containers that might be transported in the lift. Ideally they should be located in a separate core to reduce disruption to other residents and to allow the separate passenger lobby to be provided with high quality decoration and finishes.

Where shared goods passenger lifts are used, the goods passenger lift should permit the hanging of protective drapes and should be sized to accept stretchers as well as furniture and general goods etc. The minimum size for dual purpose lifts should be a 13-person lift with internal dimensions of 1100 mm wide by 2000 mm deep.

Where a dedicated goods passenger lift is used, larger cars of 1600 kg rated load should be considered to maximise the benefits of providing a dedicated goods lift.

5.3.2.10 Residential care homes and nursing homes

Goods service is unlikely to be required, unless the home is very large.

5.3.2.11 Shopping centres

Goods passenger lifts provided in shopping centres are usually placed singly, or in pairs, adjacent to vehicle loading/unloading bays or lay-bys, and along service corridors at the rear of retail units. Each lift or group of lifts will service a group of shops and stores, although some major store chains may have dedicated goods passenger lifts and delivery areas. Care should be taken to ensure sufficient goods passenger lifts are provided to allow for peak deliveries and lift breakdowns. Generally one goods passenger lift for every 10 retail units should be provided. Goods should not be moved through the public malls and walkways. The rated load should be at least 2000 kg, except where specialised goods are being transported, when smaller rated loads might be appropriate.

5.3.2.12 Universities and other education buildings

Universities have a variety of building types from low-rise to tower blocks. The use of these building types varies from residential accommodation (halls of residence), conference facilities with hotel style accommodation, bars, restaurants, lecture blocks, laboratory areas and office accommodation. The need for dedicated goods passenger lifts should be considered by reference to the relevant sections for the specific use identified.

5.3.3 Car sizes and payloads

The first step when selecting a goods passenger lift is to determine the specific type of goods to be moved along with the overall dimensions and the weight of the largest items. This enables the designer to calculate the volume and total weight expected to be moved at any one time. Additional space should be allowed for any personnel, who will normally be expected to accompany the goods.

The recommended minimum internal width for lift cars is the overall width of the goods plus 600 mm. This allows goods to be stacked to one side whilst leaving an area for accompanying personnel. In the case of 'through cars', with entrances on opposite sides, this space is essential. It is possible that the attendant will have to unload the lift through the opposite entrance and therefore access to both entrances from inside the loaded car is essential.

When considering through cars fitted with folding shutter-type gates, it is important to check that the distance between the bunched leaves of the gate is adequate. Otherwise goods loaded against the closed gate may encroach on the area required by the leaves of that gate when open and thus prevent the gate from being opened.

Having determined the minimum size required, the nearest standard size given in BS ISO 4190-1[11] or BS ISO 4190-2[12] should be selected wherever possible. BS ISO 4190-1 provides internationally recognised standard dimensions and configurations for passenger lifts and BS ISO 4190-2 provides the same information for goods passenger lifts for rated loads between 630 kg (8-person) and 5000 kg (66-person) capacities.

When loading is carried out by forklift trucks or other wheeled vehicles, the carrying capacity and design of the lift must reflect the additional load imposed by the weight of any vehicle that may enter the lift car. This does not necessarily require an increase in the size of the car, but consideration should be given to whether strengthened sills will be required to accommodate the localised high loads imposed by the vehicle wheels. It may also be necessary to consider additional stiffening for the car floor at the design stage.

The rated load of a hydraulic goods passenger lift may be to a lower ratio of rated load to available car area. This permits the drive system to be smaller for applications where it is known that the lift car will not fill to the load given by the normal ratio of rated load to available car area. Examples include airports, where baggage trolleys take up significant space, and shopping centres, where shopping trolleys and pushchairs are carried.

5.3.4 Entrances, car fittings and finishes

Door configurations are dealt with in detail in section 7.9. Goods passenger lift doors can be horizontal sliding, as used in passenger lifts. For some very heavy duty applications vertical sliding doors might be used. However these are typically slow and inefficient in operation, are not recommended for normal goods passenger applications and are unsuitable for passenger lift applications.

For horizontal sliding doors entrance widths of 1100 mm, 1300 mm, 1400 mm, 1500 mm, 1800 mm, 2100 mm and 2500 mm are available. For vertical sliding doors entrance widths of 1400 mm, 1500 mm, 1800 mm, 2100 mm and 2500 mm are available. The slide direction and entrance width will be dependent on the goods to be transported. Special width doors can be supplied by most manufacturers, but are likely to be expensive. Goods passenger lifts need to be robust in service and it is sometimes necessary to fit entrance protection to avoid damage to the doors and surrounding door frames.

Manual doors are specified for some goods passenger lifts, particularly where heavy duty usage is required such as in retail or industrial applications. These should be arranged to give an opening equal to the full width of the car if possible, for maximum flexibility. Folding shutter gates are usually preferred since they require a minimum of well space and are easily adapted to suit varying entrance widths. The standardised heights of 2000 mm or 2300 mm should be selected wherever possible.

Power-operated shutter gates are available and offer a durable, robust solution to applications where tugs, or loading vehicles are used, avoiding the need for lift users to demount and manually open the lift gates. For general goods usage, however, conventional horizontal sliding, automatic doors should be considered where manual doors are not required or suitable.

Good passenger lifts should be rugged and the finishes should be easy to clean and repair, see Figure 5.3. Walls and roofs should be constructed in sections to allow easy replacement if damaged. Many materials and finishes are available but the most common are either steel with a cellulose or powder coated finish, or patterned stainless steel. While the latter is initially more expensive, its appearance is superior and it does not require maintenance after installation. For very light duty applications, laminate-faced panels may be used. The appearance is good but the surface is more prone to damage than steel panels.

In all cases it is desirable to fit some form of bumper rail in the car to provide a level of protection for the walls. The rail should be mounted at a suitable height to absorb the impact of trolleys, loading pallets etc. Alternatively, a series of rails may be provided, spaced 100 mm apart up to a height of 1 m. Bumper rails will reduce the available interior dimensions and this should be taken into account when calculating the required car size.

The flooring should be replaceable. Many goods passenger lifts will have floors of patterned 'chequer plate' steel, but, for lighter duty applications, surfaces such as aluminium chequer plate or vinyl may be preferred. In applications

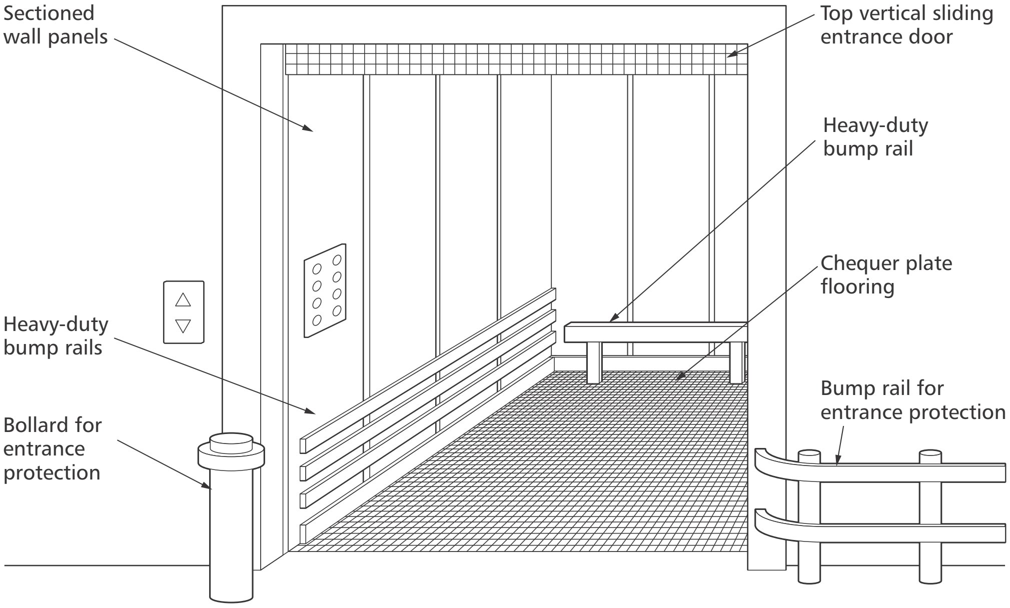

Figure 5.3 Entrances, car fittings and finishes for a rugged goods passenger lift

where corrosive fluids are carried, epoxy resin or terrazzo flooring may be required. Consideration should also be given to the consequences of cleaning lift cars if it is intended for a hospital or food preparation facility. Lifts designed to BS EN 81 are not designed for hosing down or cleaning with excessive amounts of water or cleaning fluids. Where such procedures may be required a special lift needs to be purchased with suitably protected electrical and mechanical components in the lift shaft and provision for the drainage of liquids from the lift pit.

5.3.5 Types of drive and operating speeds

For conventional goods passenger lifts, electric traction, hydraulic, and rack and pinion drives can all be considered suitable (see sections 7.2, 7.3 and 5.8 respectively). Each has its own advantages and the final choice is likely to be determined by the specific application.

5.3.5.1 Traditional electric traction drive

Electric traction drives are suitable for goods passenger lifts of any capacity, and there are virtually no travel or speed limitations. Goods passenger lifts do not depend on travel speed for quality of service since loading and unloading consume the greatest time on the round trips. Typically speeds of 1.0 m/s or 1.6 m/s are satisfactory for a dedicated goods passenger lift and it is unusual to apply speeds in excess of 2.5 m/s for dedicated goods passenger lifts, even in tall buildings in the UK.

As with passenger lifts, variable speed variable frequency (VVVF) AC drives are almost exclusively used on modern lifts and provide accurate levelling and good speed control under all loading conditions. Re-levelling should be provided since the loading or unloading of heavy loads can cause the lift to lower or raise at the landing floor, particularly with long travel lifts, due to the elastic stretch of the suspension ropes.

The limitations of electric traction drives are mainly concerned with the location of the machine room, the available headroom and the possibility of high loads being applied to the building structure.

5.3.5.2 Hydraulic drive

Goods passenger lifts do not depend on high travel speeds for quality of service since loading and unloading consume the greatest time on round trips. Therefore, the speed limitations of hydraulic drives, at 0.5 m/s or 0.63 m/s, are not such a limiting factor for goods applications. However the travel distance remains limited to 18 m.

Up to 1275 kg rated load, hydraulic drives use a single side-acting cylinder unit supporting a cantilever car. This imposes a horizontal load to the supporting wall which must be considered during the building design. Above 1275 kg capacity, the most common configuration is twin rams, located with one each side of the car (see section 7.3.2). This reduces the horizontal loading to a minimum. Single side-acting cylinders should not be considered for goods passenger lifts where there may be heavy loading requirements, e.g. using forklift trucks or large trolleys etc.

Unless modern, and currently more costly, VVVF drive and accumulator balancing is used, (see section 8.7.4) heat outputs from large hydraulic lifts will be high and will require the use of oil coolers and machine room cooling to control the ambient machine room temperature. Starting currents can also be higher than those for electric traction lifts and it is recommended that star-delta starting be used in order to limit the starting currents on large lifts. This may be critical, if the capacity of the mains supply to the building is limited and therefore should be considered early in the design process.

5.3.5.3 Machine room-less electric traction drive

Standard machine room-less goods passenger lifts are available with loads up to 5000 kg at speeds of 0.5 m/s although increased speeds up to 1.0 m/s can be used on smaller lifts. The larger applications can utilise up to 4:1

roping ratios (see section 7.15) to minimise the power requirements. The drive and suspension is arranged to transfer most of the loading vertically via the guide rails to the pit floor, in a way similar to that for hydraulic lifts.

5.3.5.4 Rack and pinion drive

Refer to section 5.8 for details of rack and pinion drives.

5.3.6 Well dimensions and construction

The construction of the lift well should comply with BS EN 81-1/2[2,3], which require minimum safety clearances within the pit, the headroom and the lift well, in order to provide a safe lift installation and safe working conditions for maintenance and service personal. These clearances are required by the Lifts Regulations[1] to allow the CE-marking to be applied to an installation.

The construction of the lift well should ensure that it will be strong enough to accept all the loads applied by the lift. This is particularly important where loading and unloading is to be carried out by forklift trucks or trolleys, or if the lift is of a cantilever design. In the case of lifts loaded using forklift trucks, large additional loads are temporarily applied to the stationary lift. This generates a turning moment with high reaction forces on the car guides (or mast assembly in the case of rack and pinion lifts). These loads are transferred to the building structure by the guide rail or mast fixings and the structure must be strong enough to accept these without degradation. While block work has a high compressive strength, it is not suitable for expanding bolts or other heavy-duty fixings. If necessary, steel or reinforced concrete sections should be used. At the very least, local areas of cast concrete blocks, suitably tied and bonded to the wall panel, should be used. It should be noted that lift installers cannot accept responsibility for the design of the building, or its structural strength.

Guidance on well sizes is provided in BS ISO 4190-2[12], although this standard deals only with lifts using automatic doors. Well dimensions for any given application will vary depending on the door type and configuration, the lift car size, the rated speed, the rated load and the type of drive. Thus, the space requirements should also be checked with a lift manufacturer, particularly for non-standard lift sizes and arrangements, such as those with manual doors and manual shutter gates, as might be required in retail or industrial applications.

BS ISO 4190-2 also provides guidance on the minimum pit depth and headroom, but since the requirements may vary between different manufacturers and drive types, headroom and lift pit dimensions should be checked with lift manufacturers at an early stage of the design process.

Appendix 5.A1 to this chapter is a summary table[16] of the BS ISO 4190-2 requirements. Further extensive guidance regarding wells can be found in BS 5655-6[4].

5.3.7 Machine room

All machine rooms and any personnel access doors must be lockable and able to be unlocked from the inside without a key. They should always open outwards.

All machine rooms should be heated and ventilated to control the temperature and remove smoke (see section 12.10) and lighting is required to a minimum of 200 lux at floor level.

Appendix 5.A1 to this chapter indicates possible machine room sizes.

5.3.7.1 Traditional electric traction lifts

Guidance on the size of the machine room is given in BS ISO 4190-1[11]. The sizes appear to be generous compared to those required using modern equipment and smaller machine rooms may be achievable but this should be checked with lift manufacturer. Depending on machine size, machine room heights providing a clear height of at least 2000 mm to any structural elements of the ceiling or lifting beams will be required. For large lift systems, higher rooms will be required to accommodate the drive machines.

For electric traction drives, the machine room is ideally located directly above the lift well (see section 7.2.7). Bottom and side drives are sometimes used, but can be costly, requiring special engineering for machine mountings and increased maintenance costs for reduced rope life caused by multiple and reverse bends introduced in potentially complicated roping arrangements (see section 7.15). In all cases access should be considered for the possible replacement of machine room equipment in the future. With top drive lifts, suitable lifting facilities by way of beams or eyes should be installed overhead to allow lifting of the equipment from a trap door to the approximate position of the machine. Access to machine rooms of bottom drive electric traction lifts must be sufficient for the passage of lift equipment and should be checked carefully, particularly when equipment is located in basements.

With bottom or side drive, an overhead pulley room is required which should be the plan size of the lift well with a minimum internal height of 1500 mm. A separate pulley room may not be required if an underslung car arrangement is employed (see section 7.15.1). Basement machine rooms must be adjacent to the lift well with a plan size to suit the equipment and to provide an adequate safe working area for maintenance. In such installations, the designer should refer to the lift supplier for guidance.

5.3.7.2 Hydraulic lifts

For hydraulic drives, the machine room is ideally located adjacent to the lift at the bottom level. However, if necessary the machine room can be located remote from the well but the distance between the machine and the hydraulic jack should not be greater than 6 metres. In these circumstances, the lift supplier should be consulted.

Guidance on the size of the machine room is given in BS ISO 4190-2[12], which recommends a minimum machine room size of the lift well width (or depth) by 2000 mm and at least 2000 mm high. This is usually adequate, except for very large capacity lifts requiring more than one tank unit. In such a case, if the machine room is on the short side of the well, it may be necessary to increase the 2000 mm dimension and advice should be sought from a manufacturer. The machine room height will need to be increased if a lifting beam is required. Access to machine rooms for hydraulic lifts must be provided for the passage of lift equipment.

Temperature control in hydraulic machine rooms can be a major issue due to the generally higher heat outputs of this type of lift. Oil coolers are often fitted to increase the lift duty cycle (typically quoted as the rated number of motor starts a lift can make in one hour) and maintain adequate performance during peak operating periods. However, the cooler is often located in the machine room and therefore the output from the cooler has to be dissipated or ventilated away to prevent excessive temperatures in the machine room, which will restrict the effectiveness of the cooler. In many cases, it is necessary to install cooling equipment by way of air conditioning units to maintain suitable ambient temperatures in hydraulic machine rooms.

Where direct acoustic communication between the lift well and the machine room is not possible, a maintenance intercom should be fitted between the machine room and the lift car.

5.3.7.3 Machine room-less lifts

The concept of machine room-less (MRL) lifts is that all equipment is located within the lift well. The pit depth and over-runs on MRL lifts tend to be less than conventional lift installations and therefore additional space is not usually required external to the lift well for MRL lifts.

Solutions for accommodating drive machine or drive unit and controller equipment within the lift well have been achieved in a variety of ways. For electric traction lifts, arrangements are available with the drive machine located within the lift pit, the headroom of the well and in some cases even on the lift car itself. For hydraulic lifts the drive unit may be placed in the pit area, or in a purpose built cabinet built into the lift well wall.

A control system for MRL lifts is often split between a maintenance panel, commonly located at either the top or bottom lift landing within the front wall and accessed from the landing for normal maintenance, and emergency release procedures. The larger components such as the drive unit and resistor banks etc. are located within the lift well.

The high efficiencies of modern traction gearless machines used for MRL lifts means that additional ventilation is rarely required. However advice should be taken from the lift manufacturer on any additional requirements for ventilating the lift well to maintain suitable ambient temperatures around the control and drive equipment.

5.3.7.4 Rack and pinion drive

Refer to section 5.8 for details of rack and pinion machine room requirements.

5.4 Goods-only lifts

Lifts are available that are designed to carry only goods and as such are legislated under the Machinery Directive[17] and not the Lifts Regulations 1997[1].

This has generated a range of products that do not require the same protective devices required by the Lifts Regulations for passenger carrying lifts. Goods-only lifts operate at restricted speeds, enabling them to be provided with minimal pit depths and over-runs.

This makes them especially useful in warehousing or industrial applications where they can easily be retrofitted if necessary to sit on a structural slab using a short ramp up to the entrance rather than constructing a deep pit. However the operational restrictions imposed by not being able to transport passengers with the goods means they are generally not suitable for commercial or retail environments or other applications where high usage might be necessary.

The recently published BS EN 81-31[18] is based heavily on BS EN 81-1[2] in terms of safety requirements and may impact on the existing product ranges.

It is recommended that where a goods-only lift is being considered, expert advice be sought to ensure the full implications of this code in its published form are taken into account.

5.5 Observation lifts

5.5.1 General

Refer to sections 3.10.4 and 5.2.1.

Observation lifts consist of a glazed, or partially glazed, lift car, running within a glazed or partially enclosed lift well, see Figure 5.4. They are referred to by various names including wall climber, scenic, panoramic, and glass lifts. They are often installed as an architectural feature in a building within an atrium or, occasionally, external to the building. All the guidance offered for passenger lifts in section 5.2 is generally applicable. However, the following additional advice should be taken into account when considering, or designing, observation lifts.

All observation lifts must comply with the Essential Health and Safety Requirements (EHSRs) of the Lifts Regulations 1997[1]. This can be achieved by lifts complying fully with BS EN 81-1/2[2,3]. These standards contain specific clauses to cover the use of glass in and around the lifts and the screening requirements around partially enclosed wells.

Most large lift manufacturers offer pre-engineered observation lift designs. These reduce costs and delivery times because the majority of the design work has already been carried out. Pre-engineered designs range from a normal lift car with a glass window in the back wall and a glass-sided lift well to very sophisticated designs, such as an octagonal car with a lobby area leading into the viewing area.

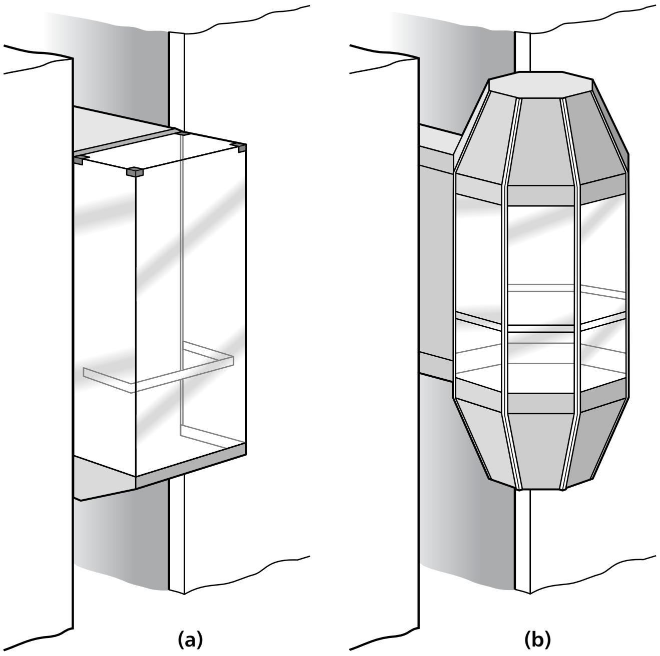

Figure 5.4 Typical observation lift cars; (a) rectangular without mullions, (b) octagonal with mullions

Observation lifts are often tailor-made to suit the particular building in which they are to be installed. For many applications, observation lifts will need to be specially engineered because of structural issues, or space limitations. An advantage of custom-designed lifts is that they can be designed to match building décor and other architectural requirements. However, it should be noted that the time required for design and manufacture will be greater than that for pre-engineered lifts. Special features, finishes and the need to obtain any approval in accordance with the Lifts Regulations 1997[1] will further increase delivery times. Therefore the detailed specification should be confirmed, and the lifts ordered, as soon as possible during the planning of the building to ensure that the lift is operational by the time the building is ready for occupation.

As discussed in section 3.10.4, observation lifts do not provide the same handling capacity as conventional lifts of the same specification. There are many reasons for this. In public buildings they attract sightseers and joyriders and many passengers will wish to enjoy an unobstructed view through the glass. This problem does not occur to the same extent in offices, or apartments, where users become accustomed to the lifts and are more likely to use them in a conventional manner.

It is common in public places such as shopping malls to position observation lifts individually around a development to create a repeating architectural feature. Where this is a consideration, the reduced handling capacity of the individual lifts should be considered within the system design to ensure that the likely traffic demands can be met by individual lifts. Alternatively, they could be grouped together at a single point to maximize efficiency. Figure 5.5 shows some possible configurations.

Observation lifts can also be part of a mixed group with conventional lifts. The two types should be clearly distinguishable to passengers before they enter the lift, as some people may dislike glazed lifts and be reluctant to use them. There are also potential negative psychological effects on waiting passengers. Where glazed doors or fronts are used, passengers are able to observe lifts passing their floor. This can occur for traffic control reasons, or because the car is fully loaded. However, passengers may think the system is malfunctioning and may initiate complaints about the lift performance.

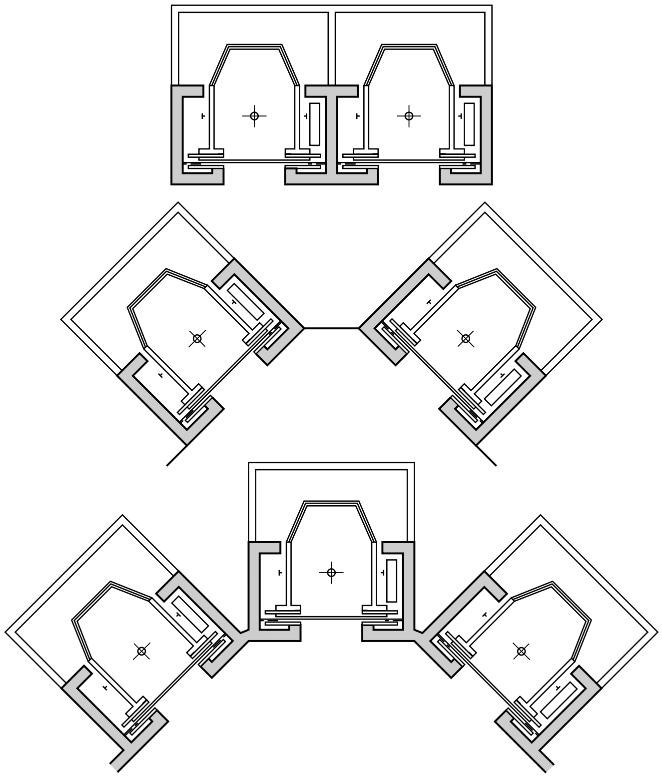

Figure 5.5 Observation lifts; some possible group layouts

5.5.2 Application of observation lifts

Refer to section 5.2.2 and its relevant subsection, the sequence of which is followed below.

5.5.2.1 Airports

Observation lifts are rare in airports.

5.5.2.2 Car parks

Observation lifts are not generally suitable for this environment, however some car park operating companies have a preference to include glass doors on lifts. This can provide enhanced security allowing passengers to see into and out of a lift car before entering or leaving. In addition, the use of CCTV allows similar vision of the car interior and the landing lobby with a single camera. In such cases, the lifts do not tend to be considered as observation lifts and little attention is expected to the location and aesthetics of well equipment that becomes visible through the glass doors.

When using glass doors on car park lifts consideration should be given to the location of the car park and the level of security and management provided to avoid any increased likelihood of vandalism that might occur, such as breakage of glass or attempted entry into the visible well.

5.5.2.3 Department stores

Observation lifts are occasionally used in larger department stores to provide a pleasing and leisurely environment. Their rated speed might be reduced to maximise the time passengers are exposed to product displays from within the car, viewed through the glass. This needs to be considered in terms of the reduced handling capacity achievable with slower lifts.

5.5.2.4 Entertainment centres, cinemas, theatres, sports centres, stadia and concert halls

Observation lifts are generally not suitable for this environment but they may be found in some exhibition centres over a low rise.

5.5.2.5 Hospitals

Observation lifts are not suitable for this environment.

5.5.2.6 Hotels

Observation lifts play an important part in large, top class hotels where they may provide a spectacular feature in lofty atria. Their performance specification should be similar to that of an enclosed lift, especially where the observation lifts form all or part of the primary vertical transportation.

5.5.2.7 Offices

Observation lifts can play an important part in prestige offices where they can provide a spectacular feature in lofty atria. Their performance specification should be similar to that of an enclosed lift, especially where the observation lifts form all or part of the primary vertical transportation.

5.5.2.8 Railway stations

Observation lifts are not generally suitable for most railway station, however they have been incorporated in some modern terminus stations where they tend to be architecturally driven bespoke units. In such cases the lifts are provided as a feature to satisfy the accessibility requirements of mobility impaired passengers, supplementing stairs and escalators, which provide the main means of vertical circulation.

5.5.2.9 Residential buildings

Observation lifts are not generally suitable for residential environments since the increased costs associated with observation lifts will ultimately be borne by the residents by way of increased rental or purchase costs and service charges. This makes them difficult to justify from a commercial perspective.

5.5.2.10 Residential care homes and nursing homes

Observation lifts are not suitable for this environment.

5.5.2.11 Shopping centres

Observation lifts are frequently used in shopping centres to provide a pleasing focal point. Their rated speed might be low in order to provide a leisurely environment but their main purpose is to provide accessibility for mobility impaired passengers, supplementing stairs and escalators, which would normally provide the primary means of transfer between floors.

5.5.2.12 Universities and other education buildings

Observation lifts offer potential benefits in an educational environment due to the increased visibility of the lift users reducing the likelihood of vandalism or general misuse of lifts that can occur in a student based environment. However, it is rare for such developments to have sufficient funding to support the increased costs of scenic lifts and they are generally not considered.

5.5.3 Car size and payload

Refer to section 5.2.3.

Although the BS ISO 4190-1[11] dimensions are still relevant they may not be applicable as the shape of the car platform may not be rectangular for aesthetic reasons. However, the rated load/available area requirements of BS EN 81-1/2[2,3] do apply. Generally the rated load of observation lifts ranges from 800 kg to 1600 kg.

The design of the controls, signals and aesthetics should comply with BS EN 81-70[6] which normally requires the car operating panel to be located in the side wall of the car to achieve a minimum distance of 400 mm from a corner to a push button. This needs to be considered where glass side walls are being considered since the control panel will need to be incorporated into the glass wall.

5.5.4 Entrances, car fittings and finishes

Refer to section 5.2.4.

It is most likely that centre opening doors will be fitted as part of the aesthetic scheme. The entrance width should be as wide as possible for the particular application and a width of 1100 mm is typical.

Special consideration is required when using glass on doors to prevent friction levels creating a risk to children's hands that might be dragged along and pinched in between the door and any trims or architraves. Such protection is available by using coatings with a low coefficient of friction, reducing the running clearances between the doors and trims or by introducing mechanical or electrical sensors to detect the presence of hands or fingers etc. A modern solution to this problem is 'active glass'. This special glass incorporates a crystal interlayer which becomes opaque when charged with an electrical current. In this way, the doors can be switched to opaque when a lift arrives or passes a floor removing the temptation of young children to lean against the glass to watch and also providing modesty screening. The method of protection will depend on the equipment supplied and should be discussed with the manufacturer.

All glass should incorporate markings indicating the name of the supplier, the type of glass and the trade mark. These should remain visible when the glass is installed.

Care also needs to be taken when using glass to ensure that adequate contrast and visibility exist so that passengers with visual impairments are not inconvenienced in any way. Building Regulations in England and Wales require the use of visual manifestation on glass walls, doors and enclosures to aid passengers with visual impairments. Low level manifestation should also be considered for glazed doors to provide modesty screening for passengers.

The car fit-out is likely to be more elaborate than for a conventional passenger lift. However, it is important that handrails, of a sturdy appearance, are fitted all round the glazed area to provide assistance and reassurance to the passengers.

5.5.5 Types of drive and operating speeds

Refer to section 5.2.5.

The power system and drive chosen for any lift installation depends on the required speed, likely usage and desired comfort of ride. Observation lifts can utilise all the different types of drives and configurations appropriate to passenger lifts (see also chapter 7). However, observation lifts are often associated with prestigious installations and the quality of ride and levelling accuracy should be appropriate to the situation.

Modern traction lifts are almost exclusively specified with variable voltage variable frequency (VVVF) AC drives that offer sophisticated control and high standards of levelling accuracy. Acceleration and deceleration are smooth, with a fast approach to floors. Overall, a smoother and more accurate ride results from the use of a system designed for intensive service.

Modern hydraulic drive systems also offer smooth and comfortable ride conditions with accurate floor levelling along with the ability to incorporate a remote machine pump room. They are, however, incapable of the short flight times and duty achieved by electric traction drives and their travel is usually limited to a maximum of 18 metres (see section 7.3). Hydraulic drives in which the cylinder is installed in a borehole can make an attractive architectural feature. With this arrangement the problems with hiding ropes and pulleys that occur with suspended lift cars are eliminated and the control equipment and pump unit can be located remote from the lift. However, the 'wall climbing' illusion is lost due to the visibility of the piston.

The available headroom, lift speed and required rise are important considerations when selecting the drive system. If there is sufficient headroom to accommodate a machine or pulley room above the lift and the rise is more than 20 m, electric traction drive would be appropriate since the required lift speed is dependent on the rise.

In situations where headroom is limited, hydraulic lifts are often more suitable although their speed and maximum rise are limited (see section 7.3). Electric traction drives using an underslung configuration (see section 7.15) or machine room-less lifts offer alternative solutions without the limitations on speed and rise that may apply to a hydraulic installation. With machine room-less lifts, the drive and control equipment may be visible as will the suspension ropes that run up the side of the car in the underslung arrangements adopted on many machine room-less lifts.

The use of machine room-less lifts for observation lift applications may result in limited options for lift car design in terms of finishes or car dimensions. However product ranges are increasing at a pace and some manufacturers are able to offer variable lift car dimensions and improved drive machine technology can offer higher torque levels giving the ability to incorporate special lift car finishes.

The speed of travel of an observation lift is very important to the comfort of the passengers. Low speeds suitable for short travel lifts will give a leisurely journey, which enables passengers to observe the view and instils a sense of safety, whilst still providing the required service levels. With higher rises, speeds need to be higher to give good service, but this can only be achieved at the expense of a leisurely journey. There is also the possibility that people may feel less secure at higher speeds, as the lift passes walls or structural elements of the building at speed.

Historically, it was considered that the speed of observation lifts should be limited to a maximum of 1.6 m/s in situations where there is a close focal point for the passengers. Modern observation lifts however, particularly in offices or other private buildings, commonly travel at speeds up to 2.5 m/s and within Europe, there are partial observation lifts that travel at 6 m/s.

Where higher speeds are required, alternative enclosed lifts should be available for people who do not like to travel in high speed observation lifts.

5.5.6 Well

Refer to section 5.2.6.

Owing to the irregular shape of many observation lift cars the dimensional recommendations of BS ISO 4190-1[11] are largely not applicable to observation lifts. As observation lifts are often installed with virtually no well structure, it is important to prevent access to unauthorised persons. BS EN 81-1/2[2,3] requires screening to a height of 3.50 m on the entrance sides of a lift well. On the other sides, screens should be provided to a height of 2.50 m, where people would otherwise have access to the lift area. This dimension can be reduced progressively to a minimum of 1.10 m where the distance to any moving part is greater than 2.0 m.

Any glass used for lift well enclosures within reach of persons should be laminated. All glass should incorporate markings indicating the name of the supplier, the type of glass and the trade mark. These should remain visible when the glass is installed. Care also needs to be taken when using glass to ensure that adequate contrast and visibility exists so that all passengers can detect its presence. Manifestation at low levels or active glass (see section 5.5.4), should be considered for glazed doors or walls to provide modesty screening for passengers.

Since the essence of observation lifts is to provide a visually pleasing installation, it is essential that early discussions be held between the architect or designer and the lift manufacturers. These discussions should develop the original design concept, taking into account both the technical and visual limitations of the lift equipment required to provide the complete installation.

Consideration may be required to concealing switches in the lift well and to specially designed guide and switch support brackets. The use of roller guide shoes running on dry guide rails is recommended for all panoramic lifts. This will eliminate oil splatter onto glazed parts of the lift car or well and in the pit, which may occur if oiled or greased guide rails are used in conjunction with sliding shoes.

Due to the unusual layout of the lift wells associated with observation lifts, the space requirements are quite different to those of conventional lifts. The counterweight and travelling cables may be required to run in a screened-off area and the shape of the car may be unusual, thereby requiring a large pit area that will need to be screened.

In addition, safe and easy access for maintenance will have to be provided over the total travel and access to the exterior panels of the lift car will be required for cleaning. Consideration of the cleaning regime is required at an early stage in the design process to ensure that safe access is available and can be accommodated within the architectural and structural design.

External observation lifts will be exposed to the elements and considerable care is required to ensure that extreme temperatures will not affect the safety and reliability of the lift and the comfort of passengers during its use. In the UK where frosts and sub-zero temperatures occur regularly, the use of trace heating should be considered on exposed equipment and, in particular, the guide rails, safety gear, buffers and door equipment. For glazed cars exposed to direct sunlight, the potential for solar gain should be considered and air conditioning installed to provide cooling. This is particularly important where a glazed lift car is located in a glazed well and where there is a possibility of passenger entrapment. It would be unwise to rely on external observation lifts as the sole means of vertical transportation for a building without some form of weather shielding.

5.5.7 Machine room

Refer to section 5.2.7.

The machine room or machine space should comply with BS EN 81-1/2[2,3]. Its position, for an observation lift, may be constrained by aesthetic requirements. If space permits, for an electric traction lift the best position is above the well. An alternative is to use a bottom drive and place the machine room at the lowest level. This option however, presents problems in hiding or disguising the extra roping required. Hydraulic lifts provide an easier option as their machine spaces can be some distance away from the lift and even below it.

5.6 Service lifts

5.6.1 General

Service lifts, or 'dumb waiters', are designed for carrying goods only and are classified as 'non-accessible good only lifts' with their internal dimensions and designs being arranged to prevent their use for carrying persons. Service lifts can be provided conforming to BS EN 81-3[19], which contains many of the provisions of BS EN 81-1/2[2,3] and should ensure reliability and safety in operation. Alternatively, as persons are not to be transported, a suitable device under the Machinery Directive[17] enacted as the Supply of Machinery Regulations[20] (as amended) could be installed and is likely to be less expensive.

Much of what follows is particular to providing a service lift to BS EN 81-3. If a unit is supplied under the Machinery Directive, specialist advice should be sought.

5.6.2 Applications

The main use of service lifts is to transport books, documents, food and beverages, money, laundry, papers, post, retail stock, refuse etc., so they find application in department stores, entertainment centres, cinemas, theatres, sports centres and concert halls, hospitals, hotels, offices, residential buildings, residential care homes and nursing homes, shopping centres, universities and other education buildings. Their principal area of use, however, is in kitchens and restaurants.

5.6.3 Car size and payloads

Most manufacturers offer a range of standard car sizes, normally in 100 mm increments, with limitations on the maximum dimensions imposed by BS EN 81-3[19] as follows:

— maximum floor area: 1.0 m^2

— maximum car depth: 1.0 m

— maximum height: 1.2 m.

The maximum height may be more, subject to the use of a permanently fixed shelf that restricts the height of each compartment to less than 1.2 m.

The rated load is not based on the available floor area as required by BS EN 81-1/2[2,3] but is limited to a maximum of 300 kg by BS EN 81-3[19].

Within these limitations, the lift car dimensions should be appropriate for the size of the goods to be carried. Any containers to be used should be taken into account since these could affect the rated load.

5.6.4 Entrances, car fittings and finishes

When deciding on the size of the car and its entrance, it is important to take into account the need for clear access for loading and unloading. The size of packaging and transportation containers should be considered as well as handling clearances.

On cars with adjacent (i.e. front and side) entrances, the width of the side entrance is normally less than that for the front entrance. When selecting such cars it is imperative to ensure that items loaded through the front entrance can be unloaded from the side entrance.

Car doors are required where there is a risk of goods being transported coming into contact with the well walls. Where car doors are not provided, it may be necessary to include means of immobilising any loads that may be prone to movement during the lift journey. Where no car doors are provided on service lifts with a through car arrangement, protection may be required in the lift well to prevent entanglement of goods with the lift well or landing door equipment during travel.

Where car entrance protection is provided, the clear entrance width is normally less than the full width of the lift car and this should be taken into account to ensure easy loading and unloading of the car.

Floor level or counter-height entrances can be provided, depending on the nature of the items being transported. Entrance doors or gates may be either manual or power-operated.

Manual vertical operating shutters (bi-parting or 'rise and fall') are normally fitted at serving height on landings and may also be fitted to the car. Hinged doors for landings are sometimes provided at floor level as an alternative.

Open collapsible gates or roller shutters may be provided for car entrance protection. A drop-bar (barrier) or similar protection for cars is also available to ensure that goods are restrained during travel, but these methods are suitable only for service lifts that carry bulky items or containers.

Power-operated vertical shutters or automatic closing hinged doors may be provided. Full power operation for hinged doors can be provided but this is expensive and normally a self-closing mechanism is adequate.

Automatic loading and unloading systems are available that employ power-operated rollers in the car with non-powered rollers on the landings. For carrying items such as documents, the car may be fitted with tilting trays and collection boxes at each landing. In both cases power-operated entrances are required.

Side runners can be provided within the car to support serving trays etc. These remain permanently in place, and would need to be specified to suit a given size of tray. Alternatively, removable frame systems, custom made to requirements, can be provided.

For transporting food, heating panels can be fitted within the car. In this application, solid protection for car entrances is required and it is also advisable to specify smooth edges and corners within the car to enable easy cleaning.

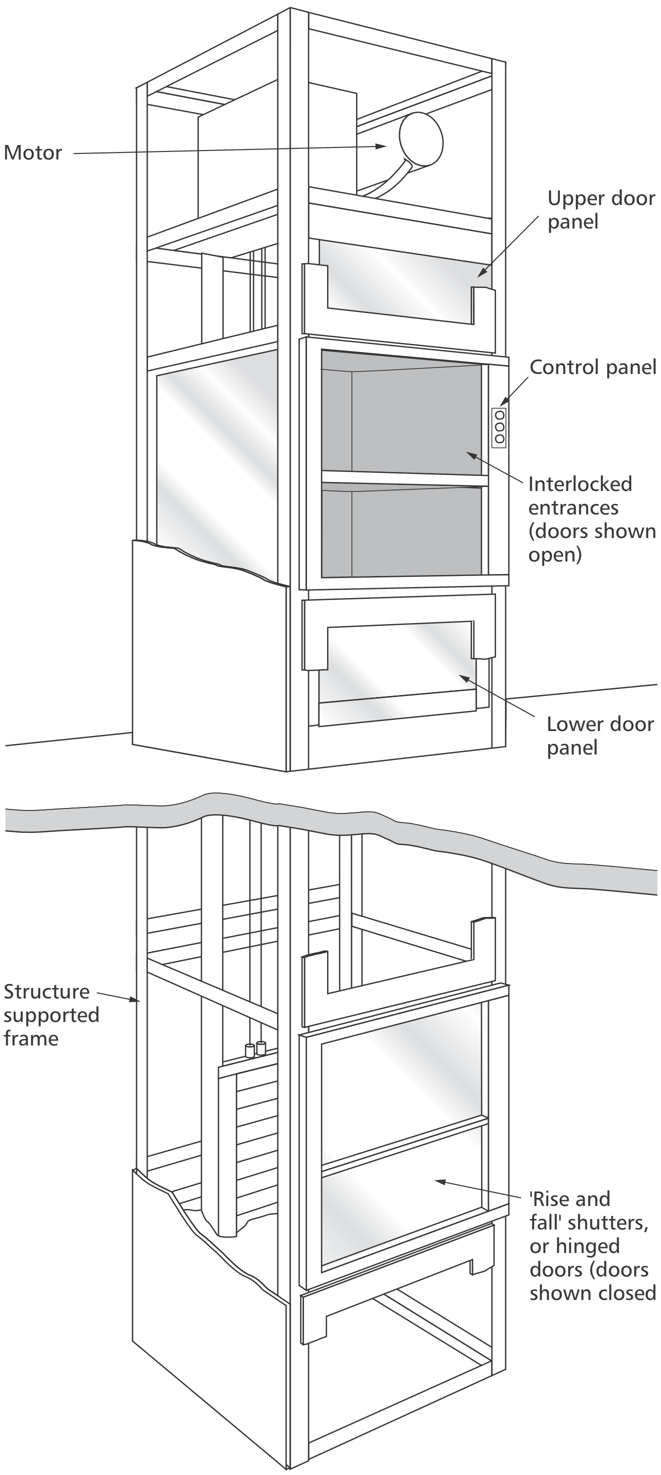

Figure 5.6 Cutaway section of a typical service lift serving two levels

5.6.5 Types of drive and operating speeds

Service lifts normally employ electric traction drive, using either a drum, sprocket or counterweight arrangement. The ideal position for the drive is directly above the well and since the machines are relatively small they can often be accommodated within a normal room height to avoid the need for more costly locations to the bottom or side of the well.

Rated speeds are usually between 0.2 and 0.5 m/s but may be as high as 1.0 m/s, if required to suit longer travel, or for special operational requirements.

5.6.6 Well

Most service lifts are supplied with their own structural frames to minimise builder's work. The lift and the frame are normally to the manufacturer's standard details and therefore well sizes for service lifts are similar and can be based on the following guidance.

For initial layout purposes, the following well dimensions can be used:

— *well width*: car width plus 500 mm

— *well depth*: car depth plus 300 mm.

The actual sizes will need to be confirmed by the lift supplier who will take into account the lift arrangement, entrance details and any necessary space required for the enclosure.

The height of the soffit of the well (i.e. to the underside of the pulley or machine room floor) from the floor level of the highest floor served should be the height of the serving hatch plus the car height plus an allowance up to 1000 mm.

Where access to all serviceable parts is not possible from the landings, the lift must be designed to accommodate service personnel in the well with a clear height of 1800 mm above the top of the car at the top floor served. This is likely to cause the enclosure to penetrate the ceiling above the top floor served and should be avoided if possible.

For floor level service, a pit depth from 150 mm to 1000 mm is required, depending on car design and landing door arrangements. A pit is also required if the height of the serving hatch is such that there is insufficient height below the hatch to accommodate the landing shutters.

Where the pit is accessible for servicing, or maintenance, a minimum clear height of 1.8 m must be provided beneath the car by using a prop that is stored in the lift well.

5.6.7 Machine room

For electric traction service lifts with a machine room above, a minimum height of 600 mm is required for the machine room. The plan dimensions should be the same as the lift well. In some instances a separate area will be required to accommodate a control panel if this cannot be accommodated within the machine room itself.

For electric traction lifts with machine room adjacent or below, a pulley room is required above the well which should have the same plan area as the well and a height of between 200 mm and 500 mm.

The machine room can be directly below the serving height of the lowest floor, positioned to either side of the well or within the well.

Items of equipment will need to be moved into and out of the machine room for installation, replacement and repair. A minimum access opening of 600 mm by 600 mm is normally recommended, but the final size depends on the equipment contained in the machine room. The area in front of the access door should be clear of ducting, piping, ceiling panels etc.

5.7 Motor vehicle lifts

5.7.1 General

There is currently no specific standard for vehicle lifts but where passengers are to be transported with the vehicle, they need to be designed to BS EN 81-1/2[2,3] as heavy duty goods lifts. Vehicle lifts will, of necessity, have to provide a relatively large platform. The platform area is required to support at least 500 kg/m^2 (Table 1.1 of BS EN 81-1) for electric traction lifts and at least 333 kg/m^2 (Table 1.1A of BS EN 81-2) for hydraulic lifts. These loading requirements may be significantly in excess of the vehicle loads to be carried.

Where vehicles only are transported, the lift can be provided under the Machinery Directive[17], enacted as the Supply of Machinery Regulations[20] (as amended), which allows a more realistic loading requirement to be provided. If vehicles and persons are to be transported, a Machinery Directive lift can still be installed provided its rated speed is less than 0.15 m/s and it is operated by 'hold to run' controls. Provision of vehicle lifts under the Machinery Directive may only be made after a risk assessment has been carried out to determine the maximum loading.

In recent times, a number of independent and multinational suppliers have developed standard design solutions for vehicle lifts based on either electro-hydraulic or MRL lifts.

Special features for operation and signals are required for motor vehicle lifts, as detailed below. Figure 5.7 illustrates the features of a vehicle lift.

5.7.2 Applications

The most common application for motor vehicle lifts is to gain access to restricted garage parking associated with commercial, office, institutional, residential, and theatrical/entertainment premises. When considering this type of lift, it is important to allow adequate space for turning from the road and for manoeuvring within the garage area. Provision should be made for the removal of fumes from the lift car and well, in addition to their removal from the garage area itself.

5.7.3 Car sizes and payloads

Unless small vehicles only are to be carried, the lift car dimensions should be adequate to accommodate the largest standard production models, to allow for driver errors in alignment and to provide room to allow the driver to leave their vehicle in an emergency.

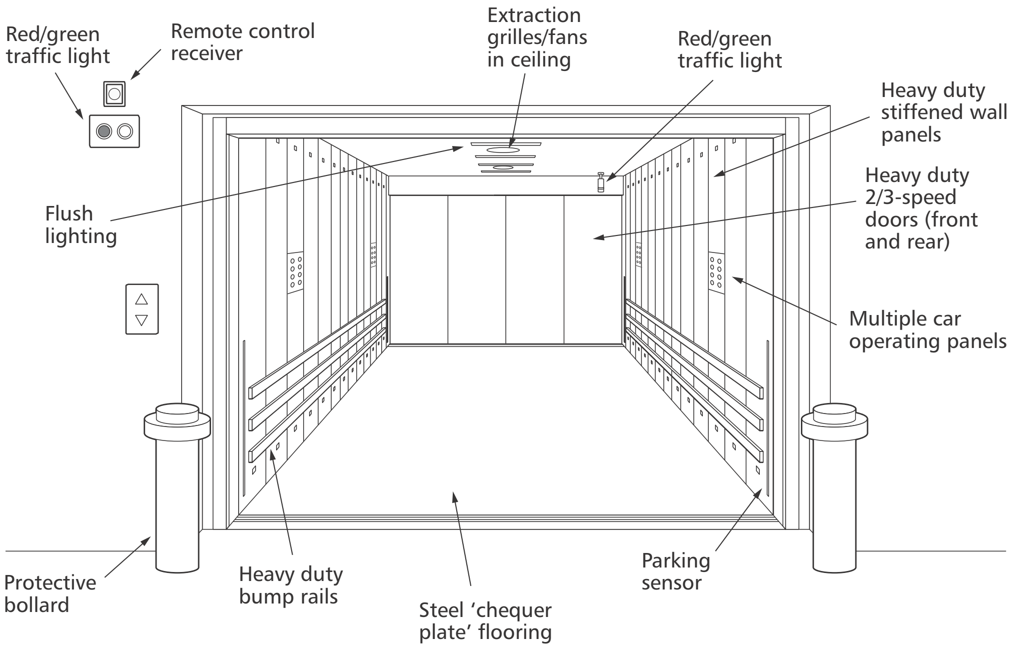

Figure 5.7 Features of a vehicle lift

Special consideration may be required if there is a possibility of accommodating 'stretch' limousines and modern off-road vehicles, or vans, which may require additional length or height for the lift car and doors.

The recommended internal dimensions are:

— *width*: motor vehicle width plus 750 mm (375 mm clearance on each side)

— *depth*: motor vehicle length plus 500 mm (250 mm clearance at each end)

A lift car height of 2100 mm is satisfactory for most applications, but an increased height should be allowed if the lift is required to carry vehicles fitted with roof racks or commercial vans or lorries. The lift car height should generally be equal to the lowest point on the access route to the lift so that if it is possible to drive up to the lift, it is also possible to use it. Where this is not the case, clear signage advising of any height restriction in the lift car must be provided on the landing outside the lift entrance.

The rated load of any lift designed to carry passengers within the car should be in accordance with the relevant BS EN 81 standard.

5.7.4 Entrances, car fittings and finishes

The entrance does not need to be the full width of the lift car, but should be large enough for easy access including sufficient clearance for wing mirrors, roof racks etc. Entrances, particularly in basement areas, will usually require to be fire rated and it is important to advise the lift supplier accordingly.

If the entrance is exposed to external elements, consideration should be given to weather-proofing the equipment, including control stations and doors. Ramps should be provided in front of such entrances to prevent rainwater from entering the lift well.

Consideration should also be given to providing mechanical protection to the landing entrances by using bollards to avoid accidental impact damage from vehicles.

The simplest form of entrance doors are folding leaf shutters. They are inexpensive, reliable, very durable and take up minimum well space but are not recommended because they are often unacceptable to users. The door leaves intrude into the lift car and it will be necessary to increase the platform length accordingly. Folding leaf shutters require the driver to leave the vehicle on three occasions (four if the gates are to be closed after egress) and therefore may not be suitable for many vehicle lift applications.

Power-operated folding shutter gates are also available and offer a durable, robust solution for vehicle lift applications. The opening and closing times of these doors are not comparable with the quicker horizontal sliding doors and should not be considered in any applications where operational times may be critical to satisfactory performance.

Older vehicle lifts often adopted vertical bi-parting door systems which take up little plan well space and are very heavy duty, making them particularly suitable for garage environments. However whilst they are still available, they are very expensive compared to conventional lift doors and they also have to be operated by continuous pressure control buttons which can prove difficult for passengers using controls from within a vehicle. This type of door is now generally only used in extreme heavy duty applications where conventional lift doors might be considered inappropriate. Where they are used, they require vertical clearance for the rise and fall door panels at the top and bottom entrances that can impact on the required pit and headroom dimensions.

Conventional power operated lift doors with four, or even six panel, horizontal sliding, centre-opening doors provide a reliable and relatively inexpensive system. These doors can require well space beyond the platform width to accommodate the open doors and should be provided with additional mechanical protection to minimise damage caused by impact or misuse.

Where automatic power-operated entrances are used, it is important to provide additional door closing protection to both the landing and the car entrances to ensure the doors cannot close on a vehicle. This protection should take the form of a light beam or series of beams in the landing architrave and lift car side wall (or the entrance front return where fitted). The beams can be connected to a traffic signal type system to indicate to the driver when the car is positioned correctly, similar to those fitted in many automatic car washes.

Control stations should be positioned to be within easy reach of the vehicle driver. Strip-type pushes, or a series of push button stations, fitted to both sides of the lift car will permit operation from within the vehicle.

Consideration will need to be given to protecting the entrances, car floor and walls. Refer to section 5.3.4 for guidance.

5.7.5 Types of drive and operating speeds

Vehicle lifts tend to be required over low rises of perhaps three or four floors with a travel of around 10 m. Twin-ram hydraulic systems, with speeds in the range 0.2–0.3 m/s, remain a good choice for this type of application. The emergence of MRL vehicle lifts offers an alternative solution with potential benefits in terms of energy efficiency and space savings due to the lack of a separate hydraulic pump room. Hydraulic lifts using a direct-acting central piston provide an economic solution where groundworks permit the required borehole. However, the cost savings resulting from the simpler system will be offset by the additional costs of providing the borehole. The need for future inspection of a borehole mounted cylinder should not be overlooked. Hydraulic lifts also tend to require lower headroom with requirements of 3.5–4.0 m being typical. The equivalent MRL vehicle lifts currently require up to and sometimes in excess of 4.5 m.

For higher travels, in excess of 12 m, either traditional or MRL electric traction drives with speeds up to 0.5 m/s become more attractive in providing faster operating times and better duty cycles. For traditional traction lifts, the ideal drive position is directly above the well. In view of the high payloads it is common to use roping factors up to 4:1 to reduce the load on the drive machine. In the past, floor levelling was an important consideration but, with modern control systems, floor levelling to an accuracy of ±6 mm would be expected and is easy to achieve.

Twin mast rack and pinion lifts can also be used with the same benefits indicated in section 5.8 and at speeds up to 0.3 m/s.

5.7.6 Well

In the absence of specific guidance in any standards, the dimensions in Table 5.2 are offered as guidance for initial space planning purposes, based on lift cars with front and rear entrances, for both hydraulic and electric traction motor vehicle lifts.

Table 5.2 Well sizes for vehicle lifts

Door type	Well width	Well depth
	Lift car width plus:	Lift car depth plus:
Manual folding leaf	900 mm	600 mm (including bunched lift car doors)
Power operated vertical	900 mm	500 mm
Power operated horizontal, centre opening	900 mm or 1.5 × clear door opening width, whichever is the greater	800 mm

Note: electric traction lifts with bottom drive and without a pulley room require the well widths to be increased by 500 mm

All dimensions should be checked with the lift installer before construction commences to avoid costly remedial works.

For initial planning of electric traction and hydraulic lifts, the headroom for a 2100 mm high lift car, should be based on 4200 mm from the top floor served to the underside of the lift well roof slab. The headroom will increase by 100 mm for each additional 100 mm of car height. For rack and pinion lifts the requirements will depend upon the location of the drive motors and should be checked with the lift manufacturer.

For electric traction and hydraulic lifts with horizontal sliding doors, the typical minimum pit depth required is 1800 mm. If vertical bi-parting doors are required, the pit depth will depend upon the configuration of the doors and should be checked with the lift manufacturer. For rack and pinion lifts the requirements will depend upon the location of the drive motors and should be checked with the lift manufacturer.

5.7.7 Machine room

The machine room requirements will be the same as those for goods lifts and are given in section 5.3.7.

5.8 Rack and pinion lifts

5.8.1 General

The basic components of a rack and pinion drive are a continuous length of machine-cut toothed bar (rack) and a pinion, or pinions, which are held in permanent mesh with the rack, mounted on a mast or masts, see Figure 5.8. Due to the ease of erection of the mast from the car roof (a practice developed over many years of experience with construction hoists) there is no need for a scaffold to be erected in the well during installation of the lift.

The virtually unlimited travel available, with minimal loading on the building fabric, is a major benefit. Travel distances are largely unlimited; the tallest known instal-

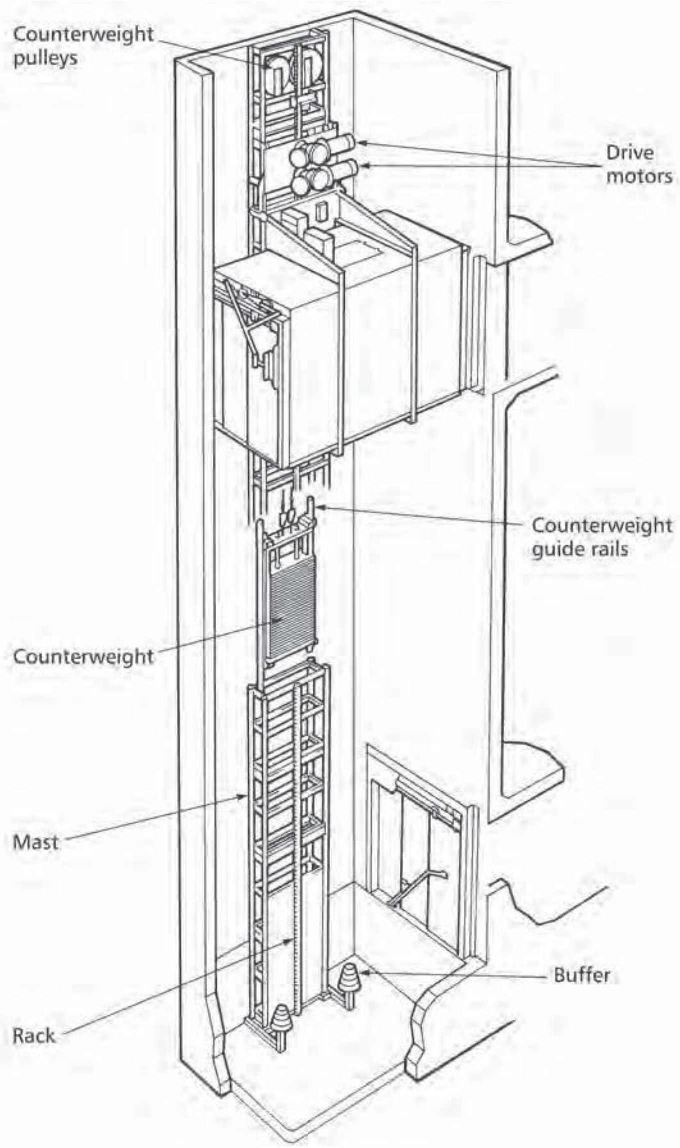

Figure 5.8 General arrangement of rack and pinion lift

lation at the time of publication, above ground, is 640 m although rack and pinions lifts have been installed to a depth of 1000 m in mining applications.

Draft British Standard BS EN 81-7[21] prescribes the minimum safety standards for permanently installed rack and pinion lifts and is largely derived from BS EN 81-1[2]. Floor call systems, alarms, telephones, car-top control and landing levelling accuracy are all as for normal lift installations.

5.8.2 Applications

The main applications for permanently installed rack and pinion lifts are in factories, warehouses and retail buildings where goods, heavy duty goods and heavy vehicle lifts are required. Rack and pinion lifts are particularly suited to situations where the lift is installed without a well, such as lifts on the exterior of a building. There is no requirement for the erection of accurately plumbed and parallel guide rails and the speed of installation and the possibility for external application makes rack and pinion lifts particularly suitable for temporary lifting facilities, e.g. in residential buildings where an existing lift is being repaired or modernised.

Another common use for rack and pinion lifts that has evolved over recent years is as a temporary working platform within lift wells to facilitate the installation of new lifts.

Rack and pinion drive has been widely applied to the vertical transportation of passengers and goods in the construction and mining industries since about 1960. The ease of initial erection and subsequent extension as building work progresses has led to the rack and pinion lift replacing the rope hoist for passenger transportation on building sites around the world. The height of travel can be increased or decreased by the addition or removal of mast sections. Relocation of the lift, as may be required when reorganising a factory, is also readily achieved. By jacking-up the mast, sections may be inserted into or removed from the base of the mast to facilitate a change in travel height.

The use of rack and pinion drive with a pre-formed rack can enable the lift car to follow a curved path whilst being retained in a vertical position. This application is particularly suitable for high chimneys and offshore platforms where the constructions do not always lend themselves to lifts that are mounted vertically in a straight run.

Rack and pinion drives are being used increasingly for heavy duty applications. They can be used with a single mast supporting a cantilever car on lifts with a capacity up to 2000 kg, or with a double mast for larger installations. The single mast arrangement imposes a horizontal load to the supporting wall, which should be considered during building design. Twin mast arrangements transfer the loading to the pit floor thus minimising any horizontal loading on the structure.

Where a rack and pinion lift solution is being considered, it must be noted that they generate much higher noise levels that conventional electric traction or hydraulic lifts. This should be brought to the attention of the purchaser or building owner to ensure that it will be acceptable.

Rack and pinion drives are also commonly used for funicular railways and inclined lifts (see section 5.9.8), where the directional flexibility is again important.

In addition to the general applications already mentioned special applications include:

— TV and radio masts
— chimneys
— cranes
— grain silos
— offshore exploration/production platforms.

5.8.3 Car size and payload

Unlike conventional electric traction lifts, rack and pinion lifts have not evolved into mass produced standardised products and can therefore generally be supplied to bespoke dimensions to satisfy the specific requirements of a project.

The load rating of the lift is dependent upon the available car area as defined in BS EN 81-1/2(2,3). The range of rated loads and car sizes are as given in BS ISO 4190-1(11) or BS ISO 4190-2(12).

Smaller cars, for loads down to 200 kg, are available for special applications such as warehouses or tower cranes where they can be located within the tower section to provide access to cabins at high level.

The car, which is fitted into the sling, is of similar construction to those found in electric traction or hydraulic lifts. The car can be cantilevered from a single guide mast, allowing applications where building support can be offered from one side of the lift only, as with some types of observation lift and installations without a well. For applications with a rated load in excess of 2000 kg a twin mast arrangement should be considered, which eliminates the high loading imposed on the building support in cantilevered applications.

5.8.4 Entrances, car fittings and finishes

Car doors, landing doors, well and pit clearance dimensions are all to the appropriate parts of BS EN 81-1/2(2,3). Doors may be manual or power-operated. However, due to the potential deflection of masts, particularly on single mast installations, special attention is required to ensure that automatic doors will operate reliably and provide correct alignment of the car and landing doors under all operating conditions. Modern solutions can incorporate automatically driven landing doors with no mechanical linkage to car doors to eliminate this problem.

5.8.5 Types of drive and operating speeds

The operation of a rack and pinion drive requires a pinion or pinions to be held in permanent mesh with the rack, see Figure 5.9. The pinions are driven by individual motors (usually electric but may be hydraulic, petrol or diesel) through reduction gearing. In order to simplify the range of components and to maintain constant motor and pinion sizes, high payload requirements are often met by

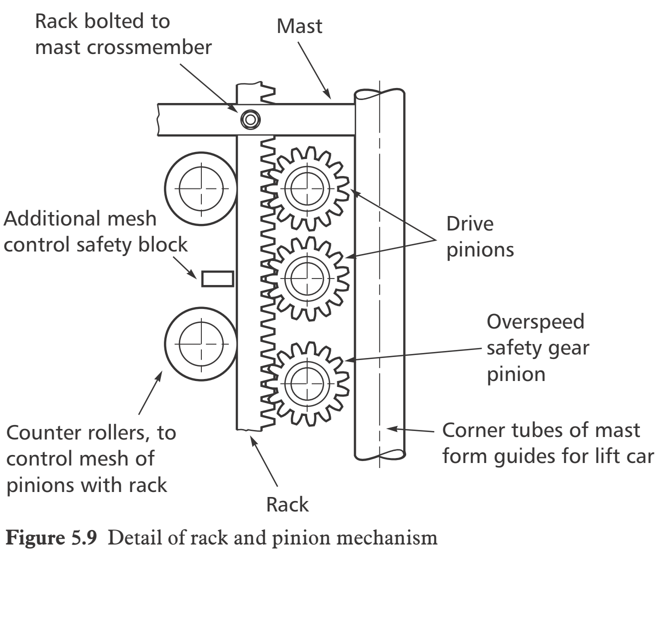

Figure 5.9 Detail of rack and pinion mechanism

using one, two or three drive units, each unit having an identical motor, gear box and pinion. The drive units are usually mounted on the lift frame, above the car.

The mechanical nature of rack and pinion drive provides the ability to maintain floor level position during loading and unloading of heavy loads, without the need for locking devices such as safety pawls, making it particularly beneficial for goods lifts applications.

The noise levels generated by the mechanical meshing of the pinion with the rack and by the motors mounted directly onto the lift car frame can prove intrusive and should be considered during the design stages to ensure that they will not become a nuisance to building owners or occupants. Noise levels can be greatly reduced by employing lower speeds and by reducing the module size, which provides a finer mesh pitch between the rack and the pinions, but are unlikely ever to match those of electric traction or hydraulic lifts.

The speed of rack and pinion lifts whilst available up to 1.5 m/s is generally considered to be more acceptable at less than 0.5 m/s due to the excessive noise generated by high speed units. Speeds above 0.5 m/s tend to be used on building site hoists where fast journey times are important to the efficient operation of the site and passenger comfort is not a priority. If noise is considered a nuisance then rack and pinion lifts should only be considered at speeds up to 0.3 m/s with a reduced module size.

5.8.6 Runway

A rack and pinion lift does not run in a conventional well, but up a mast, or masts. The rack is bolted to a rigid mast section, the rack and the mast typically being produced in standard 1.5 m lengths. These are bolted together to give the required lifting height. The mast forms the guide rails and also provides the structural support for the complete lift. The mast sections may be preformed so that the lift can follow a varying radius of curvature, as may be required on offshore platform support legs, cooling towers, etc, the car being restrained to remain vertical. The corner tubes of the mast are enclosed by the guide rollers and the car is thus cantilevered from the mast and restrained to follow the path set by the mast. At various intervals, generally between 3 m and 12 m, the mast is laterally restrained by ties to the building. These ties can be adjusted to accommodate discrepancies in building verticality.

The single mast arrangement imposes a horizontal load to the supporting wall similar to that of hydraulic lifts and again these must be considered during building design. Twin mast arrangements may be adopted to eliminate the cantilever loads or for larger lifts. The twin mast arrangement transfers the vertical loading to the pit floor thus minimising any horizontal loading on the structure.

The safety gear will normally be of the type used on construction hoists since the 1960s which require regular drop tests to prove the safety gear under loaded and mobile conditions, at least every three months. Therefore, such lifts are designed to enable quick and easy proving of the safety gear, without damage to components

The overspeed safety gear is normally mounted on the car sling and acts directly between the car and rack giving immediate response to an overspeed condition. There is neither a governor rope nor any well-mounted equipment. The overspeed governor and arrester gear are usually contained within a sealed enclosure and act as a single system. The overspeed governor is directly driven at car speed by a steel pinion in permanent mesh with the mast rack. The arrester gear applies braking torque to the same pinion and brings the lift to a halt with all the arresting forces being absorbed through the rack. Braking is very progressive and typical braking distances are about 1 m from the point of tripping.

The brakes themselves are of a centrifugal design and once activated, facilities can be provided to enable the brake to be released manually from within the car to provide a means of self rescue. This might be used on industrial applications such as chimneys, masts or cranes etc. where it is not possible to access the lift car from a conventional lift well but should not be provided on lifts used by the public or other untrained operatives.

Rack and pinion lifts are usually installed without a counterweight. However, counterweight units are used for heavy capacity applications, the weights being guided within the mast, and all vertical forces are transmitted directly to the foundation. The pulleys associated with the counterweight are mounted in the top mast section.

5.8.7 Machinery location

There is no requirement for a large machine or pump room and a well is not required to support the vertical loads and forces associated with the lift. All vertical loads from the lift are transferred via the rack to the mast. The drive motors and gearboxes are mounted directly onto the lift car frame. This greatly reduces the need for machinery space and often a small room capable of accommodating the main switchgear, distribution board and the controller cabinet is all that is required. In some cases, it is possible to mount the control cabinet behind an access panel on the lift car producing a machine room-less installation. However, maintenance access and emergency rescue procedures need to be planned carefully in such cases.

5.9 Lifts for other purposes

5.9.1 Firefighting lifts

Firefighting lifts are described in detail in section 6.3.

Building Regulations Approved Document B[22,23] and BS 9999[24] set down when firefighting lifts are required to be installed in a building within the UK. BS 9999 indicates that buildings (or parts of buildings) where either the height of the surface of the floor of the topmost storey (excluding plant rooms) exceeds 18 m, or the depth of the surface of the floor of the lowermost storey exceeds 10 m, should be provided with a firefighting well containing a firefighting stair, a firefighting lobby with a fire main, and a firefighting lift. One firefighting well is required for every 900 m^2 of floor area on any given storey. If the building is fitted throughout with an automatic sprinkler system the requirements are less onerous.

BS 9999 does not define how a firefighting lift should be designed but calls on BS EN 81-72[25] that details the special considerations required for a firefighting lift, which should have:

- a recall switch located at the fire access level
- been installed to meet the requirements of BS EN 81-1[2], or BS EN 81-2[3], as applicable
- a rated load of at least 630 kg
- internal car dimensions should be a minimum of 1100 mm wide by1400 mm deep
- run to the furthest floor of the building from the fire service access level (FSAL) in less than 60 seconds
- automatic power-operated doors
- doors at least 800 mm wide by 2000 mm high with a fire rating of at least one hour
- position indicators provided in the car and at the firefighters' access level (FSAL)
- a two-way intercom between the car, machine room or emergency and inspection panel for machine room less lifts and firefighters' access level (FSAL)
- a notice stating 'FIREFIGHTING LIFT: DO NOT USE FOR GOODS OR REFUSE'
- a notice stating: 'FIREFIGHTING LIFT: DO NOT OBSTRUCT LIFT DOORS — DO NOT LEAVE GOODS IN LIFT' at every firefighting lift lobby, where the firefighting lift is the only lift in the building
- emergency trap doors in the car roof
- provision for rescue from inside and outside the car
- buttons and controls protected from the effects of dripping water
- all electrical equipment protected against the effects of water
- an audible and visual alarm to alert maintenance personnel of operation of the firefighting switch
- a secondary electrical supply.

The provision of firefighting lifts thus requires substantial expenditure and therefore the need for such a lift should be properly established. Once installed a firefighting lift can be used for normal passenger circulation provided it is not obstructed. Some firefighting lifts may be part of a passenger group, where this can be arranged or where accommodation elsewhere in the building is not available.

Another firefighting facility found in older buildings is a 'fireman's lift'. This lift is fitted with a recall switch (behind a break-glass panel) to the main access floor. It should not be confused with a firefighting lift as it is not fire protected and does not incorporate the control features or the additional electrical and mechanical protection of a modern firefighting lift.

5.9.2 Evacuation lifts

Evacuation lifts are described in detail in section 6.5.

The requirement for evacuation lifts in the UK evolved from the requirement of UK building legislation that requires the access provision to be linked to egress provision. In response to this, BS 5588-8[26] was published originally in 1988 but has since been superseded by BS 9999[24].

BS 9999 provides detailed guidance for evacuation procedures and on the types of lift required. The type of building and its use will determine whether disabled people need to be moved by lift. Where there is a potential for large numbers of wheelchair users to be present in a building, for example, a theatre or a sporting event, consideration should be given to the provision of a number of evacuation lifts to ensure adequate provision is available in the event of an emergency.

BS 9999 recommends that the lift be operated under the direction and control of authorised persons using an agreed evacuation procedure. Only disabled persons should use the lift. It is not intended that the disabled evacuate themselves from the building unaided, even where a lift is provided. In addition to evacuation lifts, other facilities such as the provision of refuge areas incorporating emergency communication systems should also be considered in accordance with the recommendations of BS 9999.

Some of the requirements for an evacuation lift are the same as, or similar to those for a firefighting lift. An evacuation lift should have:

— a recall switch at the final evacuation floor labelled 'EVACUATION LIFT'

— been installed to meet the requirements of BS EN 81-1, or BS EN 81-2, as applicable

— a rated load of at least 630 kg

— internal car dimensions of 1100 mm width and 1400 mm depth

— run the full travel of the building in less than 60 seconds.

— automatic power-operated doors

— doors at least 800 mm wide by 2000 mm high with a fire rating of at least 30 minutes

— a secondary supply (except for two stop hydraulic lifts)

— a car substantially made of non-combustible materials

— controls at wheelchair height

— a communication system between the main lobby, machine room and all other lobbies for contact with fire marshals on each floor.

Although a firefighting lift can be used for evacuation prior to the arrival of the fire service or with their consent, an evacuation lift cannot be used as a firefighting lift.

5.9.3 Passenger lifts for use by persons with disabilities

5.9.3.1 General

Transportation systems for people with disabilities are covered in detail in chapter 11 with conventional passenger lifts detailed in section 11.7.2.

The Disability Discrimination Act[9,10] requires building owners and service providers to make reasonable provision to ensure that people with all disabilities can access buildings or services within a building. Passenger lifts designed, manufactured and installed in compliance with the Lifts Regulations 1997[1] are regarded by Building Regulations Approved Document M[8] as the best way to do this. The harmonised standard BS EN 81-70[6] provides the detailed requirements to supply or adapt a standard passenger lift to meet the needs of persons with disabilities. A summary of BS EN 81-70 can be found in chapter 11, Appendix 11.A1.

With these prescriptive requirements for the design of lift car finishes, controls and indication having been in place for a number of years, both in Building Regulations Approved Document M and in BS EN 81-70, most standard lifts now feature pushbuttons and controls in full compliance with these requirements and, in fact, it can be costly to deviate from these designs.

The prescriptive nature of BS EN 81-70, which is a harmonised standard, also imposes limitations on the flexibility of design in bespoke cars and may require consultation with a Notified Body where deviations are explored to suit architectural aspirations.

5.9.3.2 Applications

The application of lifts for people with disabilities is required in any building where there is a need to meet the requirements of the Disability Discrimination Act[9,10]. This is effectively any building accessible to the general public or where services are provided to visitors to a building or facility.

The requirement however is only for 'adequate provision' to be made and this can be open to interpretation. Some may consider the provision of a single lift that is fully compliant to BS EN 81-70[6], is adequate provision allowing other lifts to be installed in the building with non-compliant finishes or controls to suit a particular design. However, since the standard is becoming incorporated into virtually all model lift product ranges, it is generally considered good practice to provide all lifts in a building with finishes, controls and signalisation in compliance to BS EN 81-70. This is even the case with goods lifts in working and commercial environments, since staff members with disabilities also need to be considered.

5.9.3.3 Car size and payload

For adequate disabled access, the internal car sizes of passenger lifts should be suitable for the application. BS EN 81-70[6] outlines the varying requirements relating to a sole wheelchair user, accompanied user and the accommodation of different sized wheelchairs defined by BS EN 12183[27] and BS EN 12184[28] as follows:

— *For single wheelchair occupation, with no attendant*: a rated load of 450 kg (6-person), 1000 mm wide by 1250 mm deep.

In private applications, where larger lifts cannot be accommodated, this might provide a compromise solution.

— *For a wheelchair and an accompanying person*: a rated load of 630 kg (8-person), 1100 mm wide by 1400 mm deep.

This is the minimum size suitable for use in small offices, residential accommodation and residential care homes but it does not permit a wheelchair to be turned within the car. For new installations in public areas, the 630 kg lift should be considered the minimum suitable size that meets the minimum requirements of Building Regulations Approved Document M[8].

— *For a stretcher and accompanying persons*: a rated load of 1000 kg (13-person), 1100 mm wide by 2100 mm deep.

This size of lift is commonly applied in residential buildings and residential care homes where the additional space may be useful for goods and furniture movements and it can also accommodate a stretcher.

— *For full manoeuvrability of the largest wheelchairs*: a rated load of 1275 kg (17-person), 2000 mm wide by 1400 mm deep

This is the recommended size for all public buildings and larger office buildings, and will allow access and full manoeuvrability for the largest wheelchairs in a lift car.

It is becoming common practice for designers to include at least one 17-person lift in public buildings and residential applications where full accessibility and manoeuvrability for wheelchair users is required.

Since cost is often an issue during the design and construction of a building, it may become necessary to include lifts of different sizes within a single group in order to satisfy the various operational needs of the building. An example of this might be in a residential building where a lift with a rated load of 1275 kg is required, together with a lift capable of accommodating a stretcher or coffin. This would result in the need for a deep 1000 kg car and a square 1275 kg car that will have varying lift well dimensions and create a non-uniform core arrangement.

5.9.3.4 Entrances, car fittings and finishes

BS EN 81-70[6] provides prescriptive details relating to the design and location of handrails, control buttons and indicators as well as the need for the finishes to provide good contrast between the controls and the surrounding panels.

Entrances should be 800 mm wide for 6-person lifts (wheelchair only), 800 mm wide for 8-person lifts (wheelchair and accompanying person) and 1100 mm wide for the 17-person cars identified above.

Control panels should contain pushes between 900 mm and 1100 mm above the floor level on the landing. The car pushes should also be at this level, although it is acknowledged that with multiple floors, the pushes may need to extend further up a panel and a maximum of 1200 mm above floor is recognised.

Pushes must feature tactile markings and Braille may be provided, although this is not mandatory.

For full details on the prescribed requirements, refer to chapter 11, Appendix 11.A1.

5.9.3.5 Type of drive and operating speeds

Refer to section 5.2.5.

5.9.3.6 Well

Refer to section 5.2.6.

5.9.3.7 Machine room

Refer to section 5.2.7.

5.9.4 Lifting platforms for use by persons with disabilities

5.9.4.1 General

Transportation systems for people with disabilities are covered in detail in chapter 11 with lifting platforms covered in sections 11.7.3 and 11.7.4.

The Disability Discrimination Act[9,10] requires building owners and service providers to make reasonable provision to ensure that people with all disabilities can access buildings or services within a building. Whilst passenger lifts are recommended as the preferred lifting device for compliance with Building Regulations Approved Document M[8], lifting platforms may be considered in some circumstances. Lifting platforms are regulated by the Machinery Directive[17] enacted by the Supply of Machinery (Safety) Regulations 2008[20] (as amended). Recommendations related to the design of lifting platforms with an enclosed lift well are contained in prEN 81-41[29]. Recommendations for lifting platforms in a non-enclosed lift well are contained in BS 6440[30] for commercial and public environments and BS 5900[31] for domestic home lift applications. (BS 5900 is currently under revision.)

5.9.4.2 Application

Lifting platforms may be considered suitable in situations where there is insufficient space to accommodate a conventional passenger lift. This can sometimes occur in existing buildings, where there may be no possibility of excavating a pit or the existing floor heights do not provide the necessary headroom for a passenger lift. Lifting platforms also take up a smaller footprint and can therefore be used in smaller buildings where it may be impossible to accommodate a passenger lift well.

The travel distance of the lift needs to be considered since lifting platforms are limited to a maximum rise of a single storey (i.e. between two floors) when supplied to BS 5900[31] in domestic applications and to 3.0 m when supplied to BS 6440[30] in a non-enclosed lift well.

Where a longer travel is required, then an enclosed lift well is required and a lifting platform conforming to prEN 81-41[32] will be required. Generally a travel distance of 9.0 m is considered a practical limit, since with a maximum permitted rated speed of 0.15 m/s a trip of nine metres will take approximately one minute.

Many of these units tend to be in the form of a platform with a balustrade to two sides and entrance gates on opposite ends providing a through platform arrangement providing ease of access and egress for wheelchairs.

5.9.4.3 Car size and payload

Car sizes are typically based on the accommodation of a single wheelchair or a wheelchair and an attendant with minimum platform sizes for these being prescribed in prEN 81-41[29].

Refer also to section 11.7.3.

The rated load of lifting platforms is also detailed in prEN 81-41 and is calculated based on a minimum of 250 kg/m^2 of the platform area with a maximum of 500 kg limited by the maximum allowable area of 2 m^2.

5.9.4.4 Entrances, car fittings and finishes

Gates or barriers are required at all access points on lifting platforms although the requirements vary depending on the travel distance and the type of product.

Above 3000 mm travel distance, the upper landing requires a door at least 2000 mm high. Hinged doors can be arranged to open automatically, but are often manually controlled.

Refer to section 11.7.3 for more details.

Lifting platforms are mass produced and therefore tend only to be available with a limited range of finishes and enclosure designs. Enclosures are basic in design, but can incorporate glazed panels to afford some visual enhancement and transparency to the device.

Although lifting platforms are not within the scope of BS EN 81-70[6], its recommendations should be considered, where appropriate, with regard to the design of push-buttons, indicators, fixtures and fittings etc.

Periodic maintenance and inspections should be carried out at regular intervals.

5.9.4.5 Type of drive and operating speeds

Lifting platforms are available with a number of types of drives such as hydraulic ram, screw and nut, and hydraulic scissor lift drive.

The most common types are the hydraulic ram and the screw and nut where the drive mechanism is concealed to one side, normally behind the platform wall housing the passenger controls. These tend to be standard units with very little scope to change the design and only limited selections for the finishes and controls.

A scissor lift platform provides greater flexibility in allowing a bespoke designed and manufactured platform enclosure to be mounted onto a standard scissor lift mechanism with the drive mechanism and structure being underneath the platform. The use of glass for the platform enclosure can achieve levels of transparency not achievable with standard lifting platforms and so these tend to be used on projects with specific architectural aspirations.

Operating speeds are limited to a maximum of 0.15 m/s by safety standards. However, many operate at lower speeds and scissor lifts in particular may provide speeds as low as 0.05 m/s

5.9.5 Stairlifts for use by persons with disabilities

5.9.5.1 General

Transportation systems for people with disabilities is covered in detail in chapter 11 and section 11.7.5 details the recommendations and requirements for stairlifts.

The Disability Discrimination Act[9,10] requires building owners and service providers to make reasonable provision to ensure that people with all disabilities can access buildings or services within a building. Stairlifts fall under the Machinery Directive[17] enacted by the Supply of Machinery Regulations[20] (as amended). Recommendations related to the design of stairlifts are contained in BS EN 81-40[32].

5.9.5.2 Application

Stairlifts are the final choice of lifting devices under Building Regulations Approved Document M[8] and should only be used when conventional lifts and lifting platforms cannot be accommodated.

Stairlifts have a secure chair travelling along a rail running up the length of the stairs, arranged to allow a passenger to sit or perch in position. These are generally only used in private dwellings.

An alternative is the platform stairlift that incorporates a platform to accommodate a wheelchair. These are also used mainly in domestic applications but are occasionally used in some public areas.

Stairlifts are suitable for both straight and curved stairs (but not spiral stairs). The use of wheelchair platform stairlifts on curved stairs will require careful planning to ensure adequate width is available to allow the platform to turn within the stair.

Safety must be considered at all stages of a project, since the people most likely to use such a lift will be elderly or physically disabled. Safety belts, handgrips and a safe emergency exit for the user from the unit should all be considered, along with any risks from objects being left or dropped on the stairs. The stairlift installation must not impede the access of able-bodied persons to the stairs, or the fire exit arrangements for either able-bodied persons or those with disabilities.

The travel distance should be considered as the control of a stairlift requires constant pressure buttons and some users may not be able to operate a button for long continuous periods where the trip time is too long. Several boarding/alighting points may be necessary for long travel units.

5.9.5.3 Car size and payload

Stairlifts are intended for a single user at any time and are generally provided with a single seat or a perch for a standing passenger. Stair platforms designed for wheelchairs must be sized to accommodate the type of wheelchair to be carried.

5.9.5.4 Type of drive and operating speeds

Refer to section 11.7.5 for details of the types of drive. All stairlifts are limited to a maximum rated speed of 0.15 m/s.

5.9.6 Explosion protected lifts

For many decades, specialist lift manufacturers have produced a small quantity of explosion protected lifts specifically for use in hazardous areas where there is a high risk of explosion that could be triggered by loose sparks or excessive heat. The number of such lifts is controlled by the limited demand compared with the numbers of lifts in non-hazardous areas. The volume of related paperwork, the demanding quality controls and the variety of administrative demands imposed by the authorities, result in very few companies being willing to become involved in this market. The manufacturer would need to employ flexible production schedules in order to accommodate an explosion protected unit, therefore suppliers of batch produced or 'packaged' lifts usually cannot contend with such specialist demands.

When a specification is being prepared for an explosion protected lift, the first consideration is whether the lift can be located where no explosion hazard exists. If an alternative location would involve an increase in cost, this may well be offset by the higher cost of an explosion protected lift. There is usually a cost ratio of more than three to one between conventional and explosion protected lifts of otherwise similar performance, owing to the more expensive equipment required (such as motors, switches, enclosures for controls), choice of materials and, above all, the cost of the preparation and collation of supporting documentation.

Explosion protected (Ex) lifts fall under the EU EXAT Directive[33], the explosion protected type of electrical apparatus (EEx) to BS EN 60079-0[34] and the relevant BS EN 81-1/2[2,3] standard. These requirements are very stringent and, owing to the specialised nature of this type of lift, a detailed discussion is not appropriate here.

5.9.7 Goods scissor lifts

5.9.7.1 General

Goods scissor lifts provide a simple, robust and low-cost means of lifting loads through short distances. While geometrically inefficient, the lifting mechanism is all contained within the dimensions of the base frame thereby providing a very compact lifting device.

Lifting capacities range from a few kilograms to tens of thousands of kilograms and most scissor lifts are bespoke designs manufactured to suit the particular requirements of the specifier. A typical scissor lift is shown in Figure 5.10.

5.9.7.2 Application

Scissor lifts for goods applications are manufactured in accordance with BS EN 1570[35]. Static or mobile types are available and typical applications include:

— lorry loading/unloading (dock levellers)

— feeding materials to machines

— transferring of materials/equipment.

When positioning scissor lifts, consideration should be given to the configuration of the lift to ensure stability. Scissor lifts are most stable when they are loaded over the platform and the load being applied is parallel to the plane of the scissor legs.

Safety of the load on the platform can be ensured by handrails, interlocking platform and landing gates, wheel stops, loading flaps, or some combination of these or similar restraining devices.

All scissor lifts have a closed height and this may obstruct access onto the lift platform or cause an obstruction. In such cases a pit will be necessary, the depth being determined by the closed height of the lift. External pits should be provided with suitable drainage.

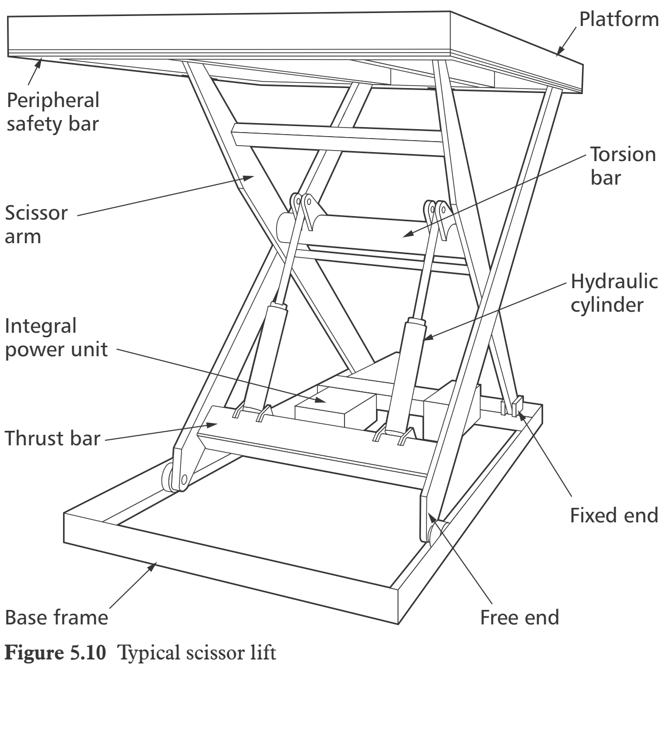

Figure 5.10 Typical scissor lift

Most scissor lifts will have a safety trip-bar, mounted around the perimeter of the underside of the platform to arrest downward travel in the case of an obstruction. Consideration should be given to guarding the underside of the lift to prevent the trapping of people and objects. In certain locations, e.g. a loading bay, barrier protection must be provided to the underside of the scissor lift to prevent access. BS EN 1570[35] gives recommendations on guarding requirements.

5.9.7.3 Platform size and payloads

The load rating depends upon manufacture, but can be as high as 30 000 kg for lorry lifting applications.

The platform length is dependent upon the vertical travel dimension because the scissor arms are accommodated beneath the platform when in the closed position. For this reason, longer travel units generally require a larger platform or a multiple scissor mechanism resulting in a deeper pit. For longer rises, consideration should be given to providing vertical guides to maintain stability of the platform when extended.

5.9.7.4 Type of drive and operating speeds

The power system usually consists of an electric pump, hydraulic fluid reservoir and control unit but some units may use a screw drive. The drive system is most frequently accommodated beneath the platform but occasionally the control panel may need to be remote from the machine. Controls can be fixed or hand-held. The maximum voltage for fixed controls is 240 volts and 110 volts for hand-held controls. The use of electronic valves is not common and therefore the starting and stopping of scissor lifts tends to be abrupt under the control of a simple solenoid valve.

Speeds are generally slower than other types of lift up to around 0.05 m/s (50 mm/s).

5.9.8 Inclined lifts

5.9.8.1 General

Inclined lifts have for many years been installed worldwide to provide access to hill-side apartments, hotels, beaches, churches etc. Older types of so-called ‘inclined lifts’, such as the cliff lifts at Bournemouth in England, or the lifts of Valparaise in Chile (built 1883–1915) are considered as funicular railways and generally come under tram codes and design specifications. These installations have often been modernised using lift equipment, but are still regarded as funiculars.

Inclined lifts are defined as permanently installed electric lifts, with traction (counterweighted) or positive drive, serving defined landings, with a vehicle designed to convey passengers, or passengers and loads, pulled by ropes, or chains, along guide rails on an inclined path at an angle between 15° and 75° to the vertical, without limitation of the travel. By contrast, conventional lifts move on guide rails inclined between 15° to the vertical and the vertical.

Modern inclined lifts adopt many of the same components that are used in conventional vertical lifts and should be designed, installed and operated according to BS EN 81-1[2] supported by the requirements of the proposed prEN 81-22[36] to deal with the range of inclination. This latter standard makes considerable variations on the requirements of BS EN 81-1 in order to deal with the wide range of inclinations possible.

5.9.8.2 Application

Many modern applications for inclined lifts still occur where access is provided to buildings up a cliff face or other naturally inclined aspects. There are however architectural based solutions like the lifts in the Luxor Hotel in Las Vegas that follow the incline of the pyramid shaped building.

This type of system may solve the accessibility problems of older underground railway stations. Inclined lifts have been installed in some applications adjacent to escalators or stairs to provide access for wheelchair users or passengers unable to use escalators. In such schemes, the lift should be arranged to run at a slower speed than the escalators so as to discourage able-bodied people from using it.

5.9.8.3 Car sizes and payload

Car sizes and payload are based on BS EN 81 requirements linking the available area to the rated load. The limitations of size and rated load will be essentially the same as that for conventional lifts and inclined lifts should be sized to accommodate the likely peak passenger volumes up to a practical limit of 100 persons.

5.9.8.4 Type of drive and operating speed

The introduction of the vector control system has made inclined lifts a viable lift system where smooth acceleration, deceleration and stopping can easily be achieved and limit the horizontal forces imposed on passengers. Inclined lifts can operate over a fixed or variable slope or angle and at speeds up to 4.0 m/s, though it is recommended that 2.5 m/s be considered a practical limit due to the slow acceleration and deceleration rates that need to be adopted.

Parameters such as acceleration and deceleration values, especially for emergency braking, need to be taken into account. Excessive horizontal acceleration or deceleration arising from the inclined movement of the lift will introduce a risk of passengers falling.

Using conventional lift machinery with geared or gearless drives and VVVF control allows the lift car mounted on wheels or rollers to be driven along tacks or tee guide rails using tension ropes on pulleys.

5.9.8.5 Travel path/runway

Being used to access remote buildings on cliffs, many inclined lifts are external and have no well and, like rack and pinion lifts, would be within a runway. Care should be taken in such instances to ensure that the runway is not accessible to people and if necessary, guarding and fencing should be installed to create a safe environment.

For internal applications, a well will typically be formed by a full enclosure. Specialist advice should be sought to establish the structural requirements of such a well.

5.9.8.6 Machine room

The configuration of the machine room will be dependent on a number of factors, notably the incline and the availability of suitable space. Specialist advice should be obtained to suit a particular application.

Figure 5.11 shows a typical inclined lift, with a counterweight.

5.10 Future concepts

There is increasing pressure from within the construction industry to reduce costs, time and space requirements while maintaining a high standard of usability. This affects all lift manufacturers and suppliers. It also has a considerable influence on future lift design and installation procedures and new passenger transportation systems are constantly being investigated whilst maintaining the generally high quality of the equipment offered.

In the 2005 edition of this Guide, the application of two separately driven lift cars in a single lift well was discussed as a future concept and, whilst only available from a single supplier, this has now been commercially available for a number of years with a growing number of installations being completed each year both in new high-rise buildings and in existing buildings where the existing single lifts were not providing the necessary capacity and performance.

The debate over using lifts for the evacuation of buildings continues and there are a number of examples around the world where lifts have recently been adopted as part of the evacuation strategy of a building. Within Europe, existing British and European standards form the foundation for the design of lifts used for evacuation whilst, further afield, these appear to be largely ignored in favour of developing strategies in conjunction with local building control and fire authorities. Internationally, research continues and conferences are held to debate the merits and limitations of using lifts for evacuation and it is only a matter of time before it gains common acceptance and design and operational strategies become formulated and standardised.

The recent introduction of credit points for lift design under the BREEAM environmental assessment method for buildings(37) points toward a rethink of the traditional counterweight system on traction lifts. Modern traction lifts generally adopt 50% balancing (i.e. the counterweight mass is set at the mass of the empty car plus 50% of the rated load) to optimise traction and minimise energy consumption by limiting the maximum out-of-balance load. BREEAM indicates that the lift motor size should be reduced by reducing the counterweight balance. In isolation, the reduction of the balance ratio will actually result in a larger motor being required as the maximum out-of-balance load will increase. However, recent patent applications (based on the use of load weighing systems linked to the drive in order to reduce acceleration and speed on lifts with reduced balance ratio) will allow smaller motors to be used and result in energy savings, albeit at the expense of overall lift performance in terms of handling capacity. This and other initiatives such as power regeneration are certain to be developed over coming years as the industry strives to make a contribution to the global initiatives for energy conservation.

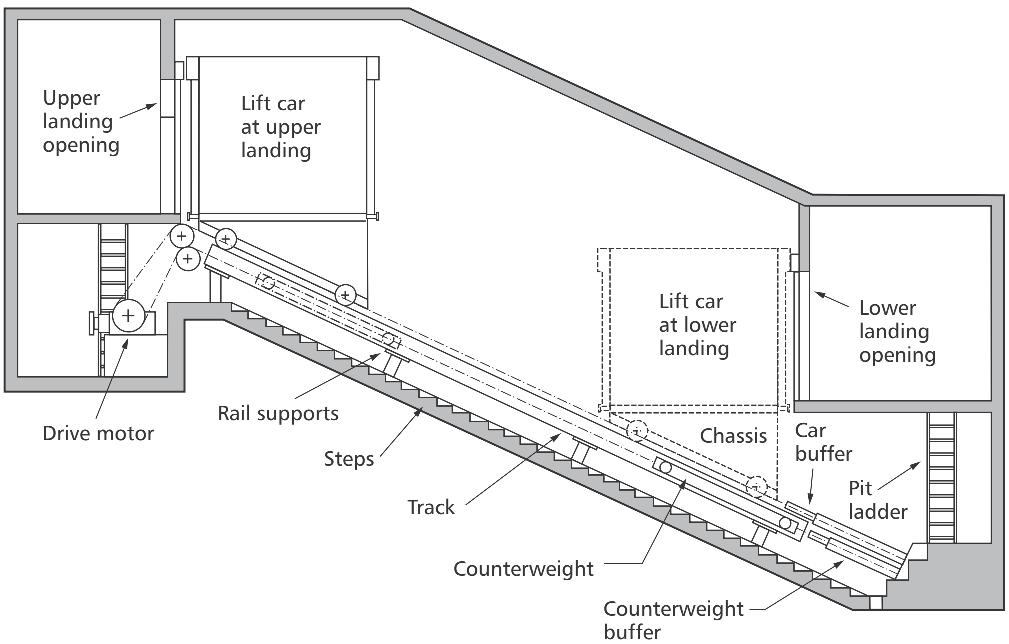

Figure 5.11 Schematic of a typical inclined lift with counterweight

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Appendix 5.A1: Car, well, headroom, pit and machine room sizes

Tables 5.A1.1 to 5.A1.7 are reproduced from *Elevator and Escalator Micropedia*(16) by G.C. Barney, D.A Cooper and J Inglis by kind permission of Gina Barney Associates. Copies may be obtained from PO Box 7, Sedbergh, LA10 5GE.

The values for car, well, headroom and pit sizes (Tables 5.A1.1 to 5.A1.3) are for guidance only as factors such as door height, door type, internal car height, position of counterweight, provision of counterweight safety gear, multiple lifts in well, equipment in the well (MRLs) etc., would require confirmation from the lift installer.

The values for machine room sizes (Tables 5.A1.4 to 5.A1.7) are the minimum sizes recommended and are for guidance only for single lifts, as factors such as access arrangements, split levels, machine room height, machine position, position of counterweight, multiple lifts in well, equipment in the well, etc., would require confirmation from the lift installer.

Table 5.A1.1 Car, well, headroom and pit sizes: residential and health care lifts (source: BS ISO 4190-1(11))

Speed (m/s)	Dimension	Size for given rated load							
		Residential class				Health care class			
		320 kg	450 kg	630 kg	1000 kg	1275 kg	1600 kg	2000 kg	2500 kg
N/A	Car:								
	— internal area (m^2)	0.95	1.30	1.66	2.40	2.95	3.56	4.20	5.00
	— width (mm)	900	1000	1100	1100	1200	1400	1500	1800
	— depth (mm)	1000	1250	1400	2100	2300	2400	2700	2700
N/A	Well:								
	— width (mm)	1500 (A)	1600 (B)	1600 (B)	1600 (B)	2100 (D)	2400 (F)	2400 (F)	2700 (F)
	— depth (mm)	1500 (A)	1700 (B)	1900 (B)	2600 (B)	2900 (D)	3000 (F)	3300 (F)	3300 (F)
	— width (mm)	—	1700 (C)	1700 (C)	1700 (C)	—	—	—	2700 (G)
	— depth (mm)	—	1700 (C)	1900 (C)	2600 (C)	—	—	—	3300 (G)
0.40*	Headroom (mm)	3600	3600	3600	3600	N/S	N/S	N/S	N/S
	Pit depth (mm)	1400	1400	1400	1400	N/S	N/S	N/S	N/S
0.63	Headroom (mm)	3600	3600	3600	3600	4400	4400	4400	4600
	Pit depth (mm)	1400	1400	1400	1400	1600	1600	1600	1600
1.00	Headroom (mm)	3700	3700	3700	3700	4400	4400	4400	4600
	Pit depth (mm)	1400	1400	1400	1400	1700	1700	1700	1900
1.60	Headroom (mm)	N/S	3800	3800	3800	4400	4400	4400	4600
	Pit depth (mm)	N/S	1600	1600	1600	1900	1900	1900	2100
2.00	Headroom (mm)	N/S	N/S	4300	4300	4600	4600	4600	4800
	Pit depth (mm)	N/S	N/S	1750	1750	2100	2100	2100	2300
2.50	Headroom (mm)	N/S	N/S	5000	5000	5400	5400	5400	5600
	Pit depth (mm)	N/S	N/S	2200	2200	2500	2500	2500	2500

* Hydraulic lifts only

Notes:
(1) Headroom is top terminal finished floor to well ceiling; pit depth is from bottom terminal finished floor to pit floor.
(2) Accommodation: 450 kg wheelchair only; 630/800/1000 kg wheelchair and attendant; 1275 kg and larger provides full manoeuvrability.
(3) Health care lifts accommodate patient trolleys, beds (various sizes), instruments and attendants.
(4) Door widths: A = 700 mm; B = 800 mm; C = 900 mm; D = 1100 mm; E = 1200 mm; F = 1300 mm; G = 1400 mm.

Table 5.A1.2 Car, well, headroom and pit sizes: general purpose and intensive traffic lifts (source: BS ISO 4190-1[11])

Speed (m/s)	Dimension	Size for given rated load							
		General purpose class				Intensive traffic class			
		630 kg	800 kg	1000 kg	1275 kg	1275 kg	1600 kg	1800 kg	2000 kg
N/A	Car:								
	— internal area (m^2)	1.66	2.00	2.40	2.95	2.95	3.56	3.88	4.20
	— width (mm)	1100	1350	1600	2000	2000	2100	2350	2350
	— depth (mm)	1400	1400	1400	1400	1400	1600	1600	1700
N/A	Well:								
	— width (mm)	1800 (B)	1900 (B)	2200 (C)	2500 (D)	2600 (D)	2700 (D)	3000 (E)	3000 (E)
	— depth (mm)	2100 (B)	2200 (B)	2200 (C)	2200 (D)	2300 (D)	2500 (D)	2500 (E)	2600 (E)
	— width (mm)	2000 (C)	2000 (C)	2400 (D)	—	—	—	—	—
	— depth (mm)	2100 (C)	2200 (C)	2200 (D)	—	—	—	—	—
0.63	Headroom (mm)	3800	3800	4200	4200	N/S	N/S	N/S	N/S
	Pit depth (mm)	1400	1400	1400	1400	N/S	N/S	N/S	N/S
1.00	Headroom (mm)	3800	3800	4200	4200	N/S	N/S	N/S	N/S
	Pit depth (mm)	1400	1400	1400	1400	N/S	N/S	N/S	N/S
1.60	Headroom (mm)	4000	4000	4200	4200	N/S	N/S	N/S	N/S
	Pit depth (mm)	1600	1600	1600	1600	N/S	N/S	N/S	N/S
2.00	Headroom (mm)	N/S	4400	4400	4400	N/S	N/S	N/S	N/S
	Pit depth (mm)	N/S	1750	1750	1750	N/S	N/S	N/S	N/S
2.50	Headroom (mm)	N/S	5000	5200	5200	5500	5500	5500	5500
	Pit depth (mm)	N/S	2200	2200	2200	2200	2200	2200	2200
3.00	Headroom (mm)	N/S	N/S	N/S	N/S	5500	5500	5500	5500
	Pit depth (mm)	N/S	N/S	N/S	N/S	3200	3200	3200	3200
3.50	Headroom (mm)	N/S	N/S	N/S	N/S	5700	5700	5700	5700
	Pit depth (mm)	N/S	N/S	N/S	N/S	3400	3400	3400	3400
4.00	Headroom (mm)	N/S	N/S	N/S	N/S	5700	5700	5700	5700
	Pit depth (mm)	N/S	N/S	N/S	N/S	3800	3800	3800	3800
5.00*	Headroom (mm)	N/S	N/S	N/S	N/S	5700	5700	5700	5700
	Pit depth (mm)	N/S	N/S	N/S	N/S	3800	3800	3800	3800
6.00*	Headroom (mm)	N/S	N/S	N/S	N/S	6200	6200	6200	6200
	Pit depth (mm)	N/S	N/S	N/S	N/S	4000	4000	4000	4000

* Using reduced stroke buffering

Notes:

(1) N/S indicates non-standard configuration.
(2) Headroom is top terminal finished floor to well ceiling; pit depth is from bottom terminal finished floor to pit floor.
(3) Accommodation: 450 kg wheelchair only; 630/800/1000 kg wheelchair and attendant; 1275 kg and larger provides full manoeuvrability.
(4) Door widths: A = 700 mm; B = 800 mm; C = 900 mm; D = 1100 mm; E = 1200 mm; F = 1300 mm; G = 1400 mm.

Table 5.A1.3 Car, well, headroom and pit sizes: goods lifts; Series A (Europe)* (source: BS ISO 4190-1[11])

Speed (m/s)	Dimension	Size for given rated load						
		630 kg	1000 kg	1600 kg	2000 kg	2500 kg	3500 kg	5000 kg
N/A	Car:							
	— internal area (m^2)	1.66	2.00	3.56	4.20	5.00	6.60	9.00
	— width† (mm)	1100	1350	1400	1500	1800	2100	2500
	— depth (mm)	1400	1750	2400	2700	2700	3000	3500
N/A	Well:							
	— width (mm)	2100 (A)	2400 (A)	2500 (A)	2700 (A)	3000 (A)	3500 (A)	4100 (A)
	— depth (mm)	1900 (A)	2200 (A)	2850 (A)	3150 (A)	3150 (A)	3550 (A)	4050 (A)
	— width (mm)	—	2400 (B)	2500 (B)	2700 (B)	3000 (B)	3500 (B)	4100 (B)
	— depth (mm)	—	2300 (B)	2950 (B)	3250 (B)	3250 (B)	3700 (B)	4200 (B)
	— width (mm)‡	—	—	2200 (C)	2300 (C)	2600 (C)	2900 (C)	3300 (C)
	— depth (mm)	—	—	3050 (C)	3350 (C)	3350 (C)	3650 (C)	4150 (C)
	— width (mm)‡	—	—	2200 (D)	2300 (D)	2600 (D)	2900 (D)	3300 (D)
	— depth (mm)	—	—	3400 (D)	3700 (D)	3700 (D)	4000 (D)	4500 (D)
0.25	Headroom (mm)	3700	3700	4200	4200	4600	4600	4600
	Pit depth (mm)	1400	1400	1600	1600	1600	1600	1600
0.40	Headroom (mm)	3700	3700	4200	4200	4600	4600	4600
	Pit depth (mm)	1400	1400	1600	1600	1600	1600	1600
0.50	Headroom (mm)	3700	3700	4200	4200	4600	4600	4600
	Pit depth (mm)	1400	1400	1600	1600	1600	1600	1600
0.63	Headroom (mm)	3700	3700	4200	4200	4600	4600	4600
	Pit depth (mm)	1400	1400	1600	1600	1600	1600	1600
1.00	Headroom (mm)	3700	3700	4200	4200	4600	4600	4600
	Pit depth (mm)	1400	1400	1600	1600	1600	1600	1600

* Series B applies for the rest of the world
† Also clear door opening width
‡ Add 150 mm for telescopic vertical sliding doors (type 6)

Notes:
(1) Headroom is top terminal finished floor to well ceiling; pit depth is from bottom terminal finished floor to pit floor.
(2) Accommodation: 450 kg wheelchair only; 630/800/1000 kg wheelchair and attendant; 1275 kg and larger provides full manoeuvrability.
(3) Door types: A = single entrance, horizontal sliding; B = two opposing entrances, horizontal sliding; C = single entrance, vertical sliding; D = two opposing entrances, vertical sliding.

Table 5.A1.4 Machine room sizes: passenger lifts (sources: BS ISO 4190-1[11], BS ISO 4190-2[12] and BS 5655-5[38])

Speed (m/s)	Dimension	Size for given rated load								
		320 kg	450 kg	630 kg	800 kg	1000 kg	1275 kg	1600 kg	1800 kg	2000 kg
0.63/1.00/1.60	Min. width (mm)	2000*	2200†	2500	2500†	3200	3200	3200	3000	3000
	Min. depth (mm)	3000*	3200†	3700	3700†	4900	4900	4900	5000	5000
2.00/2.50/3.00	Min. width (mm)	—	—	2700*	2700*	2700	3000	3000	3300	3300
	Min. depth (mm)	—	—	4700*	4900*	5100	5300	5300	5700	5700
3.50/4.00/5.00/6.00	Min. width (mm)	—	—	—	—	3000	3000	3000	3300	3300
	Min. depth (mm)	—	—	—	—	5700	5700	5700	5700	5700

* Estimated value (value not given in BS ISO 4190)
† Value obtained from BS 5655: Part 5[38] (value not given in BS ISO 4190)

Notes:
(1) For multiple lifts (side-by-side or facing), see formulae given in BS ISO 4190.
(2) Machine room clear height to be at least 1.8 m for movement and at least 2.0 m in working areas.

Table 5.A1.5 Machine room sizes: health care lifts (sources: BS ISO 4190-1[11] and BS ISO 4190-2[12])

Speed (m/s)	Dimension	Size for given rated load		
		1275/1600 kg	2000 kg	2500 kg
0.63/1.00/1.60/2.00/2.50	Min. width (mm)	3200	3200	3500
	Min. depth (mm)	5500	5800	5800
	Area (m^2)	25	27	29

Notes:
(1) For multiple lifts (side-by-side or facing), see formulae given in BS ISO 4190.
(2) Machine room clear height to be at least 1.8 m for movement and at least 2.0 m at working areas.

Table 5.A1.6 Machine room sizes: electric traction goods lifts; Series A (Europe) (sources: BS ISO 4190-1[11] and BS ISO 4190-2[12])

Speed (m/s)	Dimension	Size for given rated load		
		630 kg	1000/1600/2000 kg	2500/3500/5000 kg
0.25/0.40/0.50/0.63/1.00	Min. width (mm)	2500	3200	3000
	Min. depth (mm)	3700	4900	5000

Notes:
(1) For multiple lifts (side-by-side or facing), see formulae given in BS ISO 4190.
(2) Machine room clear height to be at least 1.8 m for movement and at least 2.0 m at working areas.

Table 5.A1.7 Machine room sizes: all hydraulic lifts (passenger and goods) (sources: BS ISO 4190-1[11], BS ISO 4190-2[12]))

Speed (m/s)	Dimension	Size for given rated load
		320/450/630/800/1000/1275/1600/1800/2000/2500/3500/5000 kg
0.25/0.40/0.50/0.63/1.00	Area (m^2)	[Well width (m) or well depth (m)] × 2.0 m

Notes:
(1) For multiple lifts (side-by-side or facing), see formulae given in BS ISO 4190.
(2) Machine room clear height to be at least 1.8 m for movement and at least 2.0 m at working areas.

6 Firefighting lifts and escape lifts for people with disabilities

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Chapter contents

6 Firefighting lifts and escape lifts for people with limited mobility

6.1 Introduction

This chapter explains the basic requirements for lifts that are intended to be used in fire situations. In the event of fire, evacuation routes for occupants of buildings are usually via fire resistant stairways. However, provision may still have to be made for a lift to operate during a fire, either to enable firefighters to access upper floors safely or, in some buildings, to assist in the evacuation of persons with limited mobility.

All new lifts installed to perform firefighting or evacuation functions should meet the requirements of the Lifts Regulations(1). This can be achieved by compliance with the harmonised standards BS EN 81-1(2) for electric traction lifts and BS EN 81-2(3) for hydraulic lifts.

In addition, requirements are specified in BS EN 81-72(4) for firefighting lifts and BS 9999: 2008: *Code of practice for fire safety in the design, management and use of buildings*(5) for evacuation lifts. It should be noted that BS EN 81-73: 2005: *Behaviour of lifts in the event of fire*(6) does not apply to either firefighting lifts or lifts used for the evacuation of a building.

BS 9999 gives recommendations and guidance on the design, management and use of buildings to achieve reasonable standards of fire safety. Readers are advised to refer to this standard to determine any national building requirements. The main sections concerning lifts can be found in clauses 16.7 and 21.3.

There are no standards for evacuation lifts at the time of writing. However, BS 9999 gives recommendations in Annex G.

Should any of the recommendations of BS 9999 or the requirements of local fire authorities necessitate a deviation from BS EN 81-1, BS EN 81-2, or BS EN 81-72, as appropriate, then notified body approval must be obtained.

6.2 Need for firefighting lifts

6.2.1 General

A standard lift fitted with a fire service switch cannot be considered as a firefighting lift. The provision of firefighting lifts requires substantial expenditure and therefore the need for such a lift should be properly established. This section provides guidance on the design of firefighting lifts. Its aim is to provide a basic understanding of the relevant standards and how they affect lifts. It is not, however, intended to be comprehensive and, where appropriate, reference should be made to the Building Regulations(7) and relevant British Standards(2–6,8–16,18–28).

6.2.2 History and development

As early as 1930, it was recognised that firefighters should be provided with a means of swift access to the upper floors of large buildings. This resulted in conventional passenger lifts being fitted with a break-glass key switch at the firefighter's access floor that, when operated, brought the lift to that floor quickly.

It was determined that such lifts should have power-operated doors 2 ft 9 in (800 mm) wide. Their capacity would be 1200 lb (550 kg) and they would be sufficiently fast to travel the height of the building in less than one minute. Additional requirements, such as fire resistant landing doors, rated at half the value of the structure (normally one hour) were gradually introduced. Some local authorities imposed further specific requirements such as those contained in Section 20 of the London Building Act 1939(17). The main requirements were taken into BS 2655: Part 12, which was superseded in 1979 by BS 5655(11,12,18–25). BS 5655: Parts 1 and 2 have subsequently been superseded by BS EN 81-1/2(2,3), which defines the fundamental safety requirements for the lift. As a product standard it provides little guidance related to the building structure as the design of buildings is a national issue. Details of requirements for the structure of the building in relation to firefighting lift shafts were contained in BS 5588-5(12) but are now within BS 9999(5).

Although these standards defined the basic requirements for 'firefighter's lifts', no guidance is given on the circumstances in which such a lift should be provided. This information is contained within the Building Regulations Approved Documents that direct the reader to BS 9999.

BS 5588-5 was first published in 1986 and has been republished in 1991 and 2004. Its content has now been incorporated within a new standard, namely BS 9999.

It is now recognised that modern firefighting techniques involve the use of equipment that needs to be moved by means of the lift. Furthermore, firefighters need a safe and reliable means of access to the upper floors of large buildings. The concept of the firefighting lift was devised to meet these requirements and today BS 9999: 2008 provides the guidance on the need for and design of the building for firefighting lifts whilst BS EN 81-72(4) defines the technical rules for the design of the lift itself.

BS 9999: 2008 is a compilation of all fire related standards into a single document. In relation to lifts little of the technical detail has changed. It includes the following:

— recommendations for vehicle access, water supplies, fire control centre, drawings for fire service use and smoke control

— removal of all recommendations relating to firefighting lifts that are now covered in BS EN 81-72[4]

— updating of recommendations to reflect new regulations and changes in practice since the previous edition.

BS 9999: 2008 directs designers to use a firefighting lift in accordance with BS EN 81-72 as this is a harmonised standard. As a harmonised standard it has been introduced to remove barriers to trade for industry, and lifts constructed in accordance with this standard are recognised and accepted across Europe. The standard is a product standard and this means that, whilst it defines in detail the requirements for a firefighting lift, it does not define when such a lift is required nor does it state requirements for the building. These matters are left to national building standards and in the UK this means BS 9999.

BS 9999 therefore has no role to play in relation to the design of the lifts itself. It defines when such lifts are required, as well as the fire resistance requirements for the structure of the lift well etc.

The ongoing development of these standards for lifts and buildings is the result of changes in the way that fires are tackled and firefighting techniques need to be understood in order to appreciate fully why the requirements should be met in full.

On arrival at a fire, the fire brigade should establish where the fire is located. This information can be gained by various means such as fire detection systems, or from persons who have seen the fire. While this information is being obtained, the firefighting lift should be called to the fire access lobby and taken under the control of the fire brigade. When the location of the fire has been established, a team of four firefighters may use the lift to travel to the floor below the floor on which the fire is located. These firefighters can be carrying various items of equipment, including breathing apparatus, and requires all of the space offered by an eight person (630 kg) lift car, even though they are only four in number.

On reaching the floor below the fire, three firefighters should leave the lift and make their way by the stairs to the floor on which the fire is located. Meanwhile the remaining firefighter may use the lift to return to the fire lobby in order to bring up more firefighters and equipment. In large fires, the floor below the fire is normally established as a base where fire crews may rest and recharge breathing equipment, and where casualties may wait for transport to the fire service access (exit) level (FSAL). In such cases, the importance of the lift increases, rather than diminishes, as the fire develops and therefore it is essential that the fire brigade can maintain good communication with the lift car and retain full control over it.

6.2.3 Scope of BS 9999: 2008

BS 9999[5] gives recommendations and guidance on the design, management and use of buildings to achieve reasonable standards of fire safety for all people in and around buildings. It is not applicable to individual dwelling-houses and might have only limited applicability to certain specialist buildings and areas of buildings (e.g. areas of lawful detention).

This British Standard is applicable to the design of new buildings and to alterations, extensions and changes of use of an existing building. It also provides guidance on the ongoing management of fire safety in a building throughout the entire life cycle of the building, including guidance for designers to ensure that the overall design of a building assists and enhances the management of fire safety. It can be used as a tool for assessing existing buildings, although fundamental change in line with the guidelines might well be limited or not practicable.

The recommendations and guidance given in the standard are intended to safeguard the lives of building occupants and firefighters. Whilst some of the recommendations and guidance might also assist in the achievement of other fire safety objectives (such as protection of property, the environment, communities and business/service viability), additional measures might be necessary that are outside the scope of the standard.

The standard does not cover fire safety design strategies for extreme events such as terrorist actions.

6.2.4 General lift requirements of BS 9999

The requirements are complex and to some extent depend on the building use, size, number of floors etc. To determine exactly what is required in a given building requires reference to the standard itself but, in essence, the following is a general guide.

The standard suggests that buildings, or parts of buildings, where either the height of the surface of the floor of the topmost storey (excluding plant rooms) exceeds 18 m, or the depth of the surface of the floor of the lowermost storey exceeds 10 m, should be provided with a firefighting shaft containing firefighting stair, a firefighting lobby with a fire main, and a firefighting lift.

The number of shafts is determined by the length of a fire hose combined with floor area; the standard recommends that sufficient shafts be provided and positioned to give one firefighting shaft for buildings with a floor area up to 900 m^2 on any storey and at least two shafts where the floor area on any storey exceeds 900 m^2. The distance between the shaft and the accommodation to any point on the storey should not exceed 60 m. If the internal layout is not known, a direct route of 45 m may be used for planning purposes.

If the building is fitted throughout with an automatic sprinkler system and the largest storey is over 18 m above ground level, then a sufficient number of firefighting shafts each containing a firefighting lift should be

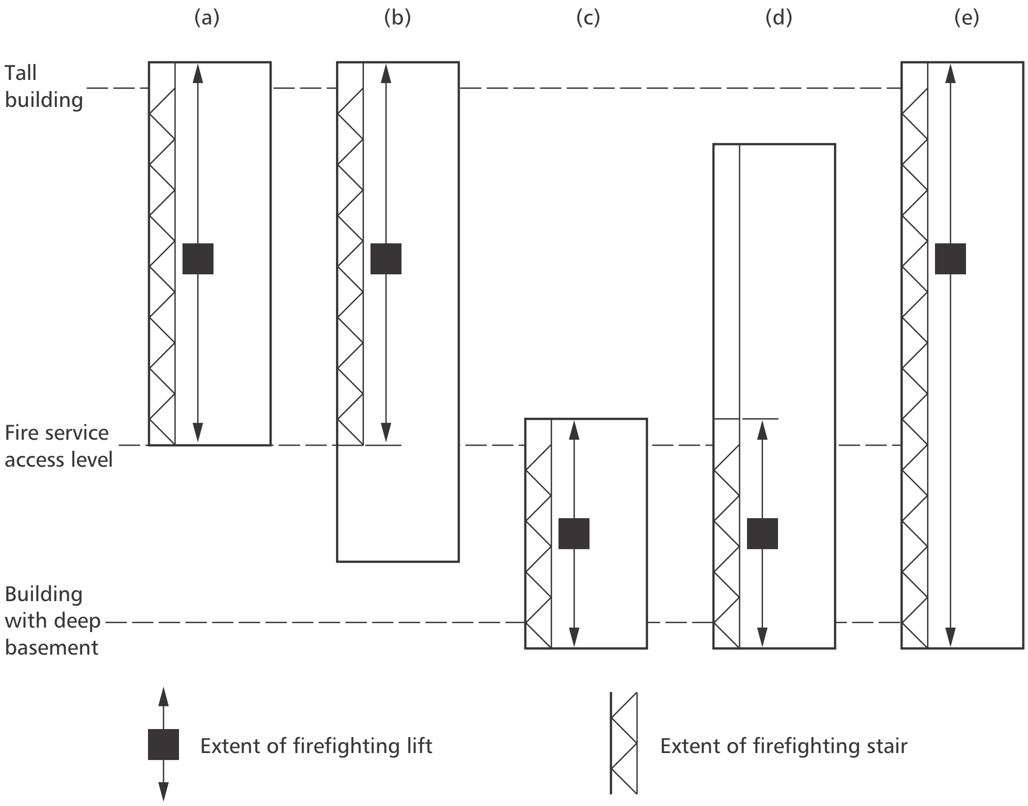

Figure 6.1 Extent of travel of firefighting lift; (a) buildings over 18 m high without basement, (b) buildings over 18 m high with basement less than 10 m deep, (c) buildings with basement only; (d) buildings less than 18 m high with deep basement, (e) buildings over 18 m high with deep basement

provided such that every part of every storey is no more than 60 m from a fire main outlet.

Whilst it is desirable for lifts to serve all storeys of a building, it is not essential. In large complexes, several lifts may be provided for firefighting, some of which may serve upper floors while others serve basements. Figure 6.1 outlines the extent of travel required by a firefighting lift.

The location of firefighting shafts should be such that they allow access to every part of every storey that they serve and should, wherever possible, be located against an exterior wall.

If it is not possible to locate the firefighting shaft against an exterior wall, the route from the fire service entrance to the firefighting shaft (protected corridor) should be as short as possible and preferably not more than 18 m in length. It should be protected by fire-resisting construction to ensure that fire does not affect the route or cut off the means of escape for fire service or other personnel within the building.

The layout of the firefighting shaft at fire service access level should be arranged so that firefighters and persons escaping down the firefighting stair do not get in each others way.

It should not be necessary for persons escaping down the stair to pass through the firefighting lobby at fire service access level. Where a protected corridor for firefighting access also forms part of the means of escape from the accommodation, it should be 500 mm wider than that required for means of escape purposes (to allow room for fire service personnel to move towards the firefighting shaft), and the firefighting lobby should have a minimum area of 5 m^2 clear of any escape routes so that it can act as a fire service mustering point.

The firefighting lobby at fire service access level should be big enough to act as a command post where firefighters and firefighting equipment can be safely assembled.

It should be noted that, although passengers may use the lift during normal operation, its primary function should not be for the transportation of goods, i.e. it should not be a goods lift.

Whichever layout or position is selected, firefighting lifts should be within a firefighting shaft that contains stairs, lobbies, fire main and the lift itself. The entire shaft should be enclosed by a structure which is fire resistant (usually for two hours). Figure 6.2 shows a typical arrangement.

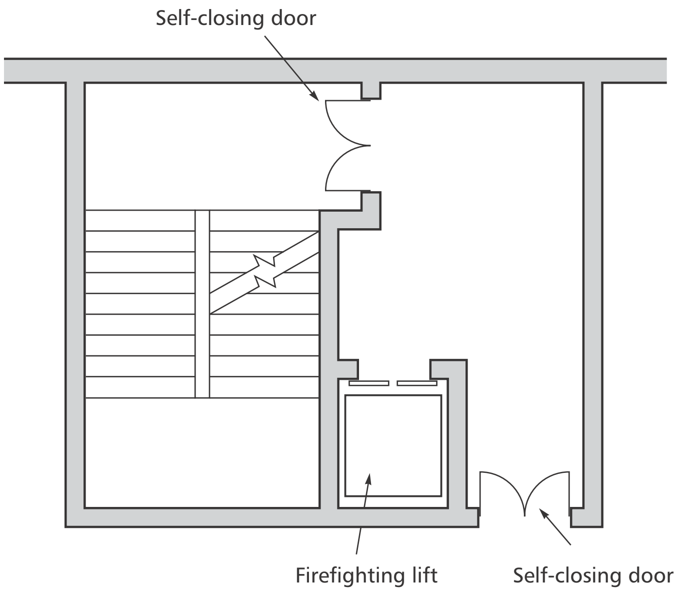

Figure 6.2 Typical layout for firefighting shaft

Without the provision of a lobby and stairs, the ability of a lift to operate during a fire is questionable. The lobby normally forms a refuge for those who are unable to escape down the stairs and may need assistance. It is not possible to ensure that the lift can withstand fire and so a lobby must be provided. In the event of a lift failure, an alternative exit from lobbies should be provided for firefighters, hence the need for stairs.

The firefighting lift may share a common well with other lifts, see Figure 6.3. In such cases it should also share a common lobby and all lifts in the shaft should be constructed to a similar standard in terms of the fire resistance of the materials used and all should have fire resistant landing doors.

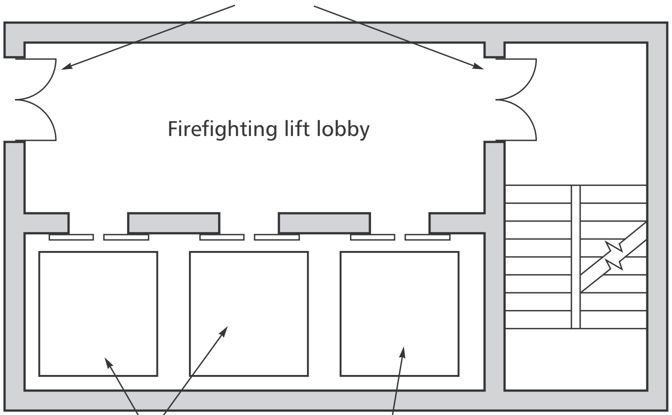

Figure 6.3 Layout of a firefighting cell with shared lift shaft

BS 9999 also provides detailed guidance on the requirements for fire escape routes, stairs and lifts. While detailed consideration of escape routes and stairs is outside the scope of this Guide, it is important to note that pressurisation of firefighting shafts may be used in certain circumstances. However, the lift supplier should be informed of this intention.

Such pressurisation systems are contained in BS 9999[5]. Following the principles given in BS 9999 the system provided should keep both the firefighting lift well and stair enclosure clear of smoke. In the event of smoke entering the firefighting lobby, the pressure within the stair enclosure should not drive smoke and hot gas into the lift well or vice versa. Information on the control of heat and smoke is contained within clause 28 of BS 9999: 2008. This includes typical leakage rates through lift doors. It should be noted that it is not practical to seal the lift doors to reduce leakage and the addition of brush or similar seals may invalidate the fire certification applicable to the doors. Typical pressure levels for such systems are in the range 30–60 Pa and, while such pressures may not generally disturb operation of the doors, it is advisable to notify the lift supplier of the intention to pressurise the installation and provide details of the likely pressures.

6.3 Design considerations for firefighting lifts

6.3.1 General

BS 9999[5] provides detailed guidance on the design of the building, the location of firefighting shafts and what should be contained within a firefighting shaft. When a firefighting lift is required BS 9999 does not define how it should be designed, but instead calls on BS EN 81-72[4] for this detail.

The lift should first meet the safety requirements given in BS EN 81-1[2], or BS EN 81-2[3], as applicable. BS EN 81-72 specifies the additional lift requirements and BS 9999 specifies various building requirements. The additional requirements are:

— Firefighting lifts should be at least 630 kg rated load; the internal dimensions of the car should be 1100 mm wide, 1400 mm deep.

— The rated speed should be sufficient to enable the lift to run the full travel of the building in less than 60 seconds. (An approximation of the minimum speed required may be obtained by dividing the total travel by 60 seconds minus 8 seconds for the car to accelerate and decelerate.)

— Automatic power-operated doors should be provided, at least 800 mm wide by 2000 mm high. A fire rating of at least one hour is usually required for the doors.

— Lift position indicators should be provided both in the car and at the firefighter's access level to show the car position at all times while power is available.

— A two-way intercom should be provided between the car, machine room or emergency and inspection panel for machine room-less lifts and firefighter's access level. It should be switched on automatically when the lift is put to firefighting operation. A handset should not be used for the fire service access level and car. These should use built-in devices. It is important to note that this lift communication system is for the fire service, but is not part of the fire service communication system that is required in firefighting shafts according to clause 24 of BS 9999: 2008.

— The lift should be clearly marked in accordance with BS 5499-1[14]:

'FIREFIGHTING LIFT.
DO NOT USE FOR GOODS OR REFUSE'

— In buildings where the firefighting lift is the only lift, every firefighting lift lobby should have a notice stating:

'FIREFIGHTING LIFT.
DO NOT OBSTRUCT LIFT DOORS.
DO NOT LEAVE GOODS IN LIFT.'

— An emergency trapdoor should be provided in the lift car roof. For a 630 kg lift this trapdoor should measure at least 0.4 m by 0.5 m. In the case of larger lifts the trap door should be at least 0.5 m by 0.7 m.

— According to BS EN 81-72, provision shall be made for rescue from inside and outside the car. This is not called for in BS 9999 but is required if claiming compliance with BS EN 81-72.

— Car buttons and controls should be protected from the effects of dripping water and, in addition to the normal storey markings, should indicate the fire service access level (FSAL) with a pictogram, see Figure 6.4, on or near the controls.

Illustration in white. Backgound in red.

Size:

- 20 mm x 20 mm for a symbol on the car operating panel
- a minimum of 100 mm x 100 mm on a landing
- on a dual entry lift the car operating panel used for firefighting operation shall have such a sign 20 mm x 20 mm

Figure 6.4 Pictogram to identify fire service access level

— Electrical equipment on landings, within the lift car and shaft should be protected against the effects of water.

— An audible (and preferably also a visual) alarm should be provided within the shaft and machine room to alert maintenance engineers of operation of the firefighting switch while on inspection control.

— The lift should have a secondary supply. In the event of loss of the mains supply and on establishment of the secondary supply, the lift should re-establish its position without moving more than two floors in the direction of the firefighter's access floor.

6.3.2 Car entrances

Cars for firefighting lifts should preferably be front opening, i.e. entrance to the car is from one side only. If a dual-entry lift with front and rear openings also serves as the firefighting lift, additional precautions for the rear entrance may be required and it is usually necessary to provide a second fire lobby, as shown in Figure 6.5. However, the additional cost of such arrangements should be carefully considered. The advice of the local building control officer and fire officer should be sought.

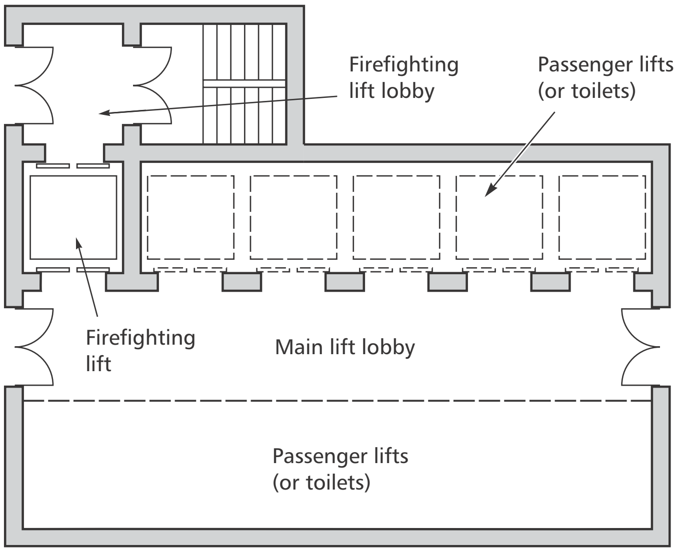

Figure 6.5 Provision of additional fire lobby for a dual-entry car

6.3.3 Machine room location

Where provided, a lift machine or pump room (machinery space) should preferably be sited above the lift shaft and access should be via the firefighting stairway adjacent to the lift. If it is essential to locate the machine or pump room at the bottom of the building, it should be towards the rear or side of the shaft rather than directly below where it is vulnerable to falling water. Access to such machine rooms should still be via a fire protected route, preferably the firefighting stairway. Any apertures in walls or floors separating machine rooms from lift shafts should always be kept to a minimum. Water should be prevented from entering the machine room.

Machine room-less lifts are now common and their use is not precluded by BS 9999(5) or BS EN 81-72(4). With these lifts, the machines, controllers, drives and other equipment that was traditionally placed in the machine room are located in the lift shaft, see section 7.2.8.

For lifts without machine rooms, the equipment should preferably be located away from the pit area to avoid complex water protection of the equipment.

Sprinklers are not required in firefighting lifts and should not be installed in machine rooms or lift wells for these types of lifts.

6.3.4 Protection of lift shaft from water

BS 9999(5) advises that, during a fire, considerable quantities of water can be present on landings. The most likely source of water may be from fire hoses or accidental discharge from risers located in the lift lobby. The flow rate from such sources may be assumed to be approximately 25 litres per second. Every effort should be made to prevent this water from entering the lift shaft. Floors in the fire lobby should be sloped away from the lift, with drains or scuppers provided to remove water from the immediate area in front of the lift doors. Water should also be directed away from stairways.

Risers should be directed away from lift doors but it is inevitable that there may be minor spillages that can find their way into the lift shaft. For this reason it is necessary to provide some degree of water protection to any electrical components in the lift.

BS EN 81-72[4] requires that protection be provided to electrical lift equipment in the shaft that is located within 1.0 m of the lobby. The protection should cater for splashing water and may be satisfied by either shrouds and covers, or by providing IPx3-protected equipment that meets the requirements of BS EN 60529[16]. Attempting to provide a higher degree of protection in the hope of avoiding the need for sloping floors or gullies is not reasonable because, whilst it may be possible to provide complete protection from water, the resulting lift design may no longer comply fully with BS EN 81-1/2[2,3].

6.3.5 Power supplies

Two independent power supply systems are required unless the lift is of the hydraulic type and serving only two adjacent floors, one of which is the final exit floor. The primary electrical supply should be from a sub-main circuit exclusive to the lift and independent of any other main or sub-main circuit, see Figure 6.6. Other lifts in the firefighting shaft may be fed from the same primary supply, provided that the supply is adequate for the purpose. Such an arrangement should be designed so that a fault occurring in any other lift in the firefighting shaft, or in the power supplies to any of these lifts, should not affect the operation of the firefighting lift. BS 9999[5] contains a note stating that for legal reasons power supply companies have reservations about offering a power supply from a secondary substation, see BS 9999 (note to clause 38.2.3.3).

The secondary power supply should be independent of the normal power supply to the firefighting shaft, e.g. a standby generator (with automatic start). The lift supplier should not be asked to provide this secondary supply since it serves not only the lifts, but also the firefighting shaft. The lift supplier cannot be expected to know what other plant is to be connected to it. The secondary supply should have sufficient capacity to:

- maintain the firefighting lift in operation for at least two hours
- support any auxiliary equipment such as ventilation or pressurisation plant
- and, if required, to be able to recover all other lifts to a specified safe location, one at a time within the firefighting shaft.

The secondary supply should be available within 30 s of the loss of the normal supply. The supplies should be via fire-protected routes with the same level of protection afforded to the lift by the structure, usually two hours. Cables for these supplies should be terminated in an automatic supply change-over device that may be located in the firefighting shaft (see BS 9999[5], clause 38.2.3.3, BS 5588-5[12]). This does not mean in the lift well itself — it means in the protected shaft provided for firefighting.

According to clause 29 of BS 9999, an indication of the status of the following should be provided adjacent to the firefighting lift switch:

- the primary and secondary power supplies
- any powered ventilation or pressurization systems.

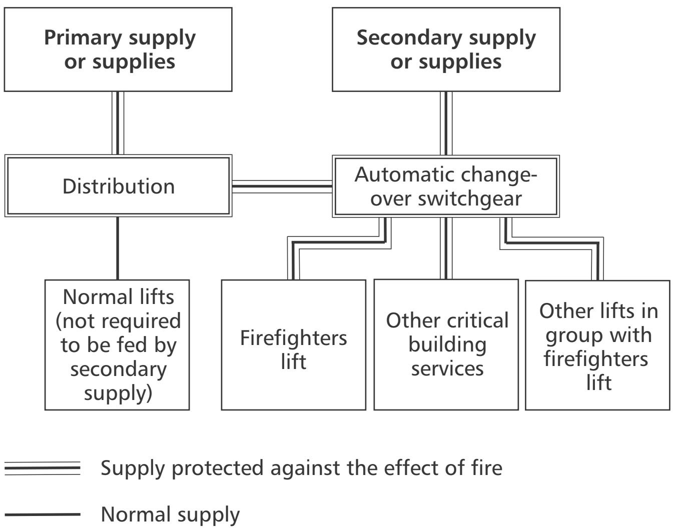

Figure 6.6 Block diagram for independent power supplies to firefighting lifts (reproduced from BS EN 81-72 by permission of the British Standards Institution)

6.3.6 Firefighter's switch and operation

A firefighter's switch located within a faceplate and marked with a pictogram (see Figure 6.4) should be positioned adjacent to the lift entrance at the fire service access level. Operation of the switch should be by means of a triangular key with the 'on' position (marked by an 'I') and the 'off' position (marked by 'O'). Operation of the switch puts the lift into firefighting service, as follows:

- All special services except inspection should be ignored. All lifts within the firefighting shaft should return to the fire access level without stopping.
- When any lift arrives at the fire service access level, it should discharge its passengers and then close its doors unless it is a firefighting lift or where local building control requires the doors to be kept open. Firefighting lifts should remain with their doors open.
- All landing calls should be made inoperative but car calls in the firefighting car remain active. On dual-entry cars only the doors on the firefighting lobby side should operate (see section 6.3.2). Passenger detectors or other similar door reversal devices should be made inoperative and the communication system, switched on automatically.

The firefighter's operation of the lift is as follows:

- If a call is entered in the firefighting lift car, it responds to that call and no other.
- While the car is in motion, it should be possible to enter other car calls and thereby stop the car in response to the first call registered.

— When the car stops at a call, this should cancel that call and all others.

— When the lift stops at a floor its doors should open only when there is sustained pressure on the door button and if the button is released while the doors are opening, they should immediately re-close.

— Once fully open, the doors should close only in response to constant pressure on another car call button. If this button is released before the doors are closed, they should re-open. The buttons should illuminate to indicate any call that is registered. Alternatively, a separate indicator light may be provided.

6.3.7 Owner's information manual

The owner should be provided with a manual that explains how the lift is to be used and how its features work. This should include a description of the firefighting lift operation and the importance of keeping the lift properly maintained.

Table 6.1 Routine checks

Frequency	Requirement
Weekly check	Operation of the firefighting lift switch by the building maintenance staff who should check that the lift returns to the lobby and parks with its doors open. Failure in this simple test should be reported immediately to the lift maintenance company.
Monthly check	Simulate failure of the primary power supply. Building maintenance staff should then operate the firefighting lift switch and observe its operation by entering a few calls. The lift maintenance company may be asked to be present at these tests but their presence will probably incur additional charges.
Six monthly check	Inspection and testing of the operation sequence of the lift should be made by the lift maintenance company.
Annual check	A full operational test of the lift should be performed at least once per year. A record of this test should be retained by the building management. This test is not normally part of a regular maintenance contract and this point should be clarified whenever a maintenance/service contract is agreed otherwise additional charges may be imposed.

6.4 Testing and maintenance of firefighting lifts

6.4.1 Operational tests prior to handover

A suitable test document for firefighting lifts is provided in Annex D of BS 8486[26,27]. A conformity verification table is provided in BS EN 81-72[4], clause 6. The lift supplier should carry out tests to satisfy themselves that the lift fully meets the requirements. There is no requirement for the supplier to actually issue to the owner a test certificate, but they are required to state on the lift's Declaration of Conformity those standards to which the lift is designed.

6.4.2 Routine inspection and maintenance

Once in service, the lift, along with all other firefighting equipment and services, should be regularly inspected and the results of the inspections recorded. For the lift the checks shown in Table 6.1 are recommended.

6.5 Evacuation lifts for persons with limited mobility

6.5.1 General

While planning fire prevention and escape routes for a building, consideration should be given to the controlled evacuation of persons with limited mobility who use the building or those who may be injured during an emergency. In the event of a fire, the occupants should usually evacuate a building by means of stairways. However, alternative provisions for the evacuation of people with limited mobility must be considered. This section provides guidance for the design of lifts intended to be used for the purposes of escape as previously given in BS 5588-8[20] but now incorporated within BS 9999: 2008[5]. Whilst the type of building and its use should determine whether persons with limited mobility need to be moved by lift, those responsible for building control may also require that such provision be made.

6.5.2 Access/egress for persons with limited mobility

It is a requirement of UK building legislation that access provision should be linked to egress provision and, since lifts were already being used to provide access for persons with limited mobility, concern was expressed over the possible use of such lifts for escape. In response to this BS 5588-8[20] was published but this information is now contained in BS 9999[5]. This latter standard provides detailed guidance for evacuation procedures and on the types of lift or other provisions that may be required. Although wheelchair and stairlifts fitted to a stairway may be suitable for access, they are not specifically mentioned as a suitable means of escape. Furthermore, stairlifts may impair evacuation if they reduce the usable width of stairways. If consideration of such devices is to be made, advice should be sought from local building control as to their suitability. Escalators are also excluded as a suitable means of escape, both for able-bodied persons and those with disabilities, other than in the most unusual and specialised situations such as airports and underground railway systems.

BS 9999 recommends that the lift be operated under the direction and control of authorised persons using an agreed evacuation procedure and the successful operation of escape lifts is very dependent upon the competence of the lift operator and the effectiveness of the building management procedure. Only disabled persons should use the lift because fixed stairs are still considered as the appropriate means of escape for able-bodied persons. It is not intended that persons with limited mobility should evacuate themselves from the building unaided, even where a lift is provided, and other means such as the provision of a refuge may need to be considered.

Fire procedures should not include the isolation of electrical circuits that supply the lift or its lighting, communication or ventilation. Any ramps used to allow changes in level or to allow entry into lifts should comply with BS 8300(15) in terms of slope and size.

6.5.3 Evacuation lifts for healthcare buildings

In hospitals and similar buildings not all the occupants can use the stairs or for that matter lifts in the conventional manner. Some patients may be compelled for medical reasons to remain in their beds. In such buildings evacuation may need to be made horizontally instead of vertically, at least in the initial stages of an emergency.

Horizontal evacuation involves moving beds and their patients horizontally through the buildings from a fire risk area to a safe area away from the emergency. The patients are then retained in this area until the emergency has passed or, if conditions deteriorate, they may be taken down and out of the building if necessary by lift.

The Department of Health has published a number of specifications for such buildings and their lifts as Health Technical Memorandums (HTMs). These include the following:

— HTM 08-02: *Lifts*(29)

— HTM 05-01: *Managing health care fire safety*(30)

— HTM 05-03: *Escape lifts in healthcare premises*; Part E: *Operational provisions*(31).

These documents call on the use of standards such as BS EN 81-1(2), BS EN 81-2(3) and BS EN 81-72(4), as well as referring to BS 9999(5).

In addition to a normal evacuation lift as described in BS 9999, evacuation and escape bed-lifts are required for the evacuation of bed-bound persons, in the case of an emergency, under the direction of either the building management or the rescue service in line with BS 9999.

The needs, requirements, mode of operation and control (lift warden) of an evacuation lift are determined by the fire strategy of the healthcare building as contained in HTM 05-03(31).

The basic requirements for the lift are similar to those called for under BS EN 81-72(4) but there are differences such as a roof trapdoor in lifts serving operating theatres to enable medical access in the event of a stoppage, different communication system, larger car and door sizes etc.

As HTMs are under continuous revision, the information provided here should be checked against the latest editions of these documents.

6.6 Design considerations for evacuation lifts

6.6.1 General

BS 9999(5) makes recommendations concerning the provision of lifts suitable for the evacuation of persons with limited mobility. These recommendations are based on the primary provision of an evacuation lift to BS EN 81-1(2) or BS EN 81-2(3) and then to the requirements of BS 9999(5). The requirements include:

— The lift car should be of at least 630 kg rated load, 8-person capacity and the internal dimensions of the car should be at least 1100 mm wide by 1400 mm deep.

— The rated speed should be sufficient to enable the lift to run the full travel of the building in less than 60 seconds (see 6.3.1 for calculation).

— Power-operated doors should be fitted, providing an opening of at least 800 mm by 2000 mm. The landing doors should provide protection from fire for at least half an hour.

— There should be two separate fire-protected power supplies. However, two-stop hydraulic lifts may not require an alternate means of supply since they can be manually lowered and may not require a special switch to enable the lift to be quickly brought to the main lobby.

— All controls should be at wheelchair height and a handrail should be provided.

— A communications system should be provided between the car and the machine room and the main lobby or in the case of machine room-less lift, between the car, main lobby and the emergency and rescue panel

— A break-glass switch or a Euro-type key switch, marked 'Evacuation Lift', should be located at the final evacuation floor. Operation of this switch should cause the lift to slow down, stop and return to the main evacuation floor without undue delay. While returning it should be prevented from answering any landing calls and once at the lobby, it should park with its doors open and then respond only to car calls. The lift should be under the sole control of the appointed user (fire warden).

BS 9999 allows alternatives to a separate escape lift, as follows:

— A firefighting lift (i.e. a lift to BS EN 81-72(4)) that the fire and rescue service has agreed may be used prior to their arrival as it should already have the main features required.

— In existing buildings, with the prior agreement of the fire authority, a normal passenger lift may be used provided it is of suitable size, has the same structural protection as a protected stairway, a duplicate power supply, a switch enabling authorised persons to take control and an agreed management procedure for its use during a fire.

6.6.2 Operation of the communication system

BS 9999 recommends that, except in two-storey buildings, some form of communication system should be provided to enable the rapid and unambiguous identification of those storeys where persons with limited mobility are present who may require evacuation, and the relaying of this information to the persons operating the evacuation or firefighting lift. Alternatively, requests may be made by the persons requiring assistance to the person controlling the evacuation using visual indicators or by telephone, and these may then be relayed to the lift operator by telephone, intercom or radio transceiver.

Communication is a key item during a fire and simple systems generally prove the most reliable. For example, at each landing, adjacent to the lift, there could be a telephone system which connects it to the lift main evacuation lobby. When the lift is required for a particular floor, the person responsible for the evacuation of persons with limited mobility from that floor can request the person in charge of the main lobby to despatch the lift, who relays the message to the lift driver by means of the lift intercom system.

An alternative or addition to this would be the provision of a break-glass switch of the push/pull type at each floor. When pushed it would latch and light an indicator lamp at the main landing. Resetting of the switch would be done manually by the person responsible for entering the call. The provision of complex automatic systems is not recommended and is unnecessary because it is not intended that persons with limited mobility should evacuate themselves from the building.

6.6.3 Other considerations

For details of other considerations see requirements given in section 6.3; i.e. machine room location (section 6.3.3), protection from water (section 6.3.4), power supplies (section 6.3.5), testing (section 6.4) and routine inspection and maintenance (section 6.4.2).

6.7 Using lifts for general evacuation

Since the destruction of the World Trade Center in New York on September 11 2001, there has been considerable discussion relating to the pros and cons of allowing all building occupants to use lifts during an emergency. The International Organization for Standardization (ISO) has carried out a major study of the possible implications of using lifts for the evacuation of everyone from a building. The study contained in ISO/DTR 25743[32] indicates that whilst it is possible to design a building using lifts for evacuation, the problems to be addressed are complex and in many instances expensive to implement. ISO/DTR 25743 provides a tool to assist all parties in the design team. It indicates major issues to be addressed and hints at how they may be addressed.

The European Committee for Standardization (CEN) has work in hand for the development of a European standard for an evacuation lift, prEN TR 81-76: *Evacuation of disabled persons using lifts*[33]. This standard should deal with lifts for those persons being assisted to evacuate, following a similar philosophy as BS 9999: 2008[5]. It does not allow for persons to evacuate themselves; this is due to the complexity of the issues raised by self-evacuation. Publication of this standard is, however, several years away.

The UK government has recognised that it may be possible to include lifts as part of an evacuation strategy in high-rise buildings but if this is done there will be no reduction permitted in the number of escape stairways or other provisions. In other words, the lifts can be an addition to all the standard provisions but not a replacement for them.

In buildings with less than 25 floors there is unlikely to be any reduction in the time to evacuate if lifts are used, and the time may well be increased above that which can be achieved by using stairs.

The decision to use lifts for general evacuation is one that cannot be taken by lift engineers. The lift can only do what it is instructed to do. If instructed to provide service to, say, floor 29, this is what it should do until a new instruction is given to tell it the floor is cleared.

These and many other issues should be addressed by the building design team. If people are told to use the lift in the event of a fire can we be sure that the fire is not in the lift? The design team must determine what strategy to adopt in the building for a given emergency and how the lift should respond.

The use of lifts should not be considered as an option without detailed discussions first taking place between the design team (which should include a fire engineer and the lift contractor) and building control.

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7 Lift components and installation

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Chapter contents

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7 Lift components and installation

7.1 Introduction

The Lift Directive 1995[1] opened the doors to much innovation in lifts. This has come about as there is no longer a legal requirement for any particular standard to be followed when designing a lift. The manufacturer is instead legally obliged to meet the requirements of the Lift Directive (Lift Regulations 1997[2] in UK) by some suitable means. This freedom has resulted in the introduction of new components and technologies into the lift market. The legislative freedom combined with requirements for ever safer products has resulted in a number of new or improved components being introduced.

This chapter describes the main components used in modern lifts, both electric traction and hydraulic, and their basic installation requirements. The main components of a lift are its prime mover (traction machine or hydraulic pump, depending on the type of drive), the lift car, counterweight (if used), guide rails, entrances, safety gear and governor, buffers, ropes and fixtures (i.e. buttons, indicators and switches).

Typical arrangements and the main components are indicated in Figure 7.1 for electric traction lifts and in Figure 7.14 for hydraulic lifts. Many variations of these basic arrangements are possible but the component parts are fundamentally the same.

7.2 Electric traction drives

7.2.1 General

Electric traction drives, see Figure 7.1, can be grouped into several categories based on the motor type and its control.

Geared traction drive systems:

— single-speed AC
— two-speed AC
— variable voltage AC
— variable voltage, variable frequency AC
— variable voltage DC.

Gearless traction drive systems:

— variable voltage DC
— variable voltage, variable frequency AC.

To the above types should now be added linear induction drives, see section 7.2.9.

Historically, the required lift speed and ride quality have determined to a large extent which type of drive is used for a particular application. Today, with solid-state control incorporating feedback techniques (see section 8.3.3), good ride comfort and levelling accuracy can be obtained for most types of electric traction lifts without large cost penalties.

In the past, DC motors have provided the best ride quality because the speed of the motor can be easily controlled using a DC generator with a variable output (see section 8.5.1). Consequently, DC motors have been used for the majority of applications requiring a smooth ride and accurate levelling. During the 1980s, static converters were replacing DC generators as the means of supply for

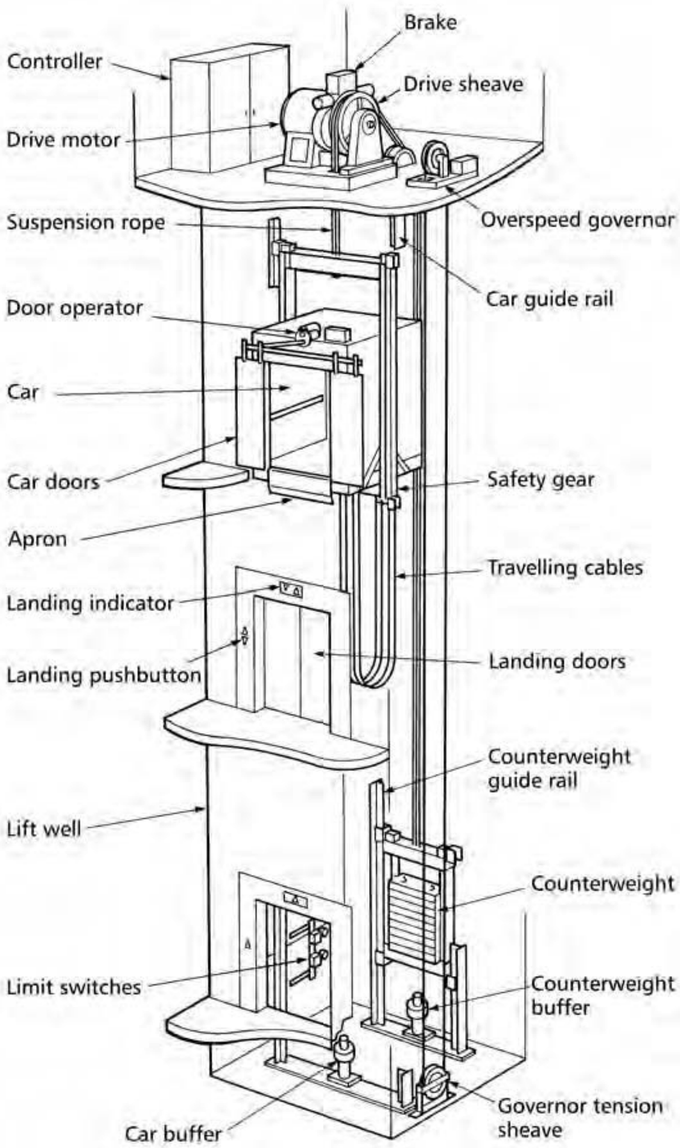

Figure 7.1 Electric traction passenger lift; principal components

large DC motors. Compared with DC generators, static converters are more efficient and provide improved control (see section 8.5.2).

Improvements in the control of AC motors mean that good ride quality may now be achieved using AC motors. Some manufacturers have used AC motors with helical or worm reduction gearboxes to attain speeds of up to 2.5 m/s. Advanced voltage and frequency control techniques have also led to the introduction of AC compact gearless permanent magnet drives. These provide ride quality to match DC gearless machines for any range of speeds.

Most modern drives use variable voltage variable frequency (VVVF) control systems with or without regeneration. Many compact designs have been developed using permanent magnet synchronous motors (PMSMs). For guidance on the application of various drive systems refer to BS 5655-6: 2002[3].

7.2.2 Gearless machines

The assembly comprises a drive motor, drive sheave, brake, direct current armature (or rotor in the case of AC drives), supporting bearings and, possibly, bedplate deflector or double wrap sheave. Gearless machines have

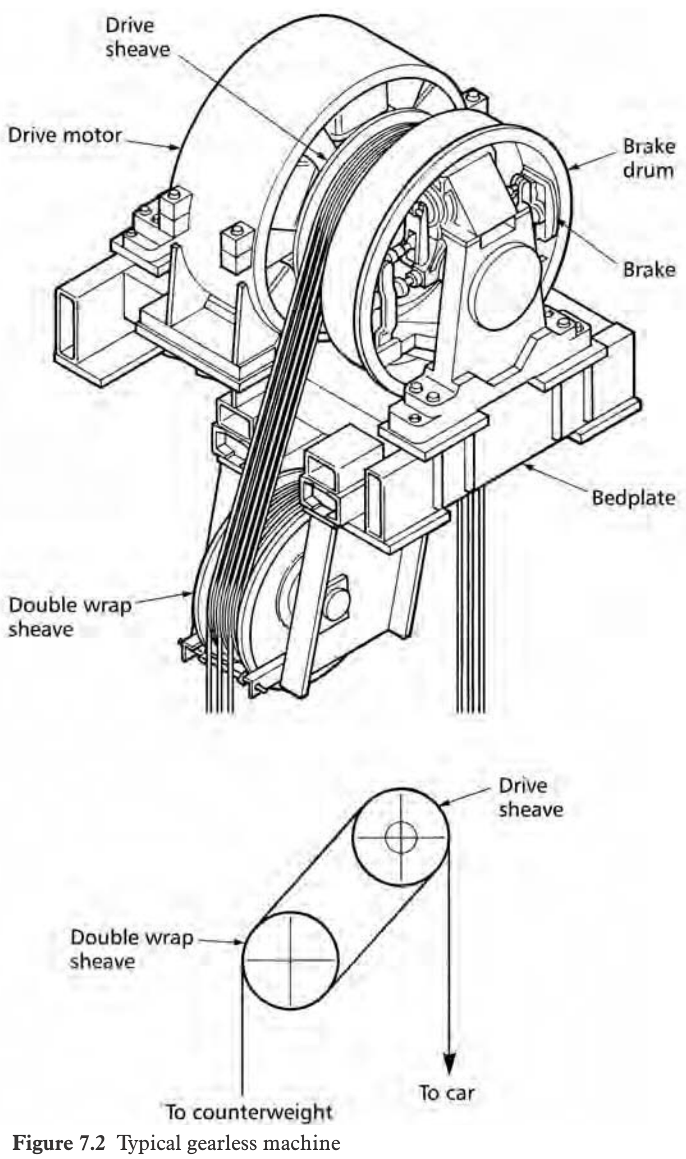

Figure 7.2 Typical gearless machine

generally been used for high-speed lifts, i.e. speeds from 2.5 m/s to 10 m/s. They are, however, now used for all speeds, including low speeds.

Figure 7.2 shows a typical gearless machine. Size, shape and weight may vary considerably between manufacturers but the basic principles and components can be the same.

Until recently, the motor in gearless machines has always been of the DC type but, with the development of high-speed variable frequency drives, AC motors are being widely used. Whichever type of motor is employed, the power developed is transmitted directly to the driving sheave which is located on the same shaft as the motor. Hence the sheave rotates at the same speed as the motor. The main shaft is supported on two large bearings that may be of the sleeve, roller or ball type.

The brake drum is usually formed as an integral part of the driving sheave and this may be one of several types, depending on the type of brake, e.g. external calliper, internal calliper or disc. Each type has advantages and disadvantages but the main consideration is that the type used should satisfy the relevant code requirements for the country in which it is to be installed. For Europe the requirement of BS EN 81-1[4] is that it should be capable of stopping the car when carrying 125% load at full speed whilst travelling down.

The brake is used only during emergency stopping and when at rest to hold the lift car during loading. Under normal operating conditions, speed controls are normally employed to bring the car to rest without the use of the brake. This means that the brake is little used and the linings can be slow to bed-in if hard materials are selected. For this reason, and because of the low rotational speed of such units, a relatively soft material is used.

7.2.2.1 Sheave shaft load

The load lifting capabilities of the machine are not limited by the power of the motor alone. During the design, certain bearings, bolts, steel section and grades of steel may have been selected for the construction of the unit. The materials used and the way in which the components are assembled can place a maximum limit on the load that the main shaft can support safely. This is referred to as the sheave shaft load, the value of which can be obtained from the manufacturer.

The sheave shaft load capability of the machine may vary depending upon the direction in which the load is applied. If the machine is located at the top of the building, with the load acting directly downwards, see Figure 7.3(a), the unit can generally support a higher load than if the ropes are deflected as shown Figure 7.3(b). Locating the machine at the bottom of the building usually results in an upward pull which can drastically reduce the sheave shaft load capability. This may necessitate the use of a much larger machine than was first envisaged. In the case of machines used in a double wrapped configuration, the sheave shaft load is approximately double the load of a single wrapped configuration. Standard layouts and other arrangements are considered in section 7.2.7.

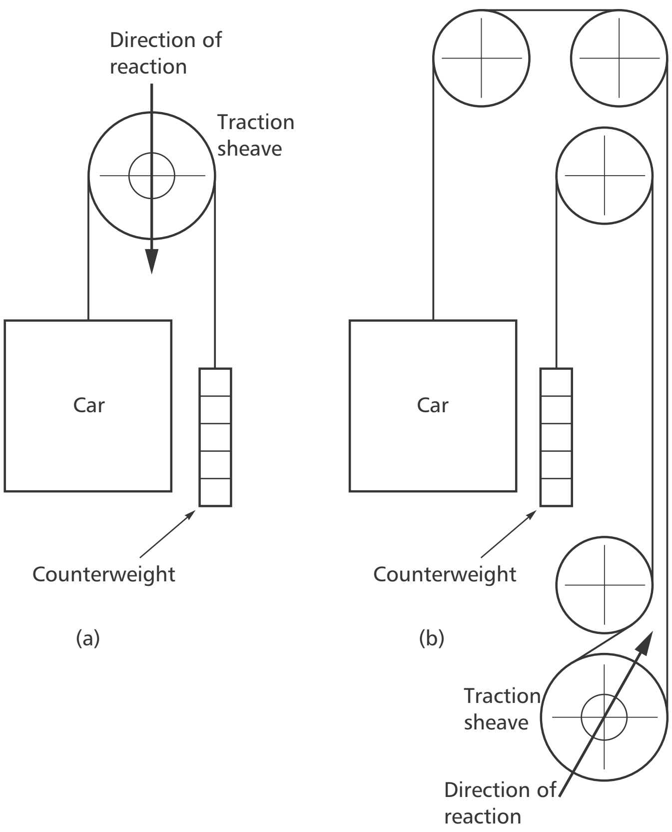

Figure 7.3 Sheave shaft load; (a) machine above with load acting directly downwards, (b) machine below with load acting upwards

7.2.2.2 Drive sheave

Gearless machines usually employ either a sheave cut with a specially formed traction groove, see Figure 7.4 (see also section 7.15.3, Figure 7.44), or are double wrapped, whereby the lift ropes pass over the drive sheave twice, see Figure 7.5.

Each method has its merits and can provide the required grip to move the car and ensure a long rope life, if properly designed. The main disadvantage of the double wrap method is that it takes up additional space since either a secondary level or pulley room should be provided or the unit should be raised to facilitate servicing of the double wrap sheave. However, with very large loads or speeds greater than 3.5 m/s, it is often the only method available.

As gear reduction is not employed, the rope speed is equal to the circumference of the drive sheave multiplied by the rotational speed (rpm) of the motor. A sheave diameter of 620 mm requires a motor of only 77 rpm to achieve 2.5 m/s. Gearless units have a slow rotational speed compared with geared machines, therefore sound isolation between the machine and structure is not usually required.

7.2.3 Geared machines

These comprise a traction sheave or drum, gearbox, brake, motor and possibly bedplate. It may also include a deflector sheave if mounted as an integral part of a bedplate assembly, see Figure 7.6. Strictly, however, the deflector sheave is not part of the machine assembly.

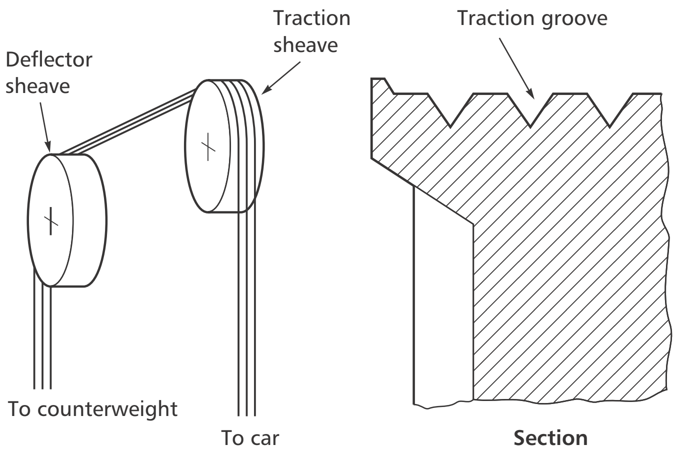

Figure 7.4 Single wrap arrangement with 'V' traction groove and detail of traction sheave

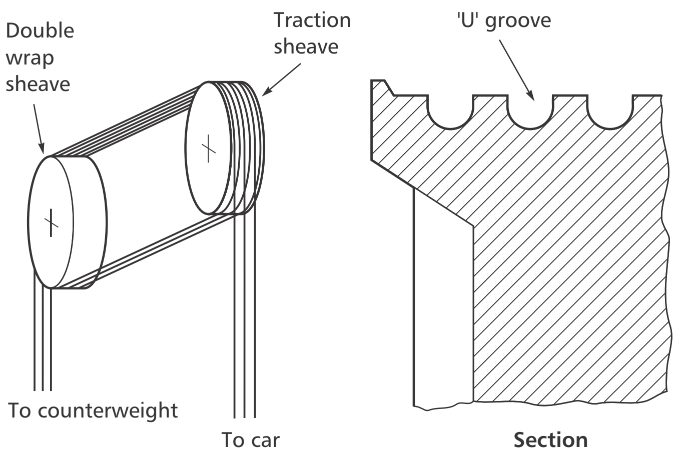

Figure 7.5 Double wrap arrangement with 'U' groove and detail of traction sheave

Geared machines are generally used for speeds between 0.1 m/s and 2.5 m/s and are suitable for loads from 50 kg up to 10 000 kg or more. The size and shape vary considerably with load, speed and manufacturer, but the underlying principles and components are the same.

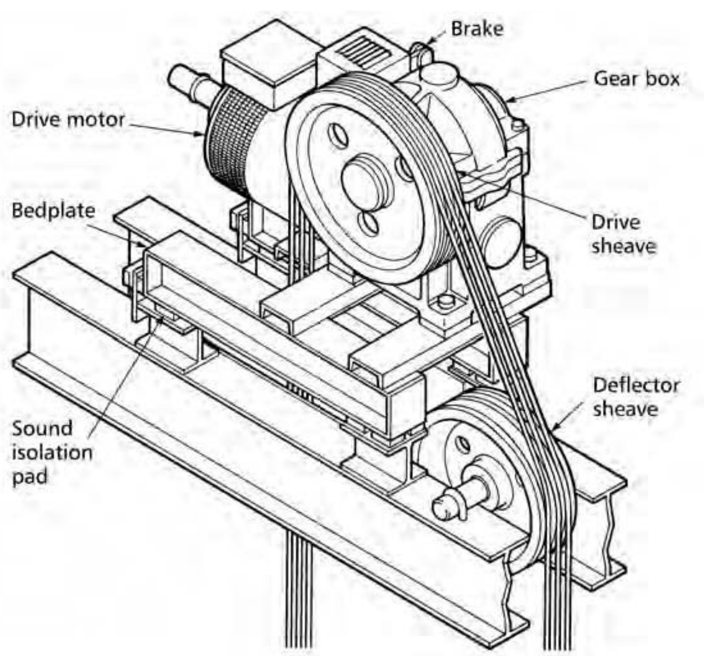

Figure 7.6 Typical geared machine

7.2.3.1 Motor

The motor may be of the AC or DC type, either foot- or flange-mounted. Foot-mounted types are available in a wide selection of sizes and makes, while flange mounting provides accurate alignment and, usually, a more compact design. There are no outstanding advantages for either type but for certain applications one particular type may be preferred. For example, for a lift on a ship, a foot-mounted motor would be preferred because of the greater availability of spare parts throughout the world. Whichever arrangement or motor type is employed, the motor transmits its power to the traction sheave or drum via reduction gear.

7.2.3.2 Gearbox

Worm reduction gear, comprising a worm shaft, cut with a coarse helical thread, and a worm wheel, is still the most common worldwide although helical gears have started to appear.

The worm shaft has a high running speed compared with that of the worm wheel and therefore is made from either case-hardened or high-grade carbon steel. Both these steels have advantages and disadvantages, but the essential requirement is the smooth running and long-life of the finished assembly. Therefore manufacturers choose materials best suited to the particular application.

The worm wheel can be made from various materials but bronze is by far the most common and has considerable advantages over the alternatives. However the performance and reliability of the complete unit is more important than the materials employed for the component parts.

The worm may be cut with one, two, three or more threads or 'starts'. The number of teeth on the worm wheel divided by the number of starts on the worm determines the ratio of the gear. For example, 48 teeth on the wheel and 4 starts on the worm gives a ratio of 12:1.

By selecting different ratios a large combination of speeds and loads can be obtained from a single machine type. Each manufacturer has its own selection of ratios for a particular machine and it is not practical to specify a special ratio as any new design can require expensive retooling and extensive testing.

The worm may be mounted vertically or horizontally, either above or below the worm wheel. Again each arrangement has its merits but none has any significant disadvantage. The worm shaft is supported by two bearings of its own or utilises one of the motor bearings. Whichever arrangement is selected, one of the bearings acts as a thrust bearing to prevent the worm from moving laterally. Depending on the design, a thrust movement of one or two thousandths of an inch may be allowed; in other cases no movement is tolerated. The manufacturer's requirements should always be met in this respect.

7.2.3.3 Worm wheel

The worm wheel may be supported on bearings, one of which may be either inboard or outboard of the traction sheave which is mounted on the same shaft. There is much argument as to the merits of inboard and outboard bearings. For example, the inboard bearing allows easy replacement of the sheave while the outboard bearing allows easy servicing of the bearing. The maintenance aspect, however, is insignificant since both components, if properly designed, can provide long service and neither arrangement should require frequent dismantling.

One of the main shaft bearings also serves as a thrust bearing to limit lateral movement of the shaft. Again, the manufacturer's tolerances should be accepted.

7.2.3.4 Gear life

As with the gearless units described in section 7.2.2, the load lifting capabilities for geared machines may be limited by the motor size, the load capacity of the main shaft and its bearings (sheave shaft load), and the load and kilowatt capacity of the gearbox. The gears may have been designed to transmit a certain amount of power for a given life. The life can be reduced by the transmission of excessive power or extended if reduced power is transmitted. While worm gears may appear simple their design is complex and there is much debate on the calculation of gear life.

BS 721[5] provides a basis for such calculations, but needs some modification to be realistic for lift gears. To make the calculation of gear life meaningful it is necessary to determine the load carried and the period for which it is carried. In a lift, the load is constantly varying between very light (i.e. empty car) and full load. The gear is not running in the same direction continuously and, for large portions of the day, it is not running at all. Most lifts spend more time at rest, being loaded and unloaded, than running.

It is easy to 'over-engineer', adding unnecessary costs to the installation, by assuming worst-case conditions, such as full load for the life calculation.

At present, gear life is usually expressed in hours, with 15 000 to 20 000 hours being typical. This roughly equates to 15 to 20 years for a lift serving the average office building. It may be tempting to select a higher figure than this, but longer life is achieved by over-sizing the gear, which results in extra costs. In most commercial buildings, lifts are modernised or replaced after 15 to 20 years (see chapter 16). At that time, the main components of the gear can also be replaced. If a 25-year gear life is selected, it is likely that the gear can be overhauled at the time of modernisation of the lift even though it may not yet be near the end of its design life. It may, however, be more cost effective to replace the unit with a modern, more efficient machine.

7.2.3.5 Drive sheave

The power transmitted by the gear results in rotation of the worm wheel shaft to which the traction sheave or drum is attached. These items are usually fixed to the main shaft by keys and bolts.

The sheave material is sometimes simple cast iron, but is more usually a complex alloy providing a combination of properties such as 'machineability', strength, coefficient of friction and durability. The aim of the traction system should be to provide sufficient traction to hoist the car whilst ensuring good rope life. These criteria are affected by the rope size, number and type, rope pressure, sheave material, sheave groove type (see Figure 7.44), acceleration rate, and the presence of pollutants and abrasives in the atmosphere.

Most manufacturers have, through experience, determined the best combination of these criteria for their particular design and should not be required to use particular materials or rope types that they do not usually employ.

Premature rope or sheave failure is more often due to unequal rope tension than any other single factor and good maintenance is therefore essential. It is not unreasonable to expect the sheave to last the life of the machine provided it is correctly serviced.

7.2.4 Brake

At some position along the motor or worm shaft a brake drum is generally provided. The usual locations are between the motor and gear or on the opposite end of the gear to the motor, see Figure 7.6. The requirements for the brake vary according to the drive system. Figure 7.7 illustrates an electromagnetic brake with spring above.

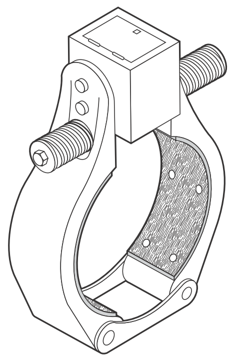

Figure 7.7 Electromagnetic brake with spring above

Simple single-speed and two-speed drives may use the brake for stopping at floors and for emergency stops. With more sophisticated motor controls, the brake may be used only for emergency stopping and parking. Whichever braking system is adopted, it should satisfy the requirements laid down in BS EN 81-1[4], i.e. it should be capable of stopping the car when carrying 125% load at full speed whilst travelling down.

7.2.5 Machine bedplate

The gearbox, motor and brake may be assembled on a common bedplate. This fabricated steel structure serves to keep all parts in accurate alignment and allows one-piece shipment. It is important that the bedplate does not deflect under load thereby causing misalignment of the motor and gear. Some machines have the motor and brake as an integral part of the gear case, removing the need for a separate bedplate.

Properly designed and installed machines should be free from perceptible vibration and unusual noises. Worm rub marking on worm wheel teeth should be at or near the centre of the teeth. Any worm shaft float or worm-to-worm wheel backlash (running clearance between meshing teeth) should not be audible in the machine room or felt within the lift car. The complete assembly can be mounted on isolation pads to separate it from the building structure. This may not be necessary in the case of bottom drive machines fixed to a solid foundation.

The unit should be installed with its sheave plumb and located within ±2 mm of its required position. Some manufacturers may employ a roping system (i.e. 'overwrap' or 'longwrap') that requires the sheave to be at an angle to the horizontal to avoid chafing of the rope, see Figure 7.8. In this case the sheave angle should be as recommended by the manufacturer.

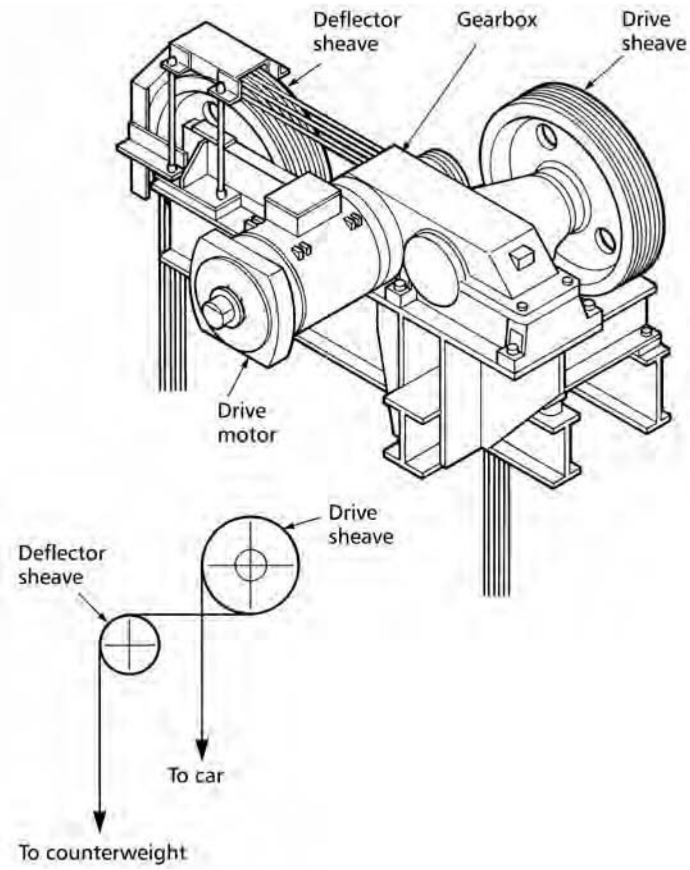

Figure 7.8 Typical longwrap machine and schematic showing rope path

7.2.6 Planning and layout

Layout dimensions for electric traction lifts are detailed in BS ISO 4190-1/2[6,7]. These dimensions should be used where possible because they are suitable for all lift equipment supplied by reputable manufacturers, excluding machine room-less lifts. The dimensions, however, may be modified provided that careful appraisal of equipment and design is undertaken to ensure that the minimum clearances required by BS EN 81-1[3] are achieved. It should be noted that deviating from the dimensions given in BS ISO 4190 may result in additional costs because non-standard components may have to be fabricated.

The plan dimension of the lift well may increase if bottom drive and/or counterweight safety gear are to be incorporated, see section 7.6.3.

When a new lift is installed in an existing building and structural constraints prevent the provision of the refuge spaces required by BS EN 81-1, a special derogation against clause 2.2 of the Lifts Regulations 1997[(2)] is required. This should be obtained from the Department of Business, Innovation and Skills (BIS). Responsibility for obtaining the derogation rests with the building designer.

The BS EN 81-21: 2009[(8)] standard defines the requirements where the headroom or pit dimensions are limited due to the structural constraints. If a derogation is granted and the requirements of BS EN 81-21 are met by the installer, approval by a Notified Body is not required as this standard is harmonised under the Lift Directive and therefore provides a presumption of conformity with the regulations.

Whilst the most common issue with installing a new lift in an existing building is either lack of sufficient headroom or pit, other issues can exist such as limited well width or depth. The BS EN 81-21 standard recognises this and permits a reduction in clearances between the car and counterweight and also permits the reuse of a counterweight that runs in an existing separate well. Sheaves may also be incorporated in the well above the line of the car if provisions are made to retain the sheave in the event of a failure of its supporting shaft.

Where the pit or headroom is limited, provisions must be made to ensure that sufficient safety spaces are created whenever a person enters the pit or car roof. These provisions can take many forms such as movable stops or a pre-triggered bi-directional safety gear system etc.

If it is not possible to use a standard depth car apron a retracting or folding version is required.

Reduced machine room height, below 2.0 m, is permitted if all low areas are marked with yellow and black stripes as a safety warning.

In addition to the above, safety notices are required to inform of the hazards that are present.

BS 5655: Part 11[(9)] should be consulted when modernising electric traction lifts in existing buildings. This standard provides guidance on reduced clearances for situations where structural constraints exist and a lift is being modernised.

Where a lift that was installed before 1 July 1999 is modernised, see chapter 16, a derogation and Notified Body approval are not required since the Lifts Regulations 1997[(2)] apply only to new lifts, installed after 1 July 1999.

Where a lift, which was installed after 1 July 1999, is modernised it should meet the requirements applicable at the date of its installation.

It is essential, however, that when any lift is modernised it is not made less safe as a result of the modernisation process.

7.2.7 Machine position

BS ISO 4190-1/2[(6,7)] gives standardised layouts utilising the traditional preferred top drive arrangement, i.e. where the lift machinery is positioned directly above the lift shaft, see Figure 7.9(a).

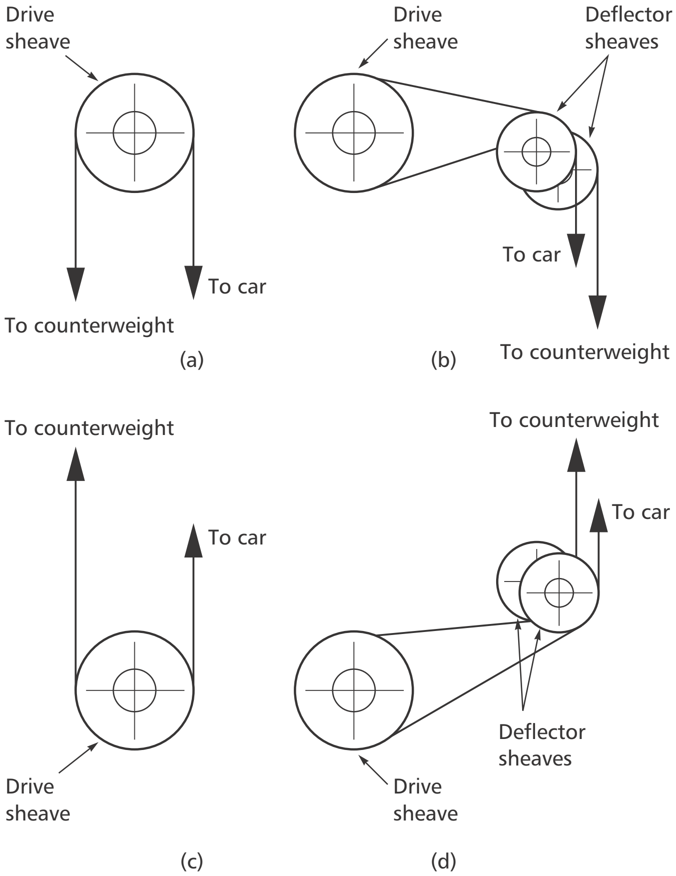

Figure 7.9 Machine position; (a) top drive, machine above, (b) top drive, machine adjacent, (c) bottom drive, machine below, (d) bottom drive, machine adjacent

Other machine positions can be utilised to minimise headroom requirements. However each of the options may have implications in terms of additional costs, reduction in rope life, increased running noise or a poorer standard of ride quality. Roping systems arrangements are illustrated in Figure 7.43.

7.2.7.1 Top drive: machine adjacent

The machine is positioned adjacent to the shaft at high level; see Figure 7.9(b). A series of pulleys is utilised to achieve the correct rope alignment in the shaft below (see section 7.15).

7.2.7.2 Bottom drive: machine below

The machine is positioned directly below the lift shaft, see Figure 7.9(c). The ropes extend the full height of the lift shaft to overhead pulleys which provide the correct rope alignment to the lift car and counterweight below. The overhead pulleys may be positioned in a pulley room directly above the lift shaft. Such pulley rooms require a minimum height of 1500 mm. However, the need for a pulley room may be avoided by using an underslung roping arrangement, see Figure 7.43(h). The top of shaft loadings are approximately double that involved where the machine is positioned overhead. Up thrust loads are also applied to the lift machine.

7.2.7.3 Bottom drive: machine adjacent

The machine is positioned adjacent to the shaft at low level, see Figure 7.9(d). The drive sheave can be supported on an extended gear shaft within the lift well or a series of pulleys can be utilised to achieve the correct rope alignment to the overhead pulleys. The pulley room arrangement is as described in section 7.2.7.2. The loadings at the top of the shaft are the same as for bottom drive with machine below.

7.2.8 Machine room-less lifts

Machine-room-less (commonly known as MRL lifts), see Figure 7.10, are now very common. In these lifts, the machine and other equipment that was traditionally placed in the machine room is located in the lift shaft or landing areas, see sections 5.2.5.3 and 5.3.7.3. With the lift machine placed in the lift shaft, special machines and servicing routines have been developed to make inspection of the equipment possible. It is very important for building designers to ascertain at an early stage exactly what may be the required to permit safe servicing and inspection of a given design. Each manufacturer may have their requirements that should be accommodated within the building design.

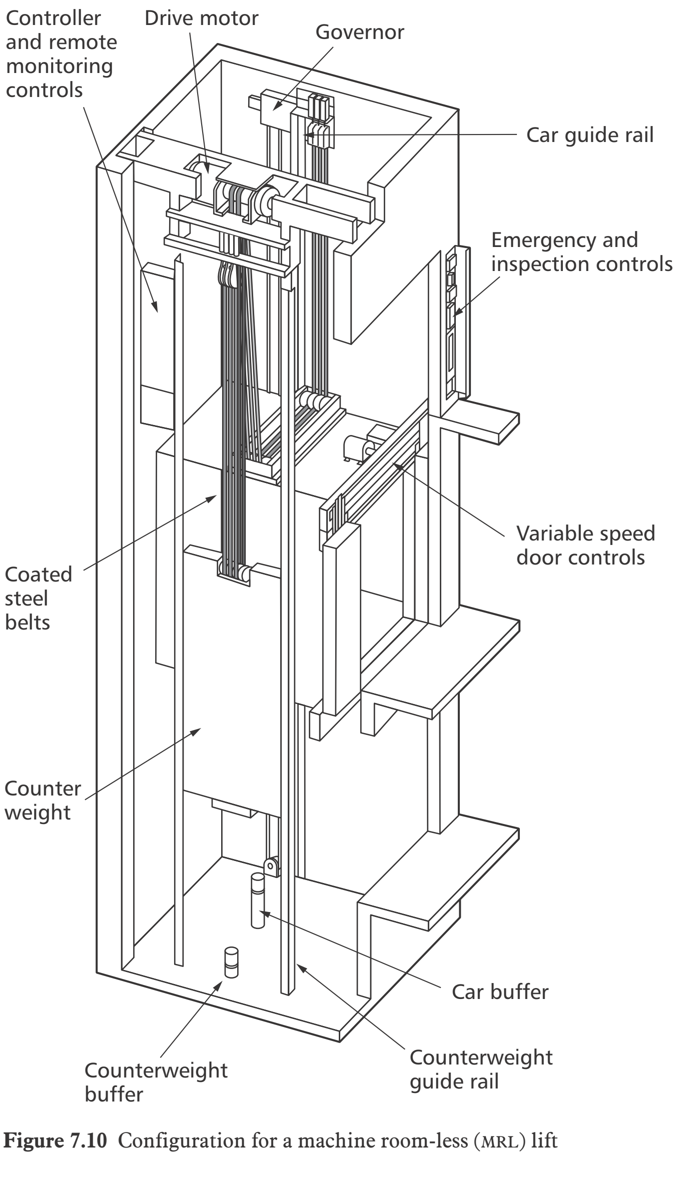

Figure 7.10 Configuration for a machine room-less (MRL) lift

The second amendment (A2: 2004) to BS EN 81-1[3] introduces requirements for machine room-less lifts to the BS EN 81-1: 1998 standard. Until recently it has been necessary for manufacturers to obtain a design examination certificate for each machine room-less lift design because BS EN 81-1 did not recognise these arrangements. Providing the manufacturer elects to follow amendment A2 of BS EN 81-1, such a certificate is no longer required.

The introduction of machine room-less lifts has lead manufacturers to look at other possible changes in design. There are now some products for sale in mainland Europe that have greatly reduced pit and/or headroom requirements. It should be noted that putting such products into service in the UK is illegal, even if the product has the approval of a recognised Notified Body for lifts. This is because Essential Health and Safety Requirement 2.2 under the Lift Regulations 1997[2], which enact European Lift Directive[1] in the UK, requires free space to be provided at the extreme positions. Derogation against this requirement is only available from the EU member states' governments and not from a Notified Body. The EU governments can only provide a derogation under special circumstances and then only on a job-by-job basis, and usually only for an existing building. In the UK derogation must be obtained by the owner from the Department of Business, Innovation and Skills (BIS), the government department responsible.

7.2.9 Linear induction drives

The principle of the linear motor is simple and has been known for many years. It may be regarded as a conventional AC motor 'unrolled' to lie flat. Such machines are sometimes referred to as 'flat-bed motors'. In principle, a linear induction motor could be mounted directly on the lift car but, in practice, this arrangement is ruled out by technical difficulties such as exposing the occupants to intense magnetic fields and, possibly, high noise levels.

Since the system may require a counterweight for reasons of efficiency, it is more logical to attach the motor to the counterweight. Figure 7.11 illustrates a typical modern lift design incorporating a linear induction drive in which the motor primary windings are within the counterweight frame. The secondary is provided by a vertical column for the full height of the lift travel. Note that the secondary is suspended from the top; the bottom fixing is simply to steady the column.

Such systems are in operation and have been proved to provide excellent service. Control is usually achieved by a variable voltage variable frequency drive as described in chapter 8. For various reasons, not least of which is cost, few if any of these products have been sold in Europe.

7.2.10 Permanent magnet synchronous motors

PMS motors are synchronous motors ideal for use where accurate control of speed and torque are required, such as in a lift. They have high overall efficiency excellent controllability, fewer component parts as speed can be

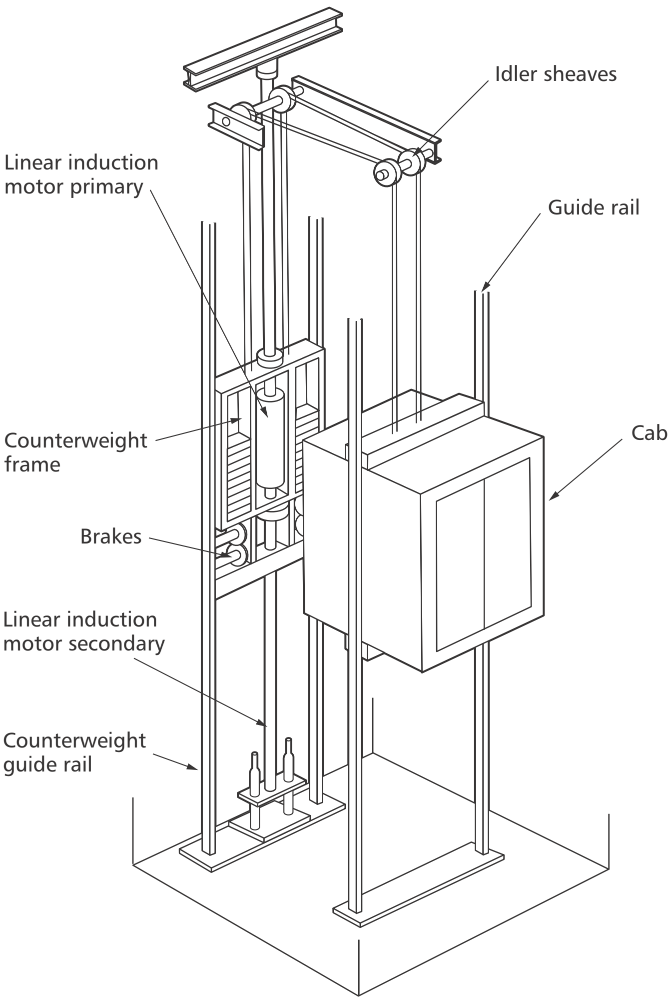

Figure 7.11 Arrangement for a lift using linear induction drive

reduced without the use of a gearbox, a smaller size and therefore are capable of being installed in limited space.

Such motors can typically replace existing machines where a motor and gearbox were previously used and are ideal for control by variable voltage variable frequency systems.

In a conventional squirrel cage AC motor, the stator, when energised, creates high current in the rotor. In the PMS motor, permanent magnets are installed in the rotor so that it has a permanent magnetic field and does not require high currents to be induced in the rotor to operate. This arrangement results in a lower magnetising current demand from the supply compared to a squirrel cage motor with the same nominal speed. In practice this means smaller frequency converters and supply demands.

These motors regenerate power under any overhauling load condition such as empty car up, or full load down. This may be regenerated back into the building or dissipated by some other load such as a resistor network.

Systems designed to regenerate to the building are a little more complex and hence more costly as the regenerated power will normally need some degree of 'cleaning' and therefore on small or non-intensively used lifts, any power savings gained may be unworthy of the higher initial cost required for a fully regenerative drive.

7.2.11 Car arrest systems

7.2.1.1 Rope brake

These devices usually consist of a pair of pads between which the main suspension ropes pass, see Figure 7.12. The pads have a material similar to a car brake lining that will grip the ropes without damaging them. If the lift car speed exceeds a preset value, up or down, the pads of the rope brake will be forced against the suspension ropes with sufficient pressure to cause the lift to be brought to a controlled stop. The force is usually applied by spring pressure or pneumatically and generated by an air compressor.

It can be made to operate on either the car or counterweight ropes, although car-side is more common. In addition to preventing excessive speed, many such devices can be used to provide extra security of the car against movement during loading or during maintenance activities.

These devices are required to be type tested, CE-marked and provided with a declaration of conformity as safety components under the Lift Directive[(1)].

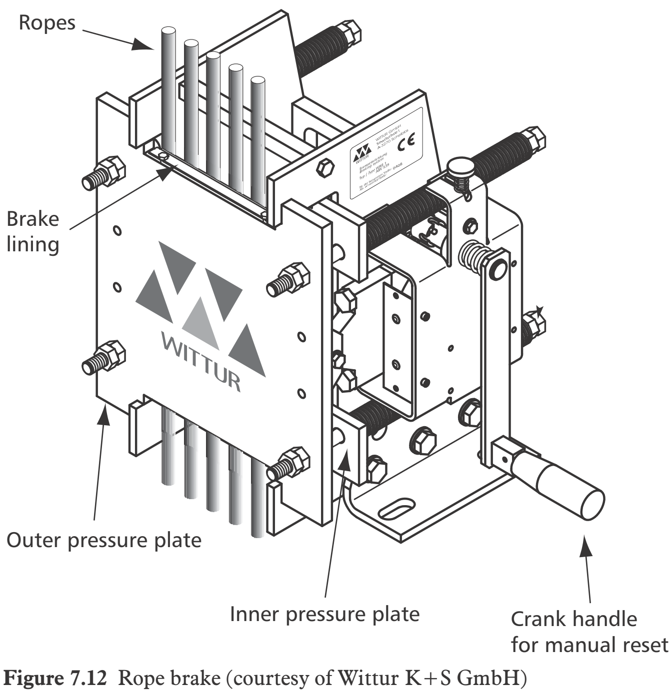

Figure 7.12 Rope brake (courtesy of Wittur K+S GmbH)

7.2.1.2 Sheave brake

These devices normally act on the traction sheave or a disc directly adjacent to the sheave in much the same way as a disc brake on a motor car, see Figure 7.13. The device is usually held clear of the sheave by a magnet or other mechanical means and applied by spring force. In the event of the lift over-speeding up or down the device is activated and it grips the sheave or sheave disc bringing the lift to a controlled stop.

These devices are required to be type tested, CE-marked and provided with a declaration of conformity as safety components under the Lift Directive[(1)].

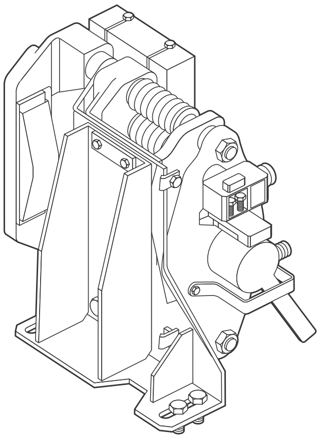

Figure 7.13 Sheave brake

According to the Pressure Equipment Regulations 1999[10], where devices use a compressor to compress the air for operation and the stored energy is less than 250 bar/litre, the stored energy is considered relatively small and therefore does not require a written scheme of examination by a competent person to ensure it remains safe. In the event the vessel has a capacity greater than 250 bar/litre, it is to be subject to inspection by a competent person or a written scheme of examination. Competent in this instance means someone competent in the inspection of pressure equipment.

7.3 Hydraulic drives

7.3.1 General

For certain applications hydraulic drives have many advantages over electric traction. However, when misapplied, hydraulic drives can cause major problems for the building owner and users.

In its simplest form the hydraulic lift comprises a cylinder and piston located directly below the car. Oil is pumped from a tank by an electric motor. This raises the lift car. To lower the lift a valve is opened that allows the oil in the cylinder to exhaust back into its tank. See Figures 7.14 and 7.15.

Low-traffic passenger and goods, vehicle and bullion lifts are all suitable applications for hydraulic drives. For applications that involve very large loads, hydraulic drives often provide the best solution because the floor of the well carries the load of the lift and its contents. Hydraulic drives, with the cylinder in a borehole (see Figure 7.14), are often specified for observation lifts in low-rise commercial buildings for aesthetic reasons, see section 5.5.

Hydraulic lifts are occasionally the only type suitable for installation in older buildings, originally designed without a lift, owing to restricted building height and possibly limited structural strength.

The practical maximum travel is about 18 m. This is due to the strength and length of the hydraulic piston. As travel increases, larger diameter pistons have to be used to resist the larger buckling forces. This increases equipment costs and makes the use of the hydraulic drive less attractive when an alternative drive is available. Although rated speeds up to 1.0 m/s are permitted the normal limit is 0.63 m/s.

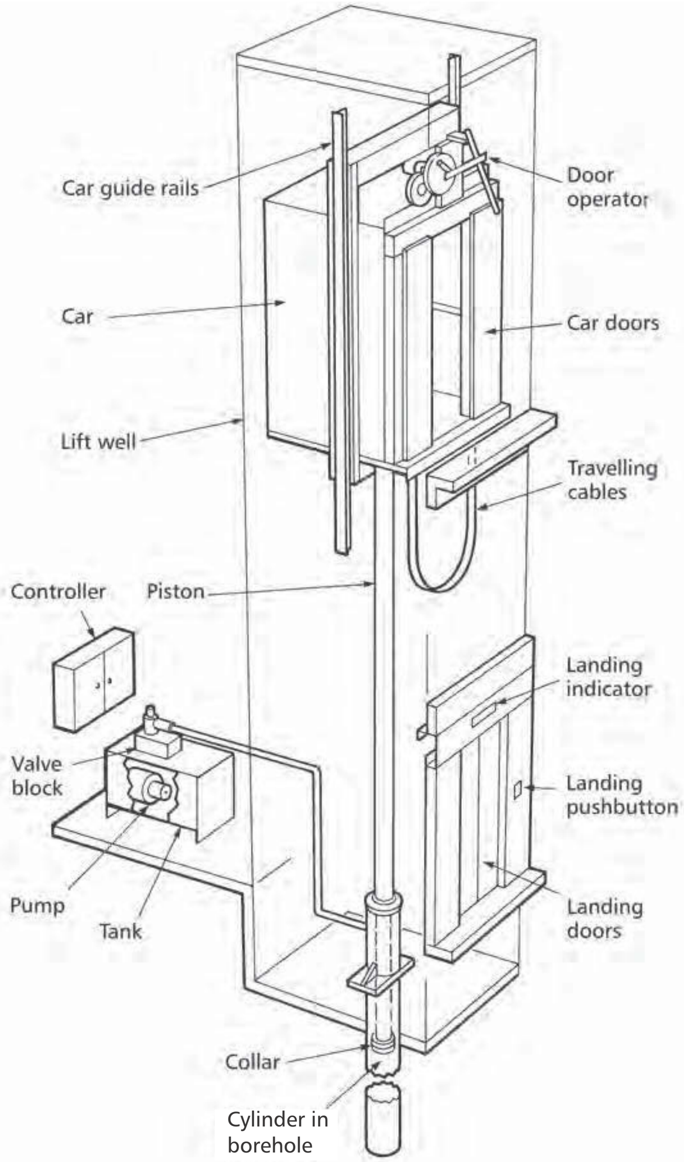

Figure 7.14 Hydraulic passenger lift; principal components

Mechanical anti-creep mechanisms may be used where very heavy loads (i.e. greater than 3200 kg) are carried or fork lift trucks are moving in and out of the lift. Active re-levelling systems may cause problems in these circumstances, especially where small-wheeled trolleys are used.

Caution should be applied in considering hydraulic lifts for commercial buildings where continuous heavy traffic is expected since this may require lift speeds of 1 m/s. Cooling is often essential under these circumstances since a rated speed of 0.63 m/s is generally accepted as the maximum operating speed for hydraulic lifts without cooling. This cooling requirement is often neglected in the design of the building.

Most hydraulic drives are not suitable for intensive use or for groups of lifts. Even duplex lift groups (i.e. two lifts) may exceed the recommended maximum number of motor starts per hour (i.e. 45) without additional cooling. Such cooling may be costly or impracticable. However, a hydraulic drive is sometimes the only solution, even in high traffic situations, due to building structure constraints. In these circumstances, extra cooling for the drive unit and oil should be provided.

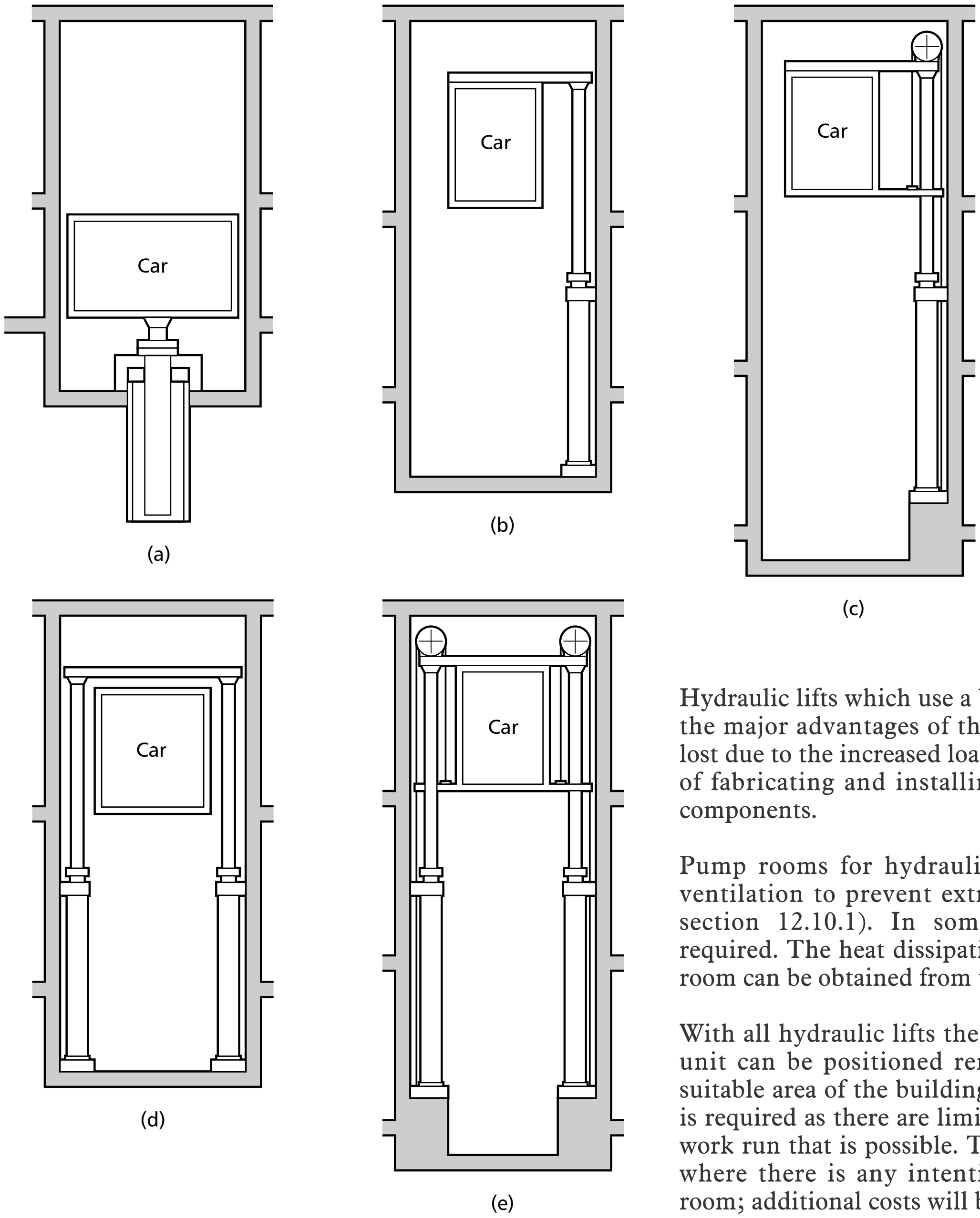

Figure 7.15 Hydraulic jack arrangements; (a) single, central, (b) single side-acting (direct), (c) single side-acting (indirect), (d) twin side-acting (direct), (e) twin side-acting (indirect)

For private residential buildings of up to eight storeys, hydraulic lifts may be used due to the low traffic levels in such buildings.

Simple hydraulic drives, which do not use a balance-weight, have the following attributes:

— low loads imposed on the building, therefore suitable for large goods lifts

— lift machine room normally positioned in the basement, or other low-cost area of the building

— economic for low-traffic, low-rise applications with either a single lift or a group of not more than two lifts

— a borehole location for a hydraulic cylinder may provide a visually attractive feature for low-rise observation lifts

— depending on the layout and number of cylinders, the lift well area may be smaller than that for the equivalent electric traction lift.

Hydraulic lifts which use a balance weight save energy but the major advantages of the simple hydraulic lift can be lost due to the increased loads on the building and the cost of fabricating and installing the additional mechanical components.

Pump rooms for hydraulic lifts should have adequate ventilation to prevent extremes of oil temperature (see section 12.10.1). In some cases air conditioning is required. The heat dissipation of the drive into the pump room can be obtained from the lift supplier.

With all hydraulic lifts the control equipment and pump unit can be positioned remote from the lift in a more suitable area of the building. In such situations great care is required as there are limitations on the maximum pipe-work run that is possible. The supplier must be consulted where there is any intention to use a remote machine room; additional costs will be incurred.

Where a new hydraulic lift is installed in an existing building and structural constraints prevent the provision of the refuge space required by BS EN 81-2[11], a special derogation against EHSR 2.2 of the Lifts Regulations 1997[2] is required. This should be obtained from the Department of Business, Innovation and Skills (BIS). Responsibility for obtaining the derogation rest with the building designer.

BS EN 81-21: 2009[8] defines the requirements where the headroom or pit dimensions are limited due to the structural restraints. If a derogation is granted and the requirements of BS EN 81-21 are met by the installer, approval by a Notified Body is not required as this standard is harmonised under the Lift Directive[1] and therefore provides a presumption of conformity with the directive.

Whilst the most common issue with installing a new lift in an existing building is either lack of sufficient headroom or pit, other issues can exist such as limited well width or depth. Where the pit or headroom is limited, provisions must be made to ensure that sufficient safety spaces are created whenever a person enters the pit or car roof. These provisions can take the form of movable stops or a pre-triggered bi-directional safety gear system.

Pulleys may also be incorporated in the well above the line of the car if provisions are made to retain the pulley in the event of a failure of its supporting shaft.

If it is not possible to use a standard depth car apron, a retracting or folding type is required.

A slightly reduced machine room height, below 2.0 m, is permitted if all low areas are marked with yellow and black stripes as a safety warning.

In addition to the above additional safety notices are required to inform of the hazards that are present.

BS 5655: Part 12[12] should be consulted when modernising lifts in existing buildings. This standard provides guidance on reduced clearances for situations where structural constraints exist and a lift is being modernised.

Where a lift that was installed before 1 July 1999 is modernised, see chapter 16, a derogation and Notified Body approval are not required since the Lifts Regulations 1997[2] apply only to new lifts, installed after 1 July 1999. Where a lift that was installed after 1 July 1999 is modernised, it should meet the requirements applicable at the date of its installation.

It is essential, however, that when any lift is modernised it is not made less safe as a result of the modernisation process.

7.3.2 Cylinder arrangements

7.3.2.1 Direct acting

The cylinder is connected directly below the lift car, see Figure 7.15(a). A lined borehole is required to accommodate the cylinder. A central cylinder is ideal for heavy loads and low-rise applications. Effectively there is no limit on the car size or on the rated load capacity. The central cylinder arrangement makes optimum use of shaft space because there is no counterweight or hydraulic cylinder alongside the lift car.

The limitations of this arrangement are:

— provision of a lined borehole can prove expensive

— inspection of the cylinders is restricted and, on rare occasions, the unit may have to be lifted out of the borehole for examination

— problems may be encountered creating boreholes with underground rock and/or water

— travel is limited to approximately 18 m by the buckling factor for the piston.

7.3.2.2 Single side-acting

Side-acting cylinders can be connected either directly or indirectly to the lift car.

With a direct side-acting cylinder, the cylinder is located within the shaft structure alongside the car, see Figure 7.15(b). In this arrangement the car applies a lateral force to the rails and structure. The cantilever loads imposed on the shaft wall (approximately 1600 kg) restrict the single side-acting arrangement to light loads only. The lift travel is limited by the piston length, usually 3.5 m.

The indirect side-acting cylinder arrangement is similar to the direct side-acting, except that the connection between the piston and lift car is achieved by means of a rope/chain and pulley arrangement, see Figure 7.15(c). This arrangement gives a 2:1 ratio of car travel to piston stroke. Safety gear is required with this arrangement, see section 7.11.

7.3.2.3 Twin (tandem) cylinders

As with single side-acting cylinders, the twin cylinder arrangement may be either direct or indirect acting.

The limitations of twin cylinders are:

— increased shaft size

— increased installation and running costs due to the use of two rams

— load limited to approximately 20 000 kg.

In the direct acting arrangement, a cylinder is positioned at either side of the lift car, see Figure 7.15(d) and this arrangement can accept heavier loads than a single side-acting cylinder.

The indirect-acting arrangement is similar to the direct-acting twin cylinder arrangement, except that the car is connected to the piston by a rope/chain and pulley arrangement, see Figure 7.15(e), giving a 2:1 ratio of car travel to piston stroke. Safety gear is required with this arrangement, see section 7.11.

7.3.3 Power units

There are two basic types: exposed and enclosed. In both cases the components and principles of operation are the same. The main components are as follows:

— tank or oil reservoir

— pump

— pump motor

— flow control valve block.

In exposed types, these items are mounted on a frame for easy installation. However, the enclosed type is now more common in which the pump and motor are submerged in the oil tank, see Figure 7.16. The control valves may sit either inside or on top of the tank unit.

The pump unit should be located as close as reasonably possible to the base of the cylinder to avoid an excessive pressure drop between the cylinder and the pump unit.

7.3.4 Pump and motor

The most common motor is the single-speed AC induction type. It is usually flange-mounted to the pump on the enclosed versions but may be foot-mounted and belt-

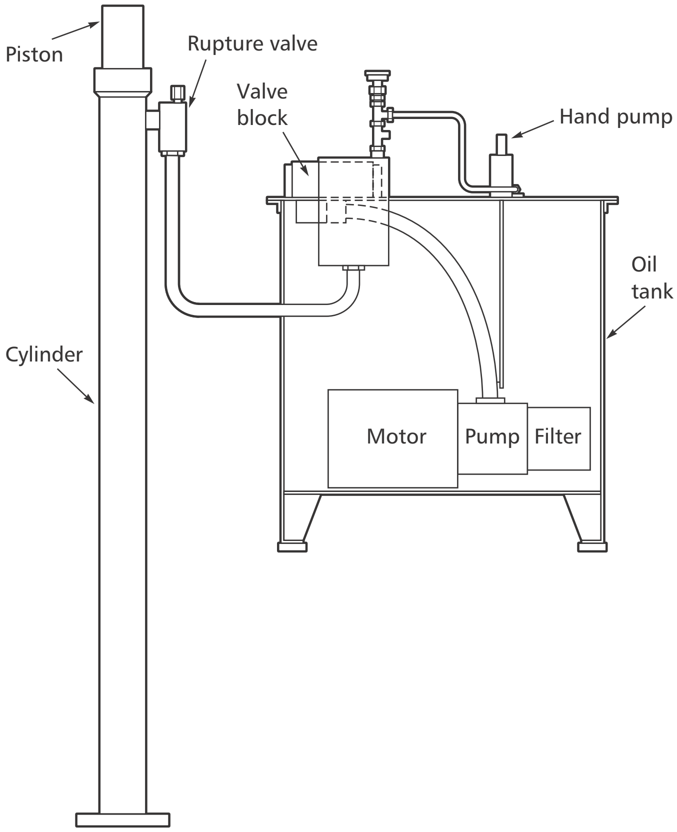

Figure 7.16 Enclosed hydraulic system

driven on exposed types. In enclosed types, open-frame motors are used to ensure that the oil circulates throughout the motor to provide cooling. This has distinct cost advantages because it enables high power outputs to be obtained from relatively small motor frame sizes. However, the heat rejected by the motor heats the oil and thus causes its viscosity to change.

The motor drives the pump, of which the multi-screw type is most common since screw pumps are generally less noisy than other types.

A means should be provided within the lift controller to ensure that the pump cannot be run in the wrong direction for any length of time if a fault develops. Submerged pumps use the hydraulic fluid as a lubricant and, if reversed, this lubricant may be pumped away causing the pump to seize. Motor protection in the form of thermistors embedded in the windings is essential and an oil temperature sensor is good practice. This checks oil temperature and ensures the unit is shut down if a certain temperature is exceeded. The tank should be provided with a gauge or dipstick to determine fluid level.

7.3.5 Control valve

When upward movement of the lift is required oil is pumped to the flow control valve block at a constant rate. The valve block allows either all the oil to flow to the cylinder or divert some back into the tank depending on the lift speed required. Most valve systems currently available use this system of speed control although construction of the valve blocks vary considerably.

A silencer may be provided, either between the pump and valve block or after the valve block. These devices usually reduce noise by about 2–3 dBA. Most noise occurs when the valve block is bypassing oil to the tank and under such conditions noise levels of 80–85 dBA are common.

A shut-off valve should always be provided on the output of the valve block so that it can be isolated from the cylinder for servicing. A pressure gauge connection point is essential although the gauge itself may not be permanently fitted.

The complete assembly should be mounted on isolating pads. It should be installed plumb and level but absolute accuracy of alignment of the assembly is not essential. The items requiring critical alignment are generally the pump and the motor and this is usually carried out by the manufacturer at the factory.

7.3.6 Hydraulic cylinder

In a hydraulic system, power is transmitted to the lift car either directly or indirectly by a hydraulic piston or pistons, see Figure 7.15. Various names are given to this component such as jack, ram, plunger or piston. The main parts of the assembly are the cylinder, piston, seals and collar. Whichever system is provided, the piston and cylinder assembly should stand perfectly plumb and be securely fixed.

The cylinder is made from steel tube and may be in several sections depending on its length. The piston is made from steel ground to fine tolerances. Chromium plating provides a longer seal life and gives protection against certain environmental conditions. However, this is costly and usually not essential.

Like the cylinder, the piston may be made in several sections and various methods of jointing are used. The only criteria for jointing, apart from mechanical strength, should be the accuracy of the joints. Properly made joints should be imperceptible to the touch. At the bottom of the piston, there should be a collar to prevent the lift from striking the top of the building structure in the event of over-travel and to prevent the piston from leaving the cylinder. The top of the cylinder (or the top of each section in the case of telescopic pistons) should have a gland or seal to retain the oil. This gland should seal by the force of the oil acting upon it rather than by being crushed by its retaining plate. When working properly the piston should be covered by a very thin film of oil; anything more than a film indicates a problem. A scraper ring protects the seals from damage by abrasive particles, and the foils guide the piston through the seals.

The piston should satisfy the buckling factor and other requirements stated in BS EN 81-2[11]. Obviously the higher the lift travel, the stronger and heavier the piston can become and this may require solid piston sections. For this and other reasons, hydraulic systems are not normally considered practicable for heights greater than 18 m.

The actual piston length depends on travel distance of the lift and the system employed. For direct-acting systems, the length is approximately equal to the travel plus the top and bottom over-travel, see Figure 7.17(a). For indirect-acting systems, the piston length is approximately equal to half of the sum of the travel and the total (i.e. top and bottom) over-travel, see Figure 7.17(b).

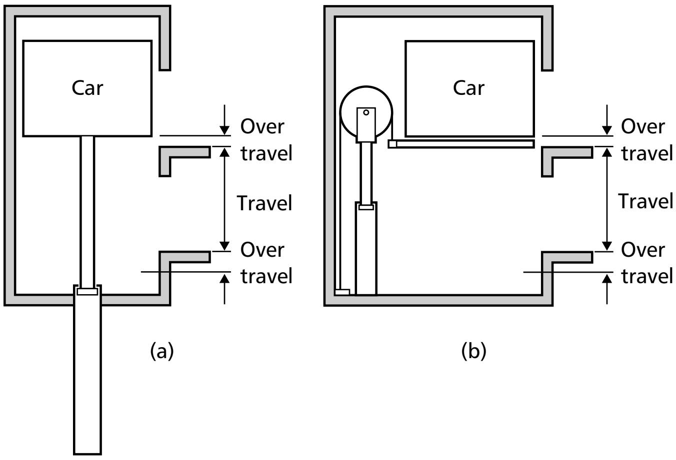

Figure 7.17 Overtravel; (a) direct-acting arrangement, (b) indirect-acting arrangement

Cylinders and pistons cannot easily be altered in length. Therefore, it is essential to ensure that the cylinder assembly is manufactured accurately and it is vital to ensure that the lift travel is not altered by the builder or architect without first consulting the supplier. Very little tolerance is provided and a variation of travel of as little as 20 mm can have serious consequences. (Note that the tolerances on the building dimensions may be considerably greater than the tolerance on the piston stroke.) With indirect-acting arrangements the travel is still critical; see Figure 7.17(b), as is the pit depth. No variations should be made, however small, without first consulting the supplier.

The most common problem associated with cylinders is premature failure of the seals. This can be caused by long-term storage in a horizontal position, defective scraper ring or impurities in the oil, misalignment of the cylinder, incorrectly installed seals or piston joints of poor quality, damage to the piston surface resulting from builders' debris. Dressing of joints is something that should be done with great care and only if essential.

After manufacture the assembly should be pressure tested to comply with BS EN 81-2[11] or other codes as specified. The assembly is installed to ensure that, when in the fully extended position and against its collar, the car does not strike any part of the structure. When the lift is at the bottom, fully compressing its buffers, the piston should not be touching the bottom of the cylinder. These conditions should be checked as part of the lift testing procedure.

7.4 Controller cabinet

The controller cabinet contains the equipment necessary to control and monitor the operation of the lift installation. The drive and control systems are considered in chapter 8 and traffic control in chapter 9.

Controller cabinets vary in size according to the complexity of the installation. Typical heights range from 0.5 to 2.5 m. They should be securely fixed, square and plumb, to the machine room wall or floor and in such a position as to ensure easy access for maintenance. Adequate lighting should be provided. Detailed requirements for safety clearances and lighting are given in BS EN 81-1/2[4,12].

Ambient environmental conditions should be maintained as specified by the controls manufacturer, see chapters 8 and 12. In some cases it may be necessary to provide coolers on the cabinet to reject the heat generated, see chapter 12. Where cooling of cabinets takes place it is essential to ensure the area in which heat is dumped is also suitably cooled.

7.5 Guide rails

7.5.1 General

Some form of guide rails are required for the car and counterweight (where provided) to ensure travel in a uniform vertical direction. The position and alignment of the guides is very important and, with the exception of the drive, no other component has such a significant effect on the ride quality. Although round and other sections have been used, T-section rail is now used almost exclusively.

7.5.2 Position of rails

The relative position of the guide rails depends upon such factors as location of the entrance, shape of the car and centre of gravity of the car. The actual location may have been determined during the design stage and lift manufacturers can advise on what is and what is not possible.

Guide rails should be kept as near to the centre of gravity of the car as possible. A cantilevered arrangement may be acceptable at speeds up to 1 m/s but ride quality may be difficult to maintain when speed is increased above this value. Where possible, the guide rails should be located on either side of the car, see Figure 7.18.

The number of guide rails depends upon the loads to be handled and the sizes available for use. Two rails for the car and two for the counterweight is the most common arrangement but there is no real limit on the number that can be used. The guides are drawn from steel and the running blade is usually machined to a finish, though not in all cases.

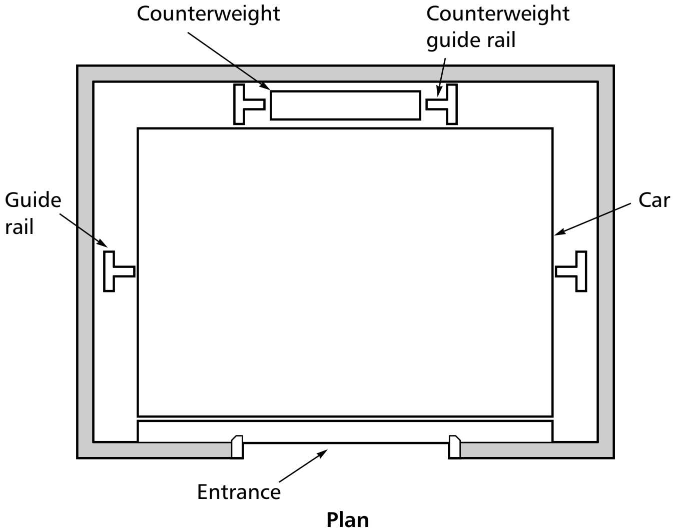

Figure 7.18 Position of guide rails

7.5.3 Size of rails

The size of the rail selected depends on the forces that it is required to withstand. During lift travel, the forces may be comparatively low, especially if the car is well balanced and the load is well distributed. During loading of the car, however, large loads may be exerted upon the rails. This is especially true of goods lifts being loaded using fork-lift trucks. These loads can produce a twisting moment in the rails. Under extreme conditions, it may be necessary to provide a means of locking the lift to the structure to relieve the rails of some of this load.

The other loads exerted on the rails occur on the application of the safety gear under emergency conditions. This can result in a large compressive load being transmitted to the rails as well as a bending stress. The means of calculating these forces, and thereby selecting rail size, is laid down in BS EN 81-1[(4)] or BS EN 81-2[(11)], as appropriate.

7.5.4 Alignment of rails

The need for accuracy in the installation of the rails cannot be overemphasised, especially for lift speeds of 2.5 m/s and above. At speeds greater than 4 m/s, rail alignment becomes critical. Manufacturers of rails usually offer two grades of finish, first grade being recommended for speeds greater than 2.5 m/s.

It is very difficult, if not impossible, to align rails correctly once the lift car is in the shaft. They should therefore be checked before the car is installed so that any error may be corrected. It is also common practice to use the rails as working centres for all dimensions. Therefore if these are wrongly aligned almost everything else may be wrong. Figure 7.19 provides a guide to installed accuracy. It is often not appreciated that the accuracy of alignment of the rails for the counterweight is as important as the alignment of the car rails to ensure good ride quality.

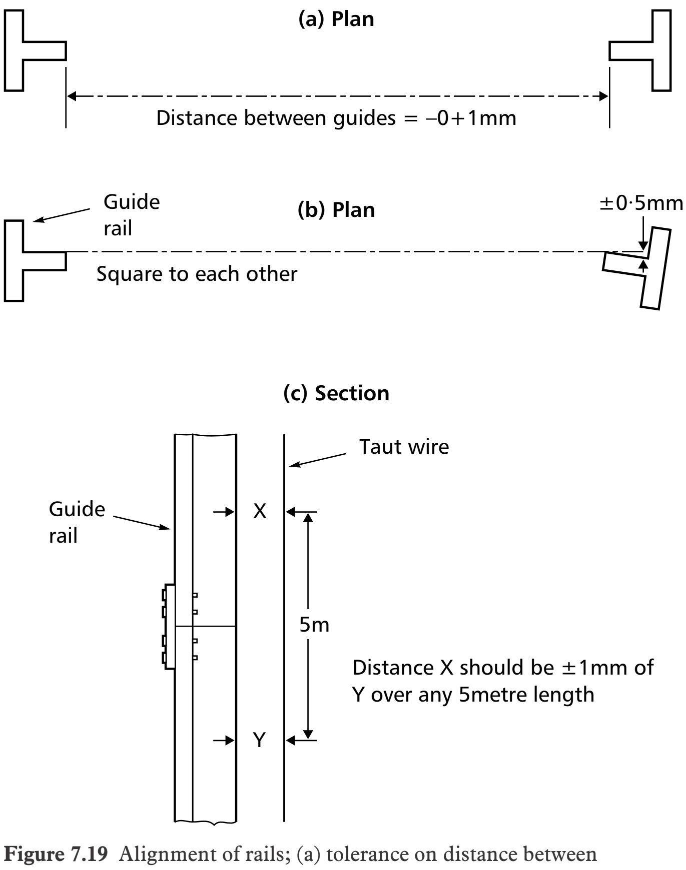

Figure 7.19 Alignment of rails; (a) tolerance on distance between guides, (b) tolerance on accuracy of angular alignment, (c) tolerance on vertical alignment

7.5.5 Rail fixings

Guide bracket and clip design is important as these items provide the means of holding the rails in alignment. For low rise installations, forged steel clips may be used to hold the rails rigid. For travels of more than 20 m, spring clips are favoured because they allow for building compression. All buildings expand, contract and move to some degree and rail alignment obtained during initial installation should be maintained while this occurs. Again the taller the building and the faster the lift, the more critical this aspect becomes.

At speeds up to 2.5 m/s, it is good practice to clean the back of rails and face of brackets and to apply a small amount of grease to facilitate movement. At 2.5 m/s and above, most manufacturers provide more sophisticated arrangements to enable movement to occur, e.g. by employing brass shims between the brackets and the back of the rail.

7.5.6 Length of rails

While the rails should be long enough to ensure that the car and counterweight never leave the rails during overtravel, clearance should be left between the top of the rails and the structure. This is to ensure that when the building compresses it does not compress the rails. The dimension is approximately 3 mm for every 3.5 m of travel. For travel above 100 m the structural engineer should be consulted regarding the anticipated compression distances. In the absence of specific data, 5 mm per 3.5 m of travel should be allowed.

7.5.7 Guide shoes

The lift car, counterweight or balancing weight (as applicable) is provided with guide shoes. There are usually two shoes at the top and two shoes at the bottom. See Figure 7.20.

The shoes, in their simplest form can be plastic, steel, iron or bronze. These shoes slide on the surface of the rails. Solid shoes are ideal for heavy goods lifts, but for passenger lifts the shoes are normally spring loaded, or resiliently mounted, to reduce noise in the lift car and to absorb small discrepancies in the guide rail alignment. The shoe is often made of steel with a nylon insert to form the running surface. The use of such materials improves noise and minimises the needs for lubrication. Sliding type shoes can be used at speeds up to 2.5 m/s, but are usually limited to 2.0 m/s.

Where the lift is required to operate at speeds greater than 2.5 m/s, roller guide shoes are used as shown in Figure 7.20. These are spring loaded and at speeds of 5 m/s may be provided with shock absorbers to reduce lift car oscillation at speed. Roller shoes provide an excellent ride provided the car is well balanced to avoid high loads on

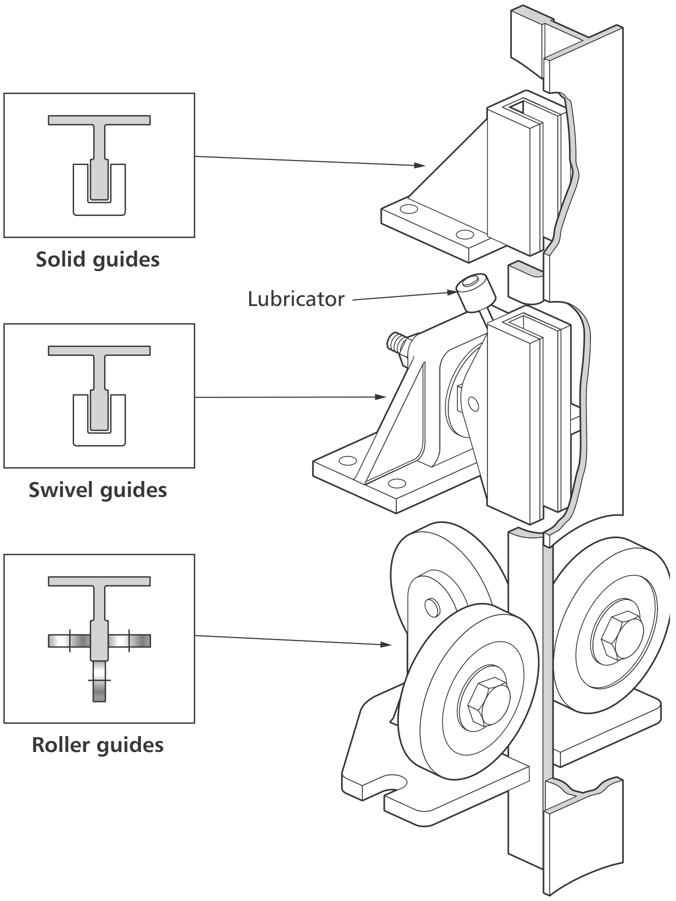

Figure 7.20 Guide shoes

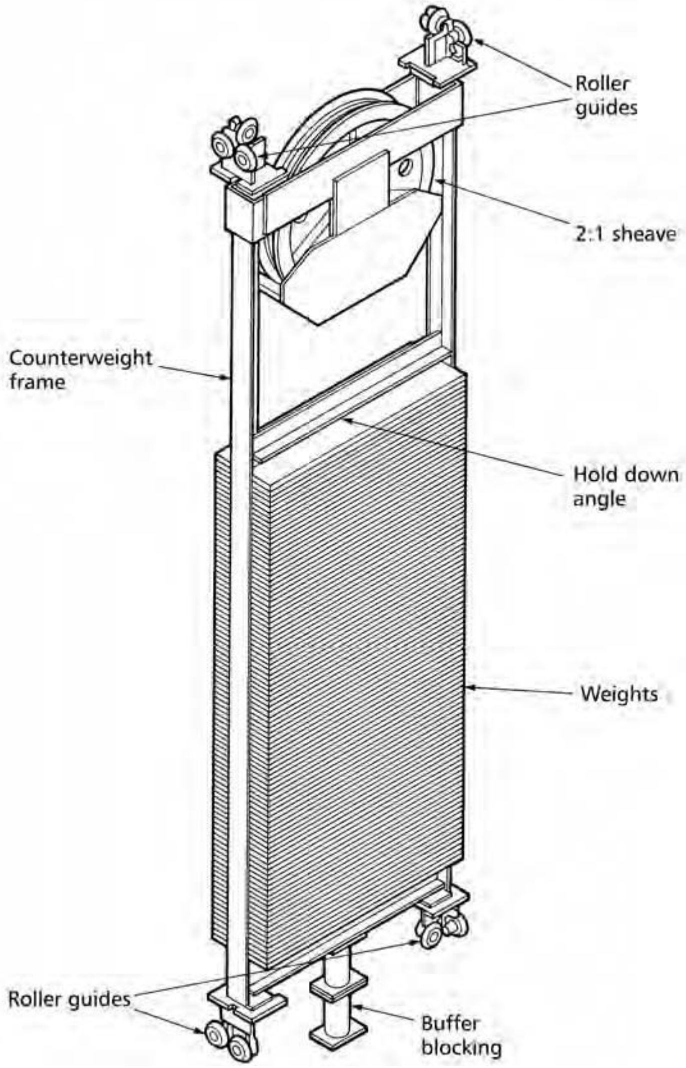

Figure 7.21 Typical counterweight

the rollers when the car is parked. If this is not the case, flat spots may develop on the rollers and these may not only create noise, but also produce a poor lift ride.

7.6 Counterweight

7.6.1 General

The counterweight provides traction between the ropes and sheave, by balancing the weight of the car and a proportion (normally 40–50%) of the load to be carried. Counterweights usually consist of a steel frame of welded or bolted construction, see Figure 7.21.

The mass of the counterweight is provided by small weights, known as filler weights, made from steel, cast iron or concrete. The material selected is not critical provided its weight stays constant with age and atmospheric changes and does not burn. Some additional weights, known as make weights, may be used for precise balancing. These weights are clamped into place in the frame with clips, rods or plates so that they cannot fall out. Wood or other blocks may be provided underneath the weight to allow for rope stretch adjustment. Sliding or roller guide shoes are fitted to the top and bottom of the counterweight to guide it smoothly along the rails.

The frame should be constructed to avoid undue distortion and should hang reasonably central of the rails of its own accord. This ensures that the shoes are subjected to minimum force and therefore minimum wear. This is particularly important for counterweights employing roller guide shoes; if the counterweight is forced into place by undue roller pressure the rollers may develop flats that may result in noise and vibration.

Counterweights with rollers should, therefore, be statically balanced in the same way as lift cars with roller guide shoes. This involves arranging the filler and make-weights, along with the rope hitch-point, into such a position that the counterweight hangs centrally within the rails without the use of the rollers. The rollers are then adjusted to provide minimal pressure on the guide blade.

In addition to checking the static balance and roller or shoe adjustments, the main considerations during installation of the counterweight are to ensure that it does not strike the building structure when the car is fully buffered and to check that the safety gear, if provided, is operating correctly.

7.6.2 Counterweight sheave

A sheave or sheaves may be provided on the counterweight, depending on the rope arrangement employed. When provided, rope 'kick-off' guards should also be included to prevent ropes leaving the sheave during sudden stopping, or if some foreign object should become lodged between the ropes and sheave.

7.6.3 Counterweight safety gear

Safety gear (see section 7.11) should be provided if the counterweight is running above an area accessible to persons. This generally means that the size of the guide rail should be increased to take account of the load the safety gear applies to the rails during application. On a low-speed unit, the safety gear may be operated by the failure of the main ropes (e.g. a broken rope). On units running at 1 m/s or faster, governor actuated safety gear is required. With speeds of up to 1 m/s the safety gear may be of the instantaneous type, but progressive types should be used above this speed.

7.6.4 Compensation

The counterweight may also carry compensation ropes, see section 7.15.2. If tied-down compensation is used, the counterweight can be subjected to considerable stress when the car safety gear is applied, over and above the usual stress for which counterweights are designed, such as striking the buffers at full speed.

7.7 Lift car

7.7.1 General

Most lift cars today consist of two distinct assemblies: the sling or car frame and the car itself. The sling is a steel frame of welded or bolted construction that provides a cradle in which the car can sit. It has to be of sufficient strength to withstand the stresses applied to it when the car is accelerated and the compressive forces resulting from a fully laden car striking the buffers at speed or when the safety gear is actuated.

7.7.2 Car frame (sling)

The main parts of the car frame are the crosshead (or crown bar), the uprights (or side posts), and the bottom channels (or plank channels), see Figure 7.22. Many designs and variations exist and, on very large lifts, more than one sling may be bolted together to provide the support the car requires. Ropes may be attached directly to the frame or pass around sheaves placed above or below it.

Shoes or rollers are provided at each of the four corners of the frame to guide it along the rails. The construction of the sling is important not just in terms of strength but of alignment. It should be assembled free of distortion, especially if roller guide shoes are to be used. Once built, distortions are difficult, but not impossible, to remove.

7.7.3 Platform/enclosure assembly

Passenger lifts usually have an isolation frame attached to the car frame, see Figure 7.22. The purpose of the isolation frame is to separate the passenger compartment from vibrations present in the car frame during running. The platform is supported by rubber pads fixed to the isolation frame. The platform should be levelled front to back and side to side before the walls are attached. The isolation pads compress under load and can therefore be used to provide information on the load in the car.

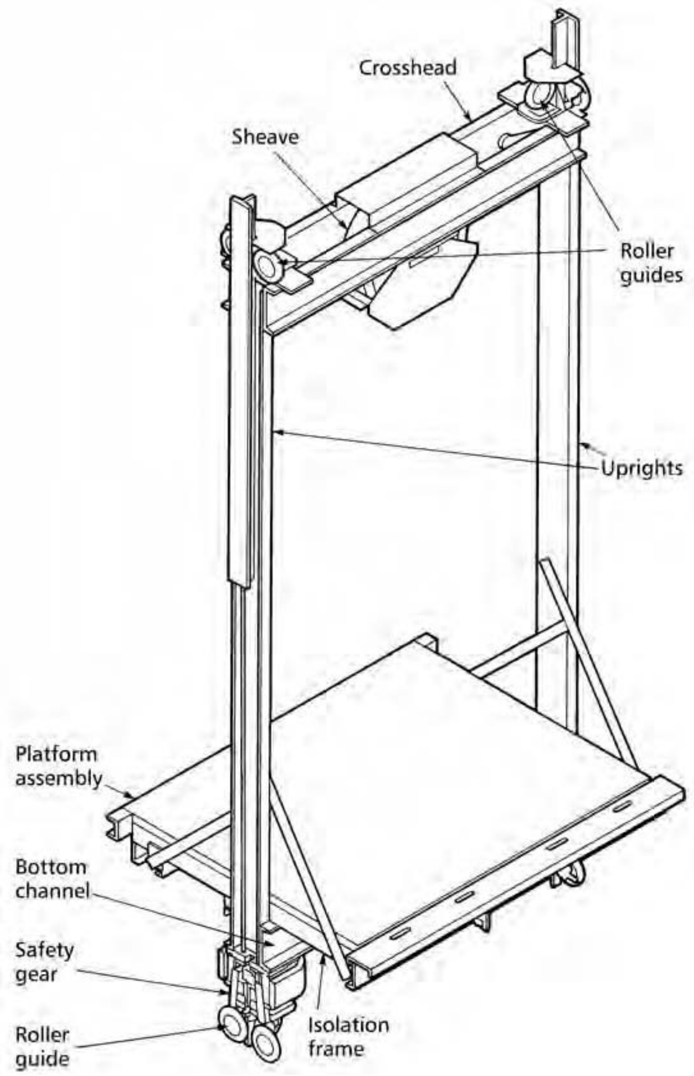

Figure 7.22 Typical car frame

For passenger lifts, the platform is usually made of steel and may have a timber overlay to reduce noise. If factory-assembled, the walls would then be installed, along with the car front, and finally the roof would be added. If assembly takes place on site, however, it may be necessary to install the roof and hang it temporarily from the crosshead while the walls are installed. The roof is often in one piece and therefore should be installed before the walls are in place. Whichever method is used, the walls should be plumb and square without being forced into position. If not, the car can quickly develop squeaks and rattles. Walls should not deflect beyond the limits indicated in BS EN 81-1/2[4,11].

The roof when installed should be able to support the weight of two persons without permanent deformation. The forces exerted on the platform during passenger transfer are not large and should be based upon the requirements of BS EN 81-1/2. The top of the car is held to the frame by isolated steady devices so that at no point is it mechanically bolted to the car frame. Figure 7.23 shows a typical passenger lift car with the car shell constructed and the door tracks, sill and doors assembled.

For goods lifts, the platform isolation and resilient steady devices are normally omitted because it is important to

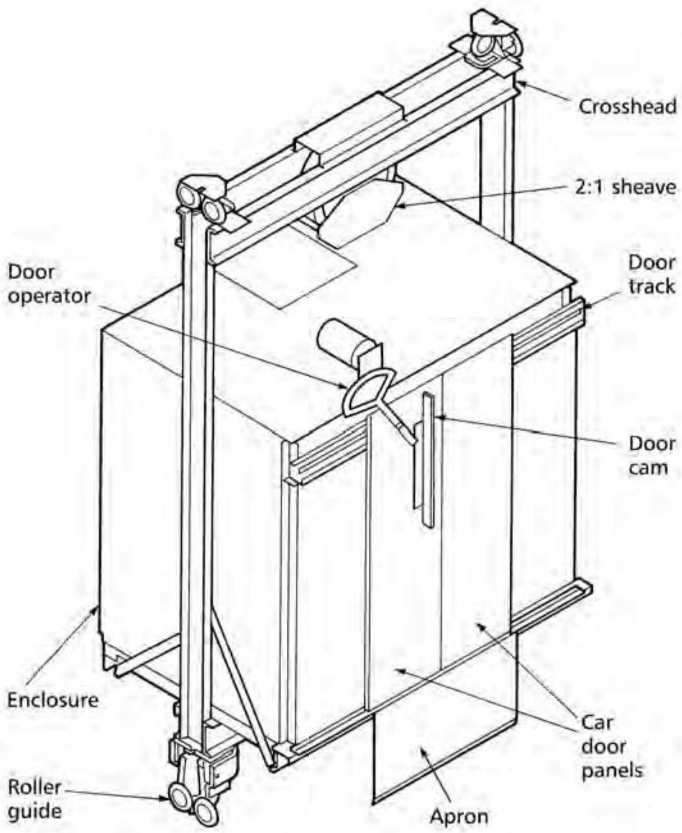

Figure 7.23 Construction of typical passenger lift car

hold the platform securely to withstand the forces applied during loading. For lifts intended to carry general goods, it is assumed that not more than 25% of the load can be placed in the car in a single operation. If the car is to be loaded using trucks (either hand or power operated), this intention should be made clear to the lift supplier since the combined weight of the truck and its load may exceed the maximum load for which the lift is designed.

Platforms for some passenger lifts may be provided with weights to ensure the finished lift car hangs in the guide rails without imposing large forces on the guide shoes. This features is knows as static balancing and is normally only provided where roller type guide shoes are used as flats may develop on the rollers if they are continuously subjected to large forces.

7.7.4 Car safety gear

Safety gear should always be provided if the car is for passenger use, or is of a size that a person can enter for the purpose of unloading even if it is not primarily for passenger use (see also section 7.11). The requirements for the provision of a safety gear on passenger lifts are defined in BS EN 81-1[(4)] for electric traction lifts and BS EN 81-2[(11)] for hydraulic lifts.

7.8 Door operators

7.8.1 General

The function of the door operator (or door engine) is to open and close the lift doors in a safe and swift manner. Various methods are used, but the most common is an electric door operator mounted on top of the car, see Figure 7.24. When the lift approaches or arrives at a floor, a mechanical device couples the car doors to the landing doors. As the car doors open they also pull open the landing doors. This method has two distinct advantages. First, only one door operator is required for each car entrance regardless of the number of landing doors on that side of the car. Secondly, the landing doors cannot be opened if the car is not at a floor.

The disadvantage of this arrangement is that the operator may have to open and close doors of different weights. For example, the main lobby may have heavy bronze doors while the doors on all the other floors may be of light panel construction. Under such circumstances the design of the operator might be a compromise; sufficiently powerful to open the lobby doors in a reasonable time but not so powerful that the doors on other floors are opened too fast since this may prevent smooth operation of the doors at all floors.

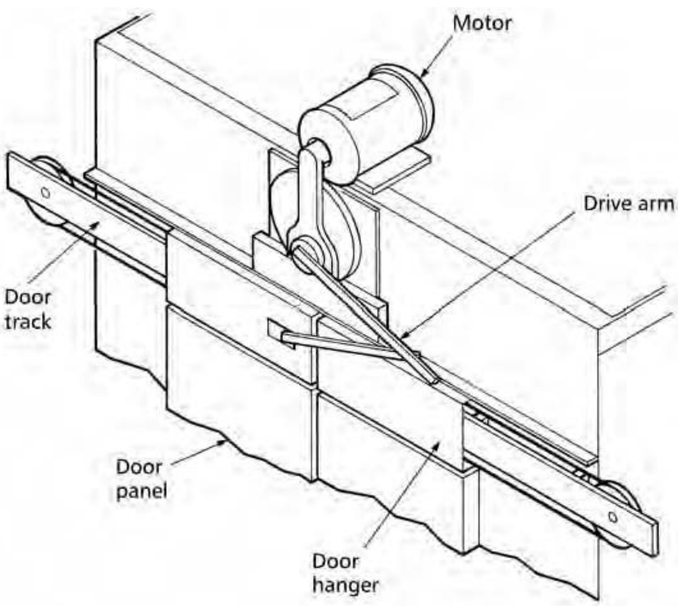

Figure 7.24 Typical door opener

7.8.2 Principles of operation

To open the doors, the operator should accelerate the door from zero to full speed and back to zero in a smooth, quiet manner. This can be achieved by speed control of the drive motor which drives an endless belt to obtain linear door movement or by a mechanical linkage which converts the rotational movement of the motor into a sinusoidal or harmonic door movement. The faster this operation is the better, as it saves time in loading and unloading. To open the doors smoothly at high speed requires good speed control, therefore high-speed door operators are generally more expensive than low-speed types. Today most operators employ variable voltage variable frequency (VVVF) technology to provide the precise control, see section 8.6.

Closing the doors raises different problems. While it may be desirable to save time by closing the doors quickly, BS EN 81-1/2[(4,11)] sets limits on the maximum kinetic energy acquired by the closing doors, in order to reduce the risk of injury to passengers. The current figure is 10 J provided that a safety device, such as a passenger detector, is in operation (see section 7.8.6). This limit applies at the average speed of the doors. In addition, the force necessary to prevent the doors closing should not exceed 150 N. If no safety device is provided, or an existing safety device is not operating, the maximum kinetic energy permitted is 4 J.

The most difficult control function, and the most mechanically severe, is the reversal of the direction of motion of the door whilst closing at high speed. Under such conditions the doors should be rapidly decelerated, stopped and then accelerated in the opposite direction. Poor design or incorrect adjustment of the system may result in premature failure of the door drive and its bearings, a common fault with door systems. Bearing and drive failure may also be caused by adding too much weight to the doors, for example by applying a heavy finish to existing doors. The type of door should not be changed unless the capabilities of the door operator are known to be adequate to accommodate the extra weight.

Although initially more expensive than the simple sinusoidal operator, the principle of linear motion, whereby the door movement is linearly proportional to the motor rotation, provides better control of the door movement. With linear door operators, interruption of door closing does not generate such high mechanical forces and this ensures long-term quietness in operation.

7.8.3 Door operator motors

The operator itself may use:

- a DC motor driving through gears or a mechanical linkage system
- an uncontrolled AC motor driving through a gearbox
- an AC or DC motor with closed-loop speed control.

Until the 1980s, only DC door operators provided a means of adjusting the door speeds and therefore these were used for lifts with higher door speeds and wider entrances. AC operators, without any speed control, were restricted to smaller lift car entrances and had fixed opening and closing times. Most manufacturers now produce electronically controlled AC and DC door operators suitable for higher door speeds. Some of these use position and velocity control along with sophisticated passenger detection and logic control.

Single-speed AC door operators are most suited for entrances up to 800 mm wide where there is a low density of traffic. In other situations, lift efficiency and passenger comfort are improved by the use of DC and controlled AC operators.

DC door operators provide good all-round performance for most applications but variable frequency controlled AC operators are now replacing them, due to their excellent performance and low cost. In the case of AC motors, variable frequency control may also be used. Control of door operators is dealt with in section 8.8. The motors are usually designed for the function and, depending on the manufacturer, may be suitable for continuous stalled operation thereby eliminating the need for stall protection.

The operating times can often be adjusted to suit user requirements for comfort. It is difficult, however, to modify the speed of the doors in response to varying traffic conditions. Nudging, to close the doors slowly when obstructed or held open unnecessarily, is easily accomplished.

7.8.4 Door operating times

The selection of a suitable door operator usually depends upon the application. Generally, high-speed door operators should be used with high-speed lifts. There is little point in having a fast ride if this is followed by slow door operation.

Table 7.1 shows typical door opening and closing times and likely applications for door operators. The terms low, medium and high speed are not well defined and therefore the figures are given only as a guide. Note that low speed operators are generally of low cost and usually cannot provide faster opening than closing. For a given width, centre opening doors can have shorter opening and closing times than side opening doors. The opening and closing times of the doors have a significant effect on the lift efficiency and cycle time; a one second saving on door operation gives approximately 5% greater traffic handling capability.

7.8.5 Installation

With power-operated doors, the operator should be installed to the manufacturer's recommendations. It may bolt directly to the car roof, with or without isolation, or it may be fixed to its own support frame that is in turn bolted to the car frame. Following installation of the door operator, it should be checked thoroughly for smooth, quiet operation. Doors and operators often account for some 80% of breakdowns on lift systems therefore good quality

Table 7.1 Door operating times

Operator and door type	Opening size† (mm)	Opening time (s)	Closing time (s)
Low speed:			
— two-panel side opening	800	4.8	4.8
	900	5.1	5.1
— two panel centre-opening	800	4.1	4.1
	900	4.7	4.7
Medium speed:			
— two-panel, side opening	800	2.9	3.3
	900	3.1	3.5
	1000	3.3	3.7
	1100	3.5	4.2
— two-panel centre-opening	800	2.3	2.5
	900	2.4	2.6
	1000	2.5	2.7
	1100	2.7	3.0
High speed:			
— two-panel side opening	800	1.8	2.8
	900	1.9	3.4
	1000	2.0	3.6
	1100	2.2	3.8
— two-panel centre-opening	800	1.5	2.0
	900	1.6	2.2
	1000	1.7	2.5
	1100	1.8	2.9

† Door height taken as 2100 mm in all cases

installation is essential. Manufacturers should state opening and closing times, as well as noise levels, and these should be checked after installation. The kinetic energy of the doors when in motion should also be checked, see section 7.8.2.

7.8.6 Passenger safety devices

Passenger detection devices are necessary for the safety and comfort of lift users, when they are moving in and out of lift cars. They also provide controller inputs for the operation of the doors and the lift drive. The time taken to react to an obstruction to door closure varies with the type of detector and several different types may be used. Figure 7.25 shows a typical mechanical safety edge and photocell passenger detector systems and Figure 7.26 shows a typical wide-field electronic safety edge.

A mechanical safety edge can be mounted on the leading edge of the car door. The safety edge moves when it strikes an object and this movement causes the doors to reverse direction. While simple to construct and reassuring to passengers, mechanical safety edges are easily damaged by trolleys etc.

Photocell detectors provide remote sensing across the complete door entrance. They can be a useful addition inside the car, either on the door returns or built into the detector edge, but they should be provided in addition to a safety edge or detector, not as an alternative. For goods lifts, a photocell detector built into the landing architrave is a good way of protecting the landing doors. Despite the claims made by manufacturers, most car door detectors provide only partial protection to the landing doors. A photocell detector can allow more efficient use of the lift, by acting as a 'door open' (dwell time) monitor. These devices modify the dwell time in response to passengers moving through the entrance. If an obstruction is present, door closure is delayed to prevent unnecessary reopening caused by safety edge operation.

More common are electronic safety edges in which a solid-state detector is located on or beside the leading edge of the car doors. This produces a detection field that may extend for a short distance (say 100 mm) in front of the door, or it may cover the whole opening width. When the field is interrupted the door reverses direction. This type of system has the advantage of reversing the door before it hits the obstruction. For this reason, electronic safety edges are preferred to mechanical types. Modern electronic edges are robust and stable, and their ability to sense obstructions without contact is more comfortable for passengers and provides better protection for the doors. In the event of failure of the detector, the doors should stay open or be permitted to close only at slow speed (nudging operation) with a warning buzzer sounding.

Optical passenger (obstruction) detectors provide even greater passenger protection in situations where heavy objects have to be moved through the entrance. Again, these detectors should be used in addition to safety edges. Optical passenger detectors use simple video cameras with local image processing to detect passengers and objects approaching the lift entrance. Situated above the car doors, the landing doors or between the car and landing doors, the field of view can be angled to meet the requirements of the application. Typical situations where these devices have proved advantageous are in airport terminals and hospitals. They can, however, interfere with normal service if located above the landing doors by detecting persons passing the lift rather than those waiting to use it. The field of view should be carefully adjusted to avoid false sensing.

7.9 Door configurations

7.9.1 General

While various types of door exist, all serve the same prime function: to prevent persons or objects from entering the path of the lift. Each type, however, offers certain features or advantages. The mechanical strength required for doors and their locking mechanism is laid down in BS EN 81-1/2[4,11]. The completed panel assembly should be designed to be as free running as possible, with all clearances within the limits laid down by BS EN 81-1/2. The face of sliding

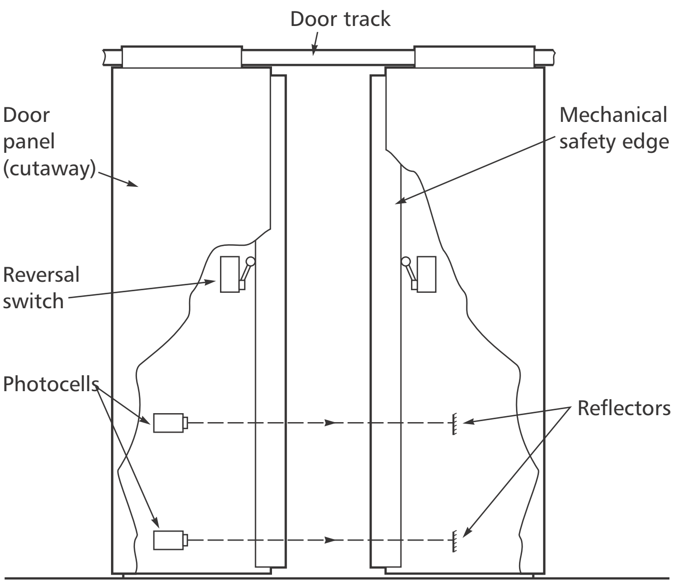

Figure 7.25 Schematic of typical mechanical safety edge

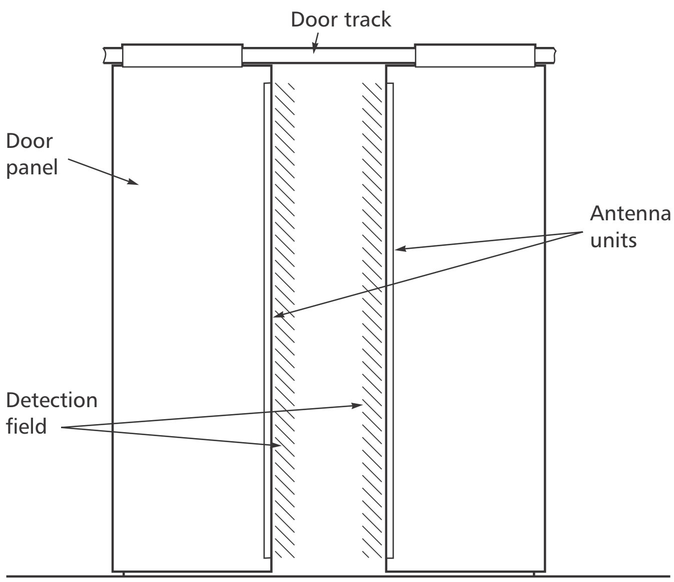

Figure 7.26 Schematic of typical electronic passenger detector

doors should always be kept as flush as possible. While the standard permits recesses and projections up to 3 mm in the face of the door, these should be avoided if possible. Safety should always be the prime consideration.

7.9.2 Single hinged, manual doors

The simplest, and generally the least expensive, type of landing door is the single hinged, see Figure 7.27. In the past, these were frequently made from wood but, because of its flammability and its tendency to warp, steel doors are now more common. Single hinged doors require very little space in terms of width since they consist of only the door and a simple frame. The disadvantage is that they usually open out to a right angle with the wall and therefore obstruct corridors. They can be difficult to open for persons in wheelchairs or elderly or disabled people. They are, however, acceptable for simple, low-cost passenger lifts serving a small number of floors. Typical opening widths for these doors are 700, 800 and 900 mm.

7.9.3 Horizontal power-operated sliding doors

The most frequently used power-operated door for passenger lifts are horizontal sliding doors, see Figure 7.28. The simplest of these is the single-slide (single-panel) version, see Figure 7.28(a). The single panel is pulled open or shut by the car door operator. As only one panel is used the construction is simple and reliable but requires a greater shaft width in many instances for a given opening, i.e. approximately twice the opening width plus 300 mm. The typical opening width is 840 mm. These types of doors were commonly used for lifts in local authority housing during the 1960s and 1970s. They are still used for some applications but less frequently so.

7.9.4 Two-speed, power-operated doors

Two-speed side-opening (two-panel side opening) doors may be used where space is at a premium but powered doors are required, see Figure 7.28(b). These doors are sometimes referred to as two-speed because while both panels close simultaneously, the leading panel travels at twice the speed of the trailing panel. This means that, although the leading panel has twice the distance to travel of the trailing panel, they cover the distance in the same time. The space required by these doors is approximately 1.5 times the opening width plus 400 mm. Opening sizes for these doors are generally between 600 and 1300 mm, the most common sizes being 700, 800, 900, 1100 and 1300 mm.

7.9.5 Centre-opening, power-operated doors

The most common entrance for passenger lifts is the single-speed centre-opening door (two-panel centre opening), see Figure 7.28(c). This arrangement is mechanically relatively simple, visually attractive and fast in operation because both panels move simultaneously, either away from or toward each other. For a panel speed during opening of 0.3 m/s, an opening of 900 mm may be created in approximately 1.6 s, whereas a two-speed door would require approximately 3.0 s. This time saving can be critical on large installations and groups of lifts. The space required by the doors is more than other types being approximately twice the opening width plus 200 mm. However, centre-opening doors are preferred to side-opening where the depth of the shaft is limited.

Opening sizes for these doors are usually between 800 and 1300 mm; larger sizes are possible but generally unacceptable because of the space required. The most common door opening widths are 800, 900, 1100 and 1300 mm.

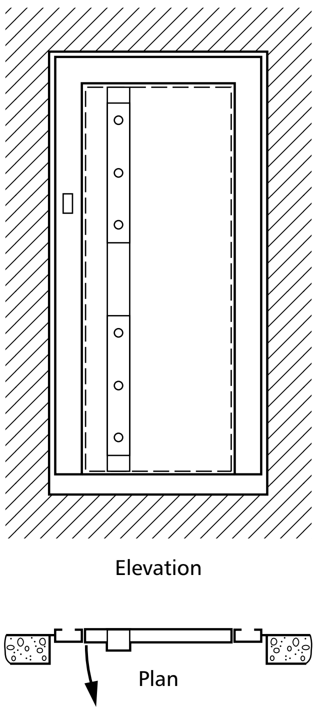

Figure 7.27 Single hinged door

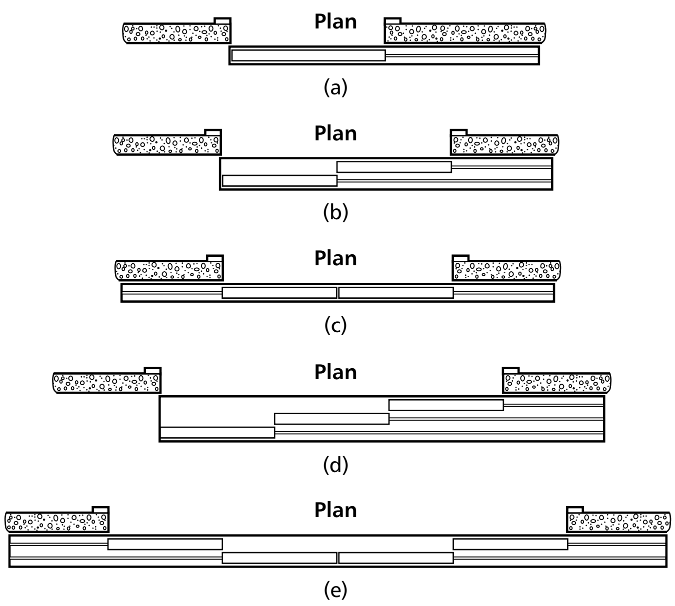

Figure 7.28 Horizontal power-operated sliding doors; (a) single slide, (b) two-speed side-opening, (c) single-speed centre-opening, (d) three-speed side-opening, (e) two-speed centre-opening

7.9.6 Wide entrance doors

For special applications, such as very large passenger or goods lifts, other horizontal doors are available. For example, two-speed centre-opening (four-panel centre opening) or three-speed side-opening (three-panel side opening) doors are suitable for opening widths from 1200 to 2500 mm or greater, see Figure 7.28(d) and (e). However, these arrangements are generally costly and can be noisy because of the complexity of mechanical linkages.

7.9.7 Multi-leaf gates

For goods lifts, the requirements are generally different. Adequate space to enter the lift and within the shaft, combined with rugged, reliable operation are more important than speed of operation. Where cost and space are at a premium, manually operated shutter gates may be used, see Figure 7.29. These are simple and rugged. The space required is the opening width plus the bunching width plus 300 mm. The space required for bunching can vary according to the widths of opening and leaf size used.

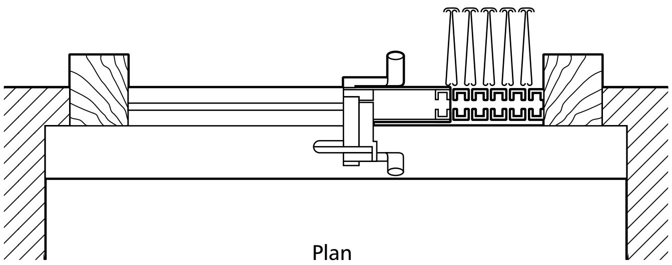

Figure 7.29 Multi-leaf gate

7.9.8 Vertical bi-parting doors

For very large goods lifts, where loading may be by powered truck, vertical bi-parting doors may be used, see Figure 7.30. These may be either manual or power operated. Space requirements vary between different manufacturers. The powered versions usually have an operator motor per entrance (i.e. on each floor served). This enables each entrance to be individually adjusted.

The two panels that form the door counterbalance each other. As the bottom panel moves down the upper panel moves up. When fully open, the top edge of the bottom panel forms a trucking sill. The doors are designed to accept different trucking loads and the intended load should be specified.

Although opening may be fully automatic, closing is performed by constant-pressure button operation. The door closing sequence may be interrupted if necessary by releasing the door close button. Fully automatic power closing of these types of doors is not permitted under BS EN 81-1/2[4,11].

7.9.9 Materials and finishes

BS EN 81-1/2[4/11] sets limits on the closing force and kinetic energy of moving doors (see section 7.8.2), and these may have a bearing on the materials selected for the door. Most doors are made from steel with either a painted or applied skin finish. While the finish is a matter of design choice, certain factors should be considered. For example, if heavy materials are used, door closing speed may have to be reduced to keep within the kinetic energy requirements of BS EN 81-1/2. Some materials, especially those with heavy embossed patterns, may be difficult to form and may therefore increase costs. Finally, heavy materials may require that the door tracks, rollers, bearings and driving operators are all increased in size to handle the extra weight, this often results in a significant increase in cost.

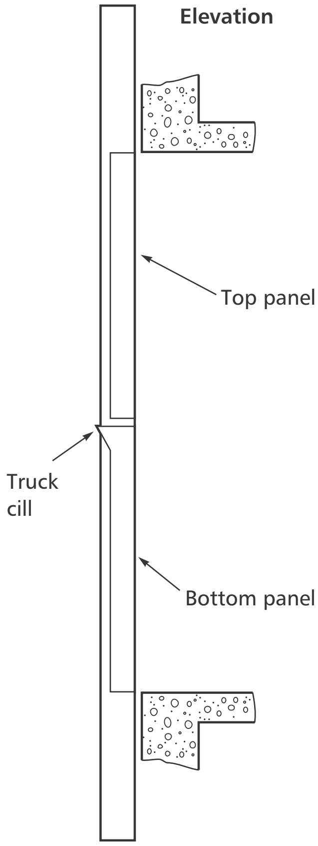

Figure 7.30 Vertical bi-parting door

7.9.10 Fire rating

Lift doors are often required to be fire rated. In the UK, testing of this property has historically been laid down in BS 476-22[13]. Unlike other fire doors, lift doors are tested from the outside only, i.e. the landing side, and the ability to stop fire from the lift shaft side is not a requirement. Doors are tested within their frames built into a typical structure in a test furnace. The test report obtained can be for a given duration, typically 30, 60, 90 or 120 minutes, and may cover both integrity and stability. Insulation properties are not required or tested nor is smoke control.

A new fire testing method has recently been published by the British Standards Institution. This is a harmonised European standard BS EN 81-58[14] and is published in support of the Lift Directive[1] (implemented in the UK by the Lift Regulations 1997[2]). BS EN 81-58 uses a test commonly known as the tracer gas test whereby carbon dioxide is introduced into the test furnace as a tracer gas and its rate of leakage through the doors is measured. Manufacturers of lift doors increasingly adopt this test method as it enables a door design to be recognised as acceptable in all European member states with only a single fire test and also provides a presumption of conformity with the Lift Directive (the Lift Regulations in the UK).

It should be noted that modifying doors by removing entrance upright sections, changing the locking system, closing system or the addition of finish materials such a woods, plastics etc. would invalidate the report. The addition of a skin may also render the report invalid if flammable materials are used and this should be borne in mind during the selection of finishes and adhesives for fixing skins. Where it is planned to make such changes a professional opinion should be sought from a Notified Body for lift who will take advice from the appropriate fire testing laboratory.

7.10 Overspeed governors

7.10.1 General

Overspeed governors have been used on lifts almost since the first lifts were installed. The purpose of the overspeed governor is to stop and hold the governor rope with a predetermined force in the event of the descending car or counterweight exceeding a specified speed. The rope may be held by traction forces developed between the governor sheave and its groove or by a special rope-clamping device designed to hold the rope without damaging it. The force exerted on the rope should be at least 300 N or twice the force necessary to engage the safety gear, whichever is greater. For governors using rope traction to obtain this force, the force should be calculated in accordance with BS EN 81-1/2[4.11].

Governors for use in new lifts are type tested and BS 8486-1: 2007[15] sets down requirements for on-site testing at completion of a new lift installation. The general requirements for governors are laid down in BS EN 81-1/2.

In the past, vertical shaft fly-ball governors were common but, although many still exist, their use is becoming less frequent. Horizontal shaft, centrifugal governors are now preferred, see Figure 7.31. The centrifugal governor consists of a sheave, flyweights and a rope clamping device. As the sheave rotates, the pivoted flyweights move outwards due to centrifugal force. At a predetermined speed, the weights strike a release mechanism that causes the rope-clamping device to grip the governor rope. The rope-clamping device is designed to allow the rope to slip through its jaws if the load on the rope is too great. This ensures that the safety gear stops and holds the car rather than the governor.

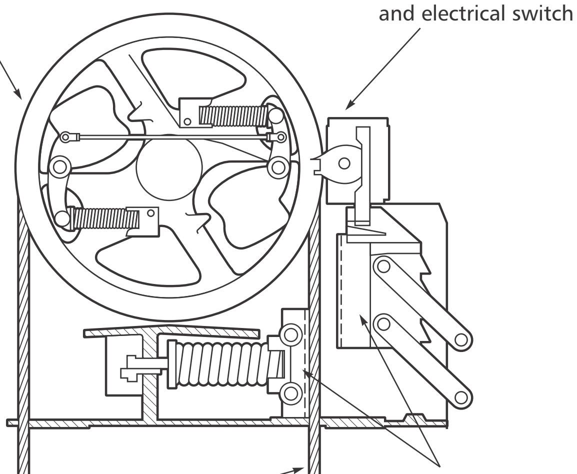

Figure 7.31 Centrifugal governor

7.10.2 Governor activation

BS EN 81-1/2[4,11] requires that tripping of the overspeed governor for the car safety gear should occur at a speed at least equal to 115% of the rated speed and less than:

- 0.8 m/s for instantaneous safety gears except for the captive roller type
- 1 m/s for safety gears of the captive roller type
- 1.5 m/s for instantaneous safety gears with buffered effect and for progressive safety gear used for rated speeds not exceeding 1 m/s
- $(1.25\,v + 0.25/v)$ for progressive safety gear for rated speeds not exceeding 1.0 m/s (where v is the rated speed).

A governor used to operate counterweight safety gear should be set to activate the safety gear at a speed not more than 10% greater than the speed at which the car safety gear is activated.

Governors are provided with an electrical switch that removes power from the lift motor and applies the brake before the safety gear is activated. However, if the rated speed of the lift is 1.0 m/s or less, this switch may trip simultaneously with the safety gear. For speeds above 1.0 m/s the switch is set to operate at approximately 115% of rated speed.

7.10.3 Governor resetting

After operation, the governor can either be reset by raising the car or it may require to be reset manually. The rope-gripping device should always be inspected for signs of wear after an application.

7.11 Safety gear

7.11.1 General

Safety gear is the term given to a mechanical clamping device located on the car and in some instances also on the counterweight, the prime function of which is to grip the guide rails to prevent the uncontrolled descent of the car if the lifting ropes were to part. Any lift car designed for transporting passengers, or into which persons may enter to load or unload goods, and that is suspended by ropes, belts or chains requires the provision of safety gear. The safety gear may be located under the car frame but may be at the top or halfway up. The position is not important provided that the gear is fixed securely to the frame. Figure 7.32 shows a typical car frame with progressive gear located at the base of the uprights. All types of safety gear should be applied mechanically and not rely on the operation of electrical circuits. Activating devices for safety gear are considered in section 7.11.6.

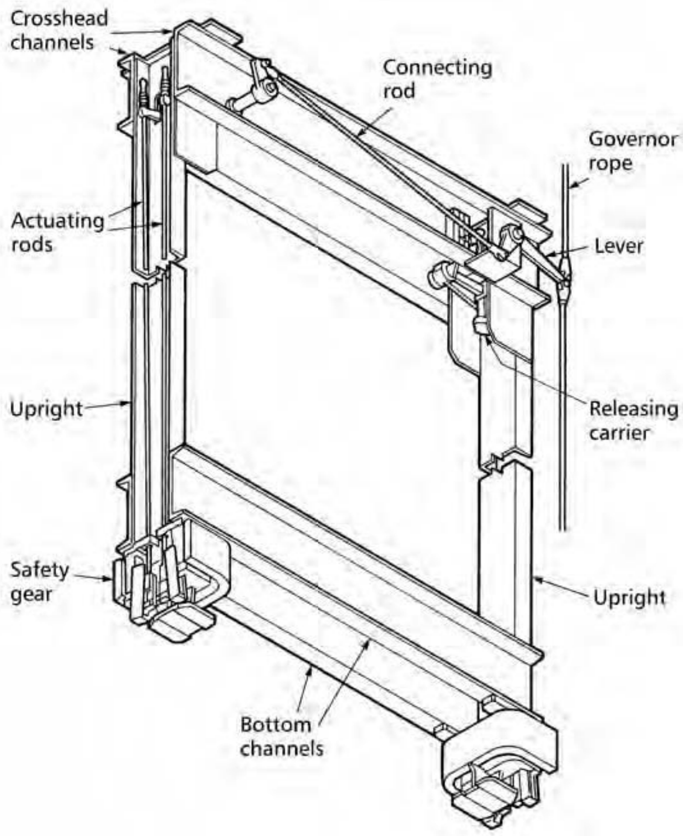

Figure 7.32 Car frame with progressive safety gear

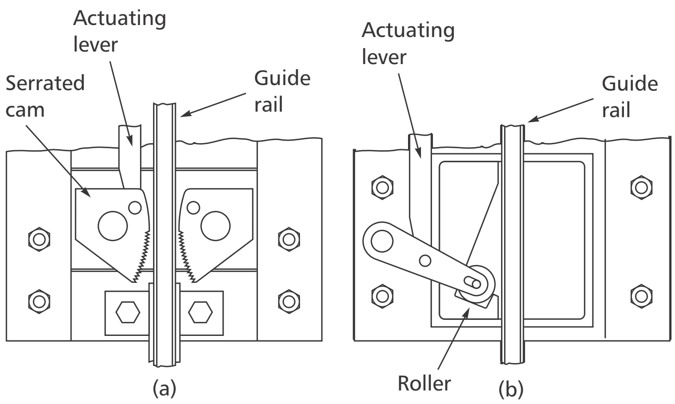

Figure 7.33 Instantaneous safety gear; (a) serrated cam, (b) roller type

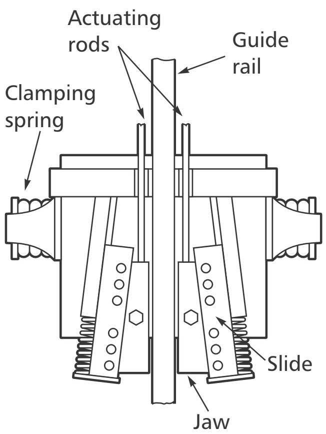

Figure 7.34 Progressive safety gear

Safety gear may also be fitted to the counterweight, see Section 7.6.3.

7.11.2 Instantaneous safety gear

This is the simplest type of safety gear, see Figure 7.33. It is almost instantaneous in operation but limited to lifts with speeds of not more than 0.63 m/s. This is because the small stopping distance results in heavy shock and strain, not only to the lift equipment but also to the passengers.

When fitted to a counterweight frame, the device may be used at speeds up to 1 m/s. Although the counterweight may be stopped instantly, the car may come to rest under the action of gravity.

7.11.3 Instantaneous safety gear with buffered effect

Instantaneous safety gear with buffered effect may be used on cars with speeds up to 1.0 m/s. The safety gear again applies a rapidly increasing pressure on the guide rails but oil-filled buffers, interposed between the lower members of the car frame and the safety gear, dissipate the energy and reduce the shock to passengers.

7.11.4 Progressive safety gear

For speeds in excess of 1 m/s, progressive safety gear should be used. This device clamps the guide rails by applying a limited constant pressure which brings the car progressively to a standstill, see Figure 7.34. These devices are also used where several safety gears are fitted to the car as is the case with some large goods lifts. Progressive safety gear may be used at speeds below 1.0 m/s, if required and designed for such speeds

The gear is designed so that under free fall conditions the average retardation of a fully loaded car lies between 0.2 g and 1.0 g. The actual distance taken to stop the lift depends upon its speed. Requirements for stopping distances and methods of testing are given in BS 5655: Part 10.1.1: 1995[16] for existing electric traction lifts and BS 5655: Part 10.2.1: 1995[17] for existing hydraulic lifts or BS 8486-1: 2007[15] for new electric traction lifts and BS 8486: 2007-2[18] for new hydraulic lifts.

7.11.5 Resetting the safety gear

All modern types of safety gear are reset after application by upward movement of the car. This requires the intervention of a competent person not only to release the safety gear and check its condition after operation but also to determine the reason for its operation.

Contrary to common belief there is no requirement within the BS EN 81-1[4] and BS EN 81-2[11] standards for the car to be able to be raised if the safety gear has applied, but if it is raised it should automatically reset.

7.11.6 Safety gear activating devices

The most common arrangement for activation of a safety gear is by way of an overspeed governor, see section 7.10. The linkage mechanism that operates the safety gear is connected to a steel rope of at least 6 mm diameter (the 'governor rope') which passes from the safety gear linkage up the lift shaft, over a governor sheave, back down the shaft to the pit, around a tension sheave and back to the lift car, see Figure 7.35. In the event of the car exceeding a predetermined speed, the governor operates a device which grips and holds the governor rope, causing the safety gear to be applied. The downward motion of the car, or counterweight, is then arrested by friction between the wedges, rollers or jaws of the safety gear and the guide rails. The safety gear should also operate an electrical switch which disconnects the motor at, or before, the instant of application of the safety gear, see section 7.10.2.

With progressive safety gear, the car may slide some distance before stopping so the governor should allow the rope to move under force. This ensures that while the safety gear is properly engaged the weight of the lift is not directly placed on the governor or governor rope. The governor should grip and hold the governor rope with a force of 300 N or twice the force required to engage the safety gear, whichever is greater. Typically, the force required to engage the safety gear is 250 N whereas the force in the governor rope is 500–600 N.

7.11.7 Bi-directional safety gear

As the name implies this is a safety gear mechanism that will grip the guide rail in the event of the lift over-speeding in the up or down direction. Such safety devices are designed to apply a progressive force to the guide rail so as to give the lift a controlled stop.

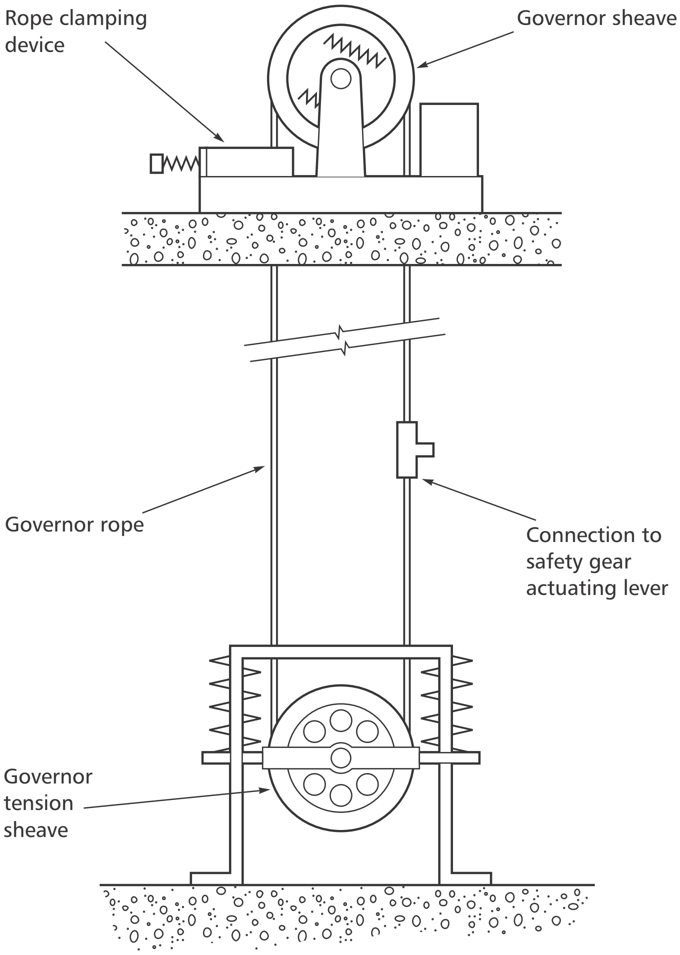

Figure 7.35 Governor rope — general arrangement

These devices are required to be type tested, CE-marked and provided with a declaration of conformity as safety components under the Lifts Directive[1].

7.11.8 Type-tested safety gear

Safety gear are now available 'type-tested'. This means they have been tested in accordance with BS EN 81-1[4] or BS EN 81-2[11] as appropriate. The tests required on-site after installation are described in British Standard specifications BS 8486-1: 2007[15] and BS 8486-2: 2007[18] and differ from those required for non-type tested safety gear as described in BS 5655: 1995, Parts 10.1.1[16] and 10.2.1[17], as appropriate.

7.12 Buffers

7.12.1 General

Buffers are placed below the car and counterweight to arrest them should they over-travel into the lift pit. In the case of positive drive lifts buffers are also required at the top of the shaft or on top of the car. The number of buffers can vary according to the design capacity of the buffers and the load to be stopped, but the stroke is dependent on the speed of the car or counterweight. There are two basic types of buffers: energy accumulation types using springs or rubber, and energy dissipation types such as hydraulic buffers. These are illustrated in Figure 7.36.

7.12.2 Energy accumulation buffers

The kinetic energy is stored in the gradual compression of springs or rubber blocks, which provides a progressive retarding force, see Figure 7.36(a). The range of speeds for which they can be used is normally limited to 1.0 m/s. For buffers with linear characteristics, the distance the contact end of the buffer can move (i.e. the stroke) should be at least equal to twice the gravity stopping distance corresponding to 115% of the rated speed, i.e:

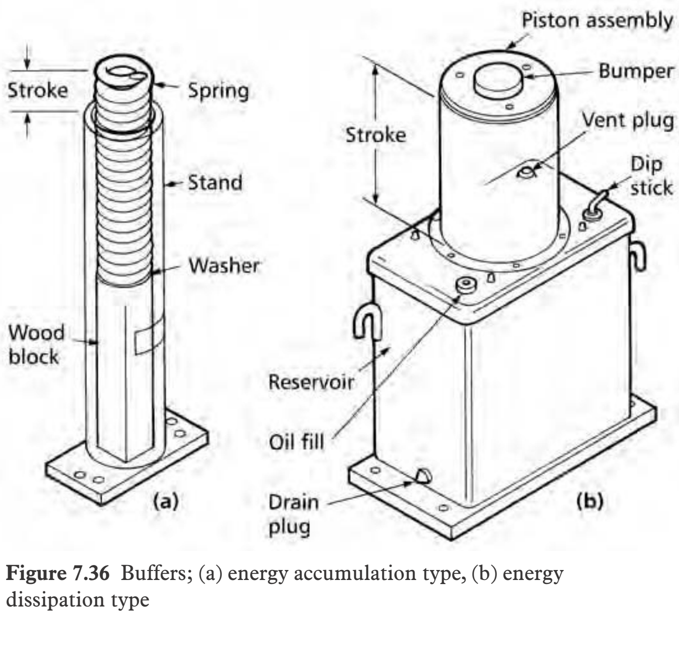

Figure 7.36 Buffers; (a) energy accumulation type, (b) energy dissipation type

$$s = 2 \times 0.0674\, v^2 = 0.135\, v^2 \qquad (7.1)$$

where s is the stroke (m) and v is the rated speed (m/s).

However, the stroke should not be less than 65 mm. The buffer should be able to cover this stroke under a static load of between 2.5 and 4 times the sum of the mass of the car and its load.

Energy accumulation buffers with non-linear characteristics are required to be type-tested. The test requires that when the car impacts the buffer at 115% of rated speed, its retardation does not exceed 2.5 g_n for more than 0.04 s, and that the average retardation does not exceed 1.0 g_n (1.0 g_n = 9.81 m/s^2)

7.12.3 Energy dissipation buffers

The kinetic energy is dissipated by forcing oil through a series of holes or slots, see Figure 7.36(b). Energy dissipation buffers provide a near constant rate of deceleration and are therefore suitable for all speeds.

The stroke (i.e. the distance moved by the buffer piston or plunger) required should be at least equal to the gravity stopping distance corresponding to 115% of the rated speed, see BS EN 81-1/2[4,11], i.e:

$$s = 0.0674\, v^2 \qquad (7.2)$$

It is permissible to reduce the stroke so as to avoid excessive pit depth, provided that additional speed monitoring equipment is installed to ensure that the car speed is reduced even under fault conditions at terminal floors. If such equipment is provided, the speed at which the car strikes the buffer may be used in the calculation instead of the rated speed. However, the stroke cannot be less than 50% of that resulting from equation 7.2 for lift speeds up to 4.0 m/s and never less than 420 mm. For rated speeds above 4.0 m/s the stroke cannot be less than 33 1/3% of that resulting from equation 7.2 and never less than 540 mm.

7.12.4 Type-tested buffers

Buffers for new lift installations are required to be type-tested and final testing at site can therefore be carried out in accordance with BS 8486-1: 2007[15] or BS 8486-2: 2007[18], as appropriate. These tests differ from those required for non-type-tested buffers as described in BS 5655: 1995 Parts 10.1.1[16] and 10.2.1[17]. Testing at full speed may not damage the buffers or the lift but the tests are severe and should not be repeated unnecessarily. Energy dissipation buffers should be inspected after testing to check that they have not lost oil and have returned to their fully extended position. BS EN 81-1/2[4,11] requires an electrical switch to be fitted to ensure the car cannot run if the buffer is not fully extended.

7.12.5 Active buffers

This device consists of a buffer, usually an energy dissipation type (hydraulic) located in the pit that is normally in a retracted position out of the line of the lift car, see Figure 7.37. When required, the device moves by gravity into the path of the lift to block its travel. Such devices will in future become more common with the introduction of new requirements for lifts with reduced lift pits and headroom spaces becoming more widespread.

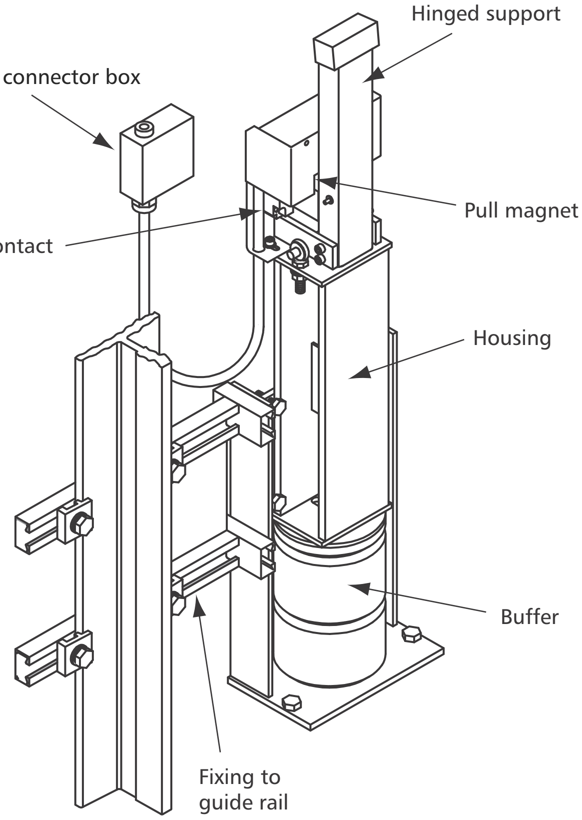

Figure 7.37 Active buffer (courtesy of Wittur K+S GmbH)

These devices are required to be type tested, CE-marked and provided with a declaration of conformity as safety components under the Lift Directive[1].

7.13 Uncontrolled movement devices

7.13.1 Uncontrolled upward movement

New lifts are now required by the Lift Regulations[2] (enacting the European Lift Directive[1]) to apply Essential Health and Safety Requirement 3.2 by providing a means to prevent uncontrolled upward movement, where such a risk exists. The risk does not exist in all lift designs, but where failure of a component (electrical, mechanical or electronic) could result in the lift travelling up at a speed greater than the designer intended, then a device to stop the condition should be provided.

In a electric traction lift a counterweight is normally employed. The lift motor may drive the car and its counterweight via a gearbox with the traction sheave attached to the low speed output shaft (see Figure 7.8). In such a design the main brake is acting on the gearbox high-speed input shaft and a failure in the gear box would in effect separate the motor and brake from the load (lift car and counterweight). In this condition gravity acting on the counterweight would result in the counterweight

weight descending and the car moving upwards. This movement could not be stopped by the brake or lift motor and so it would be uncontrolled upward movement.

In a conventional hydraulic lift without a counterweight, see Figure 7.14, the upward speed of the lift is controlled by the delivery of the pump unit. Over-speeding in the up direction is not possible and such designs do not therefore require a device to prevent the condition. (This is assuming that the up speed is equal to the maximum pump delivery.)

Various means can be employed to stop uncontrolled movement but they should act directly on the car, counterweight, main ropes or driving sheave. It is also permissible for the device to act on the same shaft as the traction sheave if it acts in the immediate vicinity of the sheave. A conventional safety gear fitted to the counterweight and activated by an overspeed governor is one simple solution. This can be economical if a counterweight safety gear is already required to address the risk resulting from it running above an accessible space. A car safety gear capable of operating in either the up or down direction is another possibility as is a brake acting directly on the traction sheave. A further possibility is a rope brake. This device can clamp the main ropes under the required conditions to arrest the car.

Whatever device is used it is required to operate at not less than 115% of rated speed and not more than 125% of rated speed. When activated it should bring the car to a stop with a rate of retardation not greater than 1.0 g_n (i.e. 9.81 m/s^2). Once activated it should be possible for a competent person to release the device without having to gain access to the car or counterweight.

Devices used for uncontrolled upward movement are classed as safety components under Annex IV of the Lift Directive[1] (implemented by the Lift Regulations 1997[2]) and, as such, should be type tested, CE-marking applied and issued with a Declaration of Conformity. Annex F of BS EN 81-1[4], defines the type test requirements for such devices.

7.13.2 Uncontrolled movement from a landing with the lift doors open

Amendment A3 to BS EN 81-1/2[4,11] introduces requirements to stop uncontrolled movement of the lift car away from a floor with doors open. This amendment requires the lift to be stopped before it has moved more than 1.2 m from the floor, see Figure 7.38.

Uncontrolled movement of the car with doors open can occur for a number of reasons. Loss of traction, failure of a gearbox shaft or gear, or failure in a drive system being examples. The amendment to the standard does not address a traction failure as it is considered that this is an unlikely event when the lift is designed to the current BS EN 81 series of standards. The current traction calculation being sufficiently robust in terms of its safety margin and traction is not something that just fails. It deteriorates over time and therefore is an observable condition unlike a gearbox failure where the gear can suddenly fail.

In principle any movement of the car at the floor is monitored and in the event that the car moves beyond certain limits with its doors open a device will be used to arrest the car before it has travelled beyond the limits indicated in Figure 7.38.

The monitoring of the car position may be performed by electronics, whilst the arrest of the car can be made by a number of different devices or a combination of devices such as bi-directional safety gear, car safety gear in the down direction with a rope brake in the up direction or sheave brake or a main brake if designed and tested for this purpose.

Where a machine brake is used it shall be a double brake as required by the current BS EN 81 standards. A double brake means that all elements acting to stop the lift, brake shoes, springs, arms, pole etc. are provided in two sets so that if one set fails the other set is capable of arresting the car.

When a brake is used for this purpose it must also possess a self monitoring system that checks the operation of the brake and in the event of one brake failing the lift should be removed from service until the situation is corrected. A brake used for this purpose should be type-tested and CE-marked as a safety component.

Whatever device is used to arrest the lift it should act on the car, counterweight, traction or compensating ropes or traction sheave if in the immediate vicinity of the sheave. It should also be a device that is not used in the normal safe movement and stopping of the lift unless its proper operation is monitored.

At the time of writing there are very few devices available to meet this new requirement.

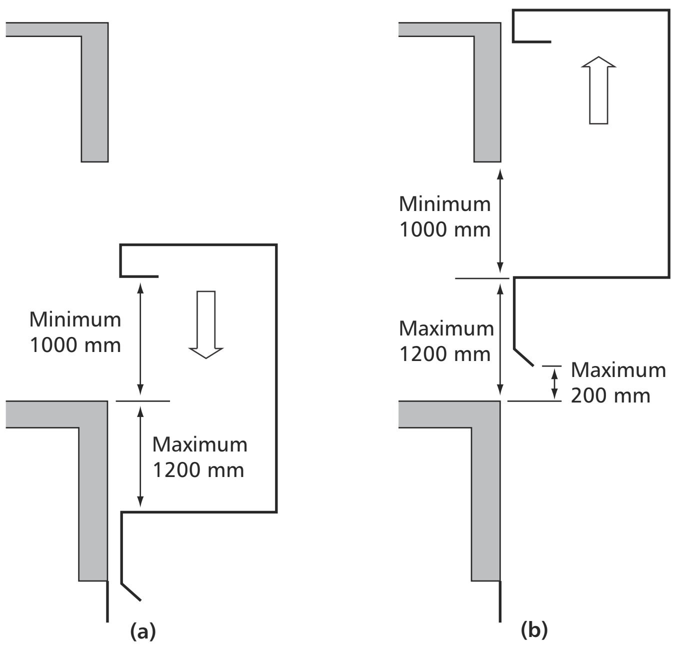

Figure 7.38 Limits to uncontrolled movement (source: BS EN 81-1/2[4,11], Amendment A3)

7.14 Suspension systems

This section discusses traditional suspension systems, but also introduces new developments in suspension including flat construction and use of non-metallic materials. These suspension systems are lighter and much more flexible than traditional ropes, enabling them to be used with smaller sheaves. They produce less noise when passing over the sheaves, and depending on the construction can have less stretch and a longer life expectancy than conventional ropes. Figure 7.39 shows a flat construction belt with a non-metallic covering.

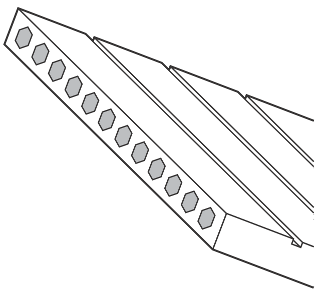

Figure 7.39 Section through a flat construction belt with non-metallic covering

7.14.1 Steel ropes

7.14.1.1 Steel ropes: general

Steel ropes used for hoisting lift cars are of standard construction, each strand consisting of a number of wires. Strength and flexibility are the most important properties. The strength is obtained by the use of steel with a high carbon content while flexibility is provided by the stranded construction.

7.14.1.2 Steel rope construction

Various rope constructions are used, and the size and tensile strength of the wires vary according to the construction. BS EN 81-1/2[4,11] states that the strength of wires for single tensile strength ropes should be 1570 N/mm or 1770 N/mm; and for dual tensile strength ropes 1370 N/mm for the outer wires and 1770 N/mm for the inner wires. The wires are often formed around a fibre core. This core is impregnated with a lubricant to reduce friction of the internal parts when in use and prevent corrosion when not in use.

Rope construction is referred to by numbers such as 6×19(9/9/1), see Figure 7.40(a). The first number '6' indicates the number of strands used to form the rope whilst the second number '19' indicates the number of wires used per strand. The way the strand is constructed is indicated by '(9/9/1)'; nine outer wires around nine inner wires around a single central wire. A rope designated as 6×19(12/6+6F1), see Figure 7.40(b), indicates six strands each made up of 19 wires. The 19 wires are arranged with 12 on the outside, within which is a ring of six wires, plus six smaller 'filler' wires (i.e. 'F') around a single central wire.

Conventional lift ropes use wires of round sections, see Figure 7.40(a) and (b). In the dyform rope, the outer wires are not of simple circular section but are shaped to provide a larger exposed area, see Figure 7.40(c). This

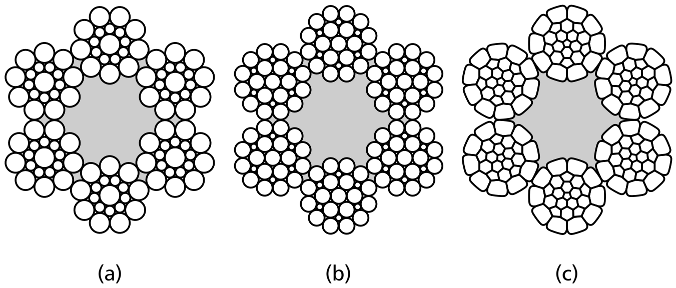

Figure 7.40 Types of rope construction; (a) 6×19(9/9/1), (b) 6×19(12/6+6F1), (c) 6×26 Dyform rope with fibre core

results in an increased breaking load, reduced stretch, and maintains fatigue resistance. Dyform ropes have been developed for high-speed high-rise applications but may also be used for other applications.

7.14.1.3 Steel rope sizes

The size of a rope is its nominal diameter which, for lifts, is usually between 8 and 22 mm, according to the strength required. The most common sizes are 11, 13, 16 and 19 mm. The diameter is that of the circumscribed circle and is measured over each pair of opposite strands. BS EN 12385-5[19] specifies that the actual diameter when supplied is that measured with the rope under a tension of 10% of the minimum breaking load. The size should be within +3% and –0% of the nominal diameter. Some special ropes may be manufactured to even tighter tolerances.

7.14.1.4 Steel rope lays

Generally, two types of lay are employed in lift ropes: Lang's lay and the 'ordinary' lay, see Figure 7.41.

In the Lang's lay, the direction of the twisting of wires in the strand is the same as the direction of the twisting of the strands that form the rope, see Figure 7.41(a). The advantages of this arrangement over the ordinary lay are that it offers a greater wearing surface when in use and therefore a longer life. It is also more flexible but the rope is easy to kink if mishandled during installation and any benefits are then lost. A disadvantage with Lang's lay is that it does not exhibit the same surface strand breakage as ordinary lay, thus making their detection more difficult.

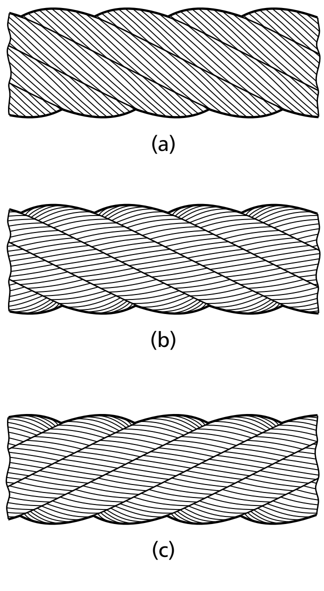

Figure 7.41 Rope lays; (a) Lang's lay, (b) ordinary lay, right hand, (c) ordinary lay, left hand

In the ordinary lay, see Figure 7.41(b), the wires in the strand are twisted in the opposite direction to the strands in the rope. Ordinary lay ropes are now used more frequently because they are more tolerant of mishandling and, provided the rope and sheave system is properly designed, give adequate life.

For both Lang's and ordinary lays, the length of lay of a rope is the distance, measured parallel to the axis of the rope, in which a strand makes one complete turn about the axis of the rope. The length of lay of a strand, similarly, is the distance in which a wire makes one complete turn about the axis of the strand. The rope strands can rotate either clockwise (right hand) or anti-clockwise (left hand) for both types of lay.

7.14.2 Aramid ropes

7.14.2.1 Aramid rope construction

Aramid (sometimes referred to as Kevlar®) is a high tensile synthetic fibre that can be spun to form rope of round section which can provide the strength of a conventional steel ropes with a significant reduction in weight and increased flexibility. The increased flexibility allows the rope to be passed over small diameter sheaves whilst the reduction in weight allows for ease of handling during installation and reduced power demand on the machine.

Rope weight is a significant factor in high rise lifts and conventional steel rope imposes a rise limit of approximately 600 m. The introduction of lightweight suspension systems may allow this rise limit to be extended significantly.

7.14.2.2 Aramid rope condition monitoring

This material requires new rejection criteria and devices have been developed to monitor the rope condition. Conductive fibres can be spun into ropes that allow a current to be passed through the rope. Deterioration can be detected by monitoring this current.

7.14.3 Flat belts

7.14.3.1 Flat belt construction

For many years lifts have used steel wire rope for the suspension system but today materials other than steel are being used and in new ways. Amongst these are flat belts, see Figure 7.39. These consist of a series of steel cords placed side-by-side and encapsulated within a polyurethane jacket.

Such belts possess the same strength as conventional steel ropes whilst weighing considerably less. Their slender thickness (approximately 3mm) permits the belt to pass over a small diameter sheave whilst introducing very limited fatigue to the steel cords.

The use of small sheaves permits considerable savings in space whilst the belt has reduced weight with high traction properties from the jacket and protection of cords from containments by the jacket.

Such an innovation has many advantages, not least of which are increased life, ease of handling, reduced motor power demand etc.

7.14.3.2 Belt condition monitoring

The inspection and rejection criteria for conventional steel ropes have long been established, but the introduction of flat belt technology has resulted in the need to develop new rejection and inspection criteria by the manufacturers.

The condition of a belt can be determined by visual inspection. Detailed inspection is time consuming and it is not surprising to note that remote belt monitoring devices have been developed. These consist of a small box of electronic equipment mounted at one of the belt termination points in the lift well. The electronics monitor the internal condition of the belt and can either remove the lift from service if a serious defect is detected or notify a remote monitoring centre of belt deterioration.

7.14.4 Safety factor for suspension

The rope safety factor is the ratio between the minimum breaking load of rope and the maximum force in the rope when the car is stationary at the lowest landing.

$$S_r = n\,F\,K/w \tag{7.3}$$

where S_r is the safety factor for the rope, n is the number of separate suspension ropes, F is the nominal breaking strength of one rope (N), K is the roping factor (1 for 1:1, 2 for 2:1, etc.) and w is the load suspended on the ropes with the car at rest at the lowest floor (N).

The load suspended includes the weight of the rope, the car and its rated load, a percentage of the suspension ropes plus a percentage of the compensation, if provided. BS EN 81-1(4) states that a minimum safety factor of 12 should be used for traction lifts with three or more ropes; 16 in the case of traction drive with two ropes, and 12 for drum drive arrangements. Greater factors of safety may result from use of the calculations in Annex N of BS EN 81-1.

7.14.5 Terminations

Various methods of terminating the rope are available, the most common being bulldog grips, swaged, and socketed end, see Figure 7.42. Whichever form of termination is used, its strength should equal at least 80% of the minimum breaking load of the rope. With bulldog grips, see Figure 7.42(a), it is important to use the correct number, tightened to the correct torque. Where socket terminations are used, the ends of the rope are bent over and tucked into the socket, see Figure 7.42(c). The socket is then filled with white metal (also known as babbitt) or resin.

The introduction of non-metallic ropes has resulted in the development of new types of terminations, however all

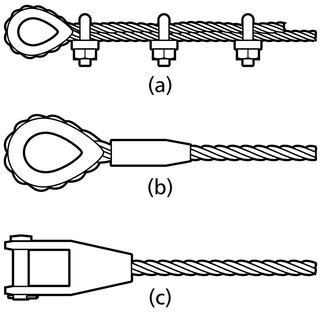

Figure 7.42 Rope terminations; (a) bulldog grip, (b) swaged end, (c) socket end

types of termination must provide at least 80% of the strength of whatever suspension is used.

7.14.6 Rope length and rope stretch

When installed on a traction lift, the rope length should be such that when the car is on its buffers, and the buffers are fully compressed, the counterweight is clear of the underside of top of the lift shaft or any other obstruction. When the counterweight rests on its fully compressed buffers, no part of the car may touch the top of the shaft or any obstruction in it. The actual clearance depends upon car speed. BS EN 81-1[4] stipulates requirements for these dimensions.

When a load enters a car, elongation of the rope occurs. The amount depends on the type of rope, its length and the load applied. On high-rise installations this elongation can cause the car to rise or move down below the floor by a small amount. To compensate for this the lift can be provided with a re-levelling feature to maintain the lift at floor level.

7.15 Roping systems

7.15.1 General

There are many different roping systems, some of which are shown in Figure 7.43. The best method to employ depends upon the particular situation, e.g. machine position, available headroom, rated load and speed. However, whatever the requirements, the simpler the roping system the better.

The lift machine is usually situated either at (or near) the top or bottom of the shaft. All types of electric traction drive are suitable for either top or bottom drive, but the best, and simplest, roping system is with the machine at the top. This usually provides the best rope life, lowest capital cost, least power consumption and minimum structural loads. Bottom drive is generally mechanically more complex in its roping arrangement and hence more expensive than top drive.

Typically, the structural load applied to a building with the machine above is the total weight of the lift machine, control gear, car, car load and counterweight. With the machine below, the structural load is approximately twice the sum of the weight of car, car load and counterweight. If the weight of the machine and control gear is considerably greater than the combined weights of the car, car load and counterweight, the structural load may be less with the machine below, but this is unusual.

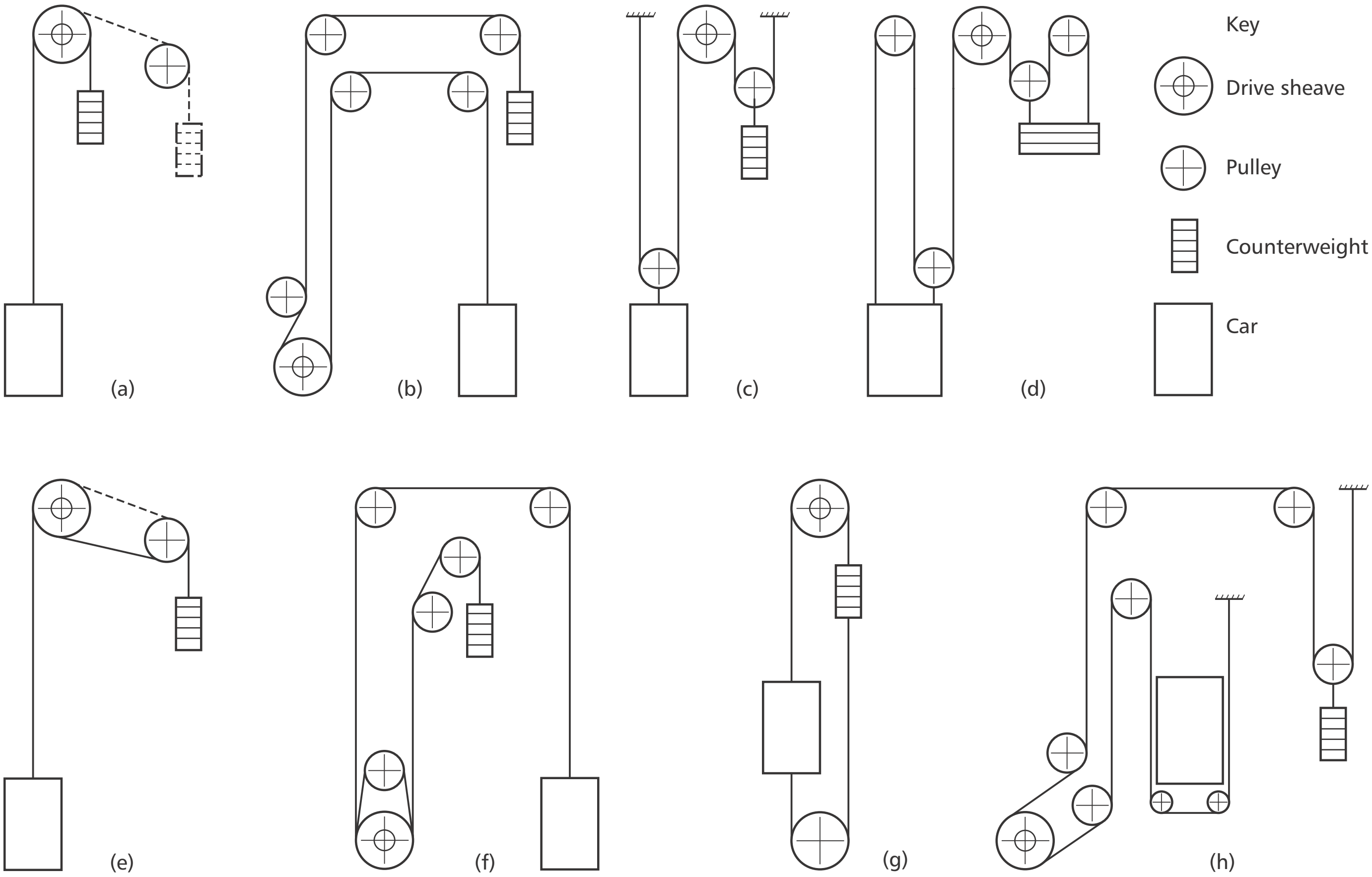

Figure 7.43 Roping systems; (a) 1:1 single wrap, machine above, (b) 1:1 single wrap, machine below, (c) 2:1 single wrap, machine above, (d) 3:1 single wrap, machine above, (e) 1:1 double wrap, machine above, (f) 1:1 double wrap, machine below, (g) 1:1 machine above with compensation, (h) 2:1 single wrap, machine below, underslung car

For a machine located at the top of the building, the simplest rope arrangement is that of the single wrap 1:1 system in which the ropes pass over the traction sheave once and the rope ends are terminated at the car and counterweight, see Figure 7.43(a). With this system, the car travels 1.0 m for every metre of rope moved over the traction sheave.

Figure 7.43(b) shows a single wrap 1:1 arrangement with the machine located below. This arrangement removes the need for a full height machine room at the top of the building, but space for the overhead sheave may still be required. The saving is generally about 900 mm in height but extra costs may result due to the additional rope and sheaves. Figure 7.43(g) is also a single wrap 1:1 arrangement but with the drive sheave in a different location.

With a 2:1 roping system, the car travels 0.5 m for every metre of rope moved over the traction sheave. This means that the speed of the car is half that of the driving machine. Either top- or bottom-located machines may be used with a 2:1 roping system. An advantage of this arrangement is that it enables a small number of machines to cover a wider range of speeds and loads since, by halving the speed, the load may be doubled. In addition, the load imposed on the machine sheave shaft is effectively halved as half the mass of the car and half the mass of the counterweight is supported by the building structure, see Figure 7.43(c). The reduction in the load carried by the ropes passing over the traction sheave reduces rope pressure and may enable fewer ropes to be used. The system does, however, require longer ropes and rope life may be reduced by the additional bending stress caused by the number of sheaves that the ropes should pass over. Figure 7.43(h) is also a 2:1 arrangement but with sheaves located below the lift car.

Where bottom drive is employed, a reduction in headroom may be obtained using an under-slung arrangement for the lift car. This involves mounting pulleys on the underside of the car and positioning high-level pulleys and rope anchorages (outside the line of the car roof) at the top of the lift shaft, see Figure 7.43(h). No pulley room is required with this arrangement. It should be noted that increased running noise may be apparent with the under slung arrangement, therefore speeds are usually limited to 1.6 m/s.

Many other rope systems have been used, such as 3:1 (see Figure 7.43(d)) but these are not commonly used except for very large goods lifts or other special applications.

Figure 7.43(e) and (f) show double wrap arrangements. The ropes pass twice over the drive sheave and as a result the traction is increased dramatically.

7.15.2 Rope compensation

Ropes may be hung under the car to the counterweight in order to compensate for the weight of main ropes, see Figure 7.43(g). Compensation is used to ensure that adequate traction is available, wherever the car is in the shaft, and/or to reduce the power requirement for the drive motor. For lift speeds up to 2.5 m/s, chains or free ropes may be used, tensioned by gravity. For speeds above 2.5 m/s, a tensioning device is required. This usually takes the form of a weighted sheave fixed between two guides. For speeds above 3.5 m/s, an anti-rebound device is required. This prevents the counterweight from rising through its own inertia if the car should be stopped abruptly, and prevents the car from continuing upwards if the counterweight should be stopped suddenly. This is sometimes referred to as 'tied-down' compensation, see section 7.6.4.

7.15.3 Traction systems

In all traction rope systems, the power developed by the machine is transmitted to the ropes either by a single-wrap or double-wrap traction system. In the single-wrap system the ropes pass once over the sheave, into which specially shaped grooves are cut. These are known as traction grooves. The traction force depends on the specific pressure between the ropes and the sheave, the frictional properties of the rope and sheave materials, the groove angle (shape) and the amount by which the ropes wrap around the sheave.

These factors govern the ratio which can exist between the rope tensions on the two sides of the sheave before slipping occurs. The traction developed should be sufficient to enable the car plus 125% load to be safely supported but should be low enough to ensure that, if the tension in either the car or counterweight side of the rope is reduced to zero, the traction is insufficient to permit the car or counterweight to be hoisted. Excessive traction can also result in excessive sheave and rope wear. BS EN 81-1[(4)] provides formulae for the calculation of traction using conventional steel ropes.

The shape of the groove has a considerable influence on the tractive force. Figure 7.44 shows typical grooves that may be employed. The straight V-shape provides the greatest traction, the least support to the rope and, therefore, the greatest wear. The round-seat type provides the most support and the least traction and wear.

Flat construction belts do not use shaped grooves to develop the required traction. Traction is achieved by means of the large surface area of material in contact with

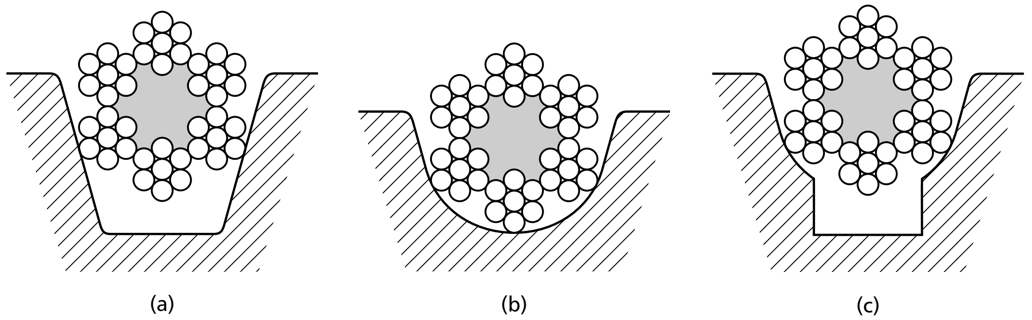

Figure 7.44 Common types of groove; (a) 'V' groove, (b) round seat ('U' groove), (c) progressive or undercut groove

the sheave, the surface of which is also virtually flat. The absence of a groove avoids pinching the rope which greatly extends the life of the rope.

The number of variables involved in the traction and rope life means that it is unreasonable to request a particular groove or material and the manufacturer should be allowed to provide the combination that they feel to be the most appropriate. Ropes may be expected to last seven to ten years for the lifts in a typical office building. However, this may not be achievable in environments such as large hotels, where lifts operate for up to 20 hours per day.

7.16 Car and landing fixtures and inspection controls

7.16.1 General

The term fixtures embraces car operating panels, indicators, push buttons, hall lanterns and any signs, magnetic card readers or key-pads. If properly designed, they can help to make a lift more 'user friendly' and can improve service. While these items can contribute greatly to the appearance of the lift, their prime function is to inform users of what is happening and/or to enable instructions to be given to the lift control system. Essential fixtures such as buttons, indicators and hall lanterns should be large, conspicuous and easy to see against the surrounding walls.

BS EN 81-70[20] defines requirements for lift controls and fixtures that enable all users including those with disabilities to use the lift with relative ease.

7.16.2 Push buttons

Buttons may be square, round or any other shape but should not be small. Ideally, the area pressed should be at least 400 mm^2 and no side should be less than 20 mm. Some means of informing users that their call has been registered is good practice and this may be by illumination of the button or a surrounding halo or by a separate indicator. In addition to this visual feedback, audible feedback may also be provided. Illumination is best provided by light emitting diodes (LEDs), which give long trouble-free life. Faceplates should be of sufficient size to make the buttons easily noticed. Buttons without faceplates are difficult to see and therefore should never be installed without a faceplate. The faceplate should contrast both with the button and the surrounding wall to ensure that it is easily noticed.

Markings on buttons should be in a clearly, easily read typeface such as Helvetica and by some form of tactile indicator, if possible. Braille markings are sometimes provided, to assist those persons with impaired vision who can read Braille. Simple tactile markings are preferred since these are discernible by all. Any such markings should be on the button itself or adjacent to it. The size of the markings should be of the order of 15 mm in height and located at between 10 and 15 mm from the button.

The height of the buttons above floor level in the car should be between 900 mm and 1200 mm. Where it is intended that the lift should be accessible to wheelchair users, buttons inside cars should be not less than 400 mm from any wall at right angles to the buttons. This dimension should be 500 mm on any landings.

7.16.3 Lift position indicators

Preferably indicators should be provided within the car and on the main landing. On single units, an indicator at all floors is a useful addition that provides users with a visible indication of the progress of the lift. It may be desirable to indicate when lift cars are unavailable for passenger use, although this is not required by BS EN 81-1/2[4,11]. On non-collective lifts, a 'lift busy' indicator is necessary so that users know that the lift cannot accept calls.

Some lift systems deliberately order a car to bypass a landing call in order to optimise overall response times. Passengers observing this operating sequence are likely to interpret it as a fault. Thus, when two or more lifts are operating together, it is better not to provide indicators on every landing but only at the main entrance floor for the building. Figure 7.45 illustrates three types of indicators: multi-light, dial and digital.

Incandescent lamps are not a good choice for position indication since they consume more energy and have a shorter life than other forms of illumination. On large groups of lifts, indicator lamp replacement can become a frequent maintenance task. The power requirements are illustrated by the fact that the car lighting and indication can consume half the total energy required to run the lift.

Digital-type indicators are by far the most popular and many versions exist. Illumination may be by LCD (liquid crystal), TFT (thin film transistor or solid-state indication using LEDs (light emitting diodes). LED displays provide a compact, energy efficient solution. Dot matrix displays allow great flexibility in floor identification. Large dot matrix displays can be used to display messages which can be read easily from anywhere in the car.

Whichever type is chosen, the display should be clear to all users including the partially sighted. This requires that any symbols should preferably be between 30 and 60 mm in size and located between 1600 and 1800 mm from floor level. It is also good practice to provide audible feedback with any such signals. Voice annunciators are useful in situations where the lifts are regularly used by the general public or by blind or partially sighted people. However, the announcements can become a source of irritation to lift users. This can be avoided in part by enabling the volume to be adjusted between 35 and 55 dBA.

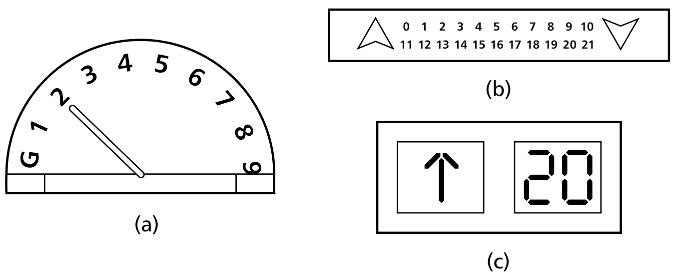

Figure 7.45 Lift position indicators; (a) multilight, (b) dial type, (c) combined hall lantern and digital indicator

Fixtures should be displayed against a dark background to provide a sharp contrast in colour and should be visible from acute angles, especially where there is only one indicator, placed to one side of the car entrance. In large cars (i.e. 1600 kg and above), two operating panels, each with an indicator, should be considered.

7.16.4 Lift direction indicators

On any simplex collective lift, passengers should be provided with a means of determining the direction of travel of the car before they enter. This can be achieved by providing a hall lantern or direction indicator at each landing or a single direction indicator within the car, positioned so as to be visible when the doors open. Again illuminations by LEDs or vacuum display are preferable because of their high reliability. The sizes and sound levels should follow the guidelines for lift position indicators given in section 7.16.3.

7.16.5 Hall lanterns

Hall lanterns should always be provided at each landing for groups of two or more cars and may be provided on single lifts, if desired. The lantern should illuminate and chime before the car arrives at the floor to alert waiting passengers. This enables the passengers to start moving toward the arriving lift so that door dwell times can be kept to a minimum. To assist the partially sighted, the chime should emit notes of different tones and sound once for up and twice for down. Numerous designs are available but again the essential points are reliability and practicality. It should be borne in mind that the principal function of lanterns is to provide the passengers with information. The sizes and sound levels should follow the guidelines for lift position indicators given in section 7.16.3.

7.16.6 Passenger communication and alarm devices

All lifts require an alarm device for use in an emergency. In the past, this has taken the form of a simple bell to summon help. However, the Lift Regulations 1997[2] require new lifts to be connected to a device that allows trapped passengers both to summon help and to communicate directly with those who can arrange for their rescue. BS EN 81-28[21] is a harmonised standard that defines requirements for such devices. Other designs are still possible but as a harmonised standard it may be increasingly used by lift suppliers as it offers a presumption of conformity with the Lift Directive[1], thus avoiding the need for an approval from a Notified Body for lifts.

The button or other device used to activate the alarm provided in the car operating panel should be yellow and marked with a bell shape symbol. When operated it should provide both audible and visual information to the user. A yellow pictogram should indicate that the alarm has been sent. A green illuminated pictogram in addition to any audible signal should indicate when the alarm call has been registered by the rescue organisation.

The design of the system should be such that once the alarm has been raised there should be no need for further action or speech by the trapped passenger. The system should inform the rescue service of the location of the lift. This ensures that in the event of the person being unable to communicate for any reason, their predicament and location is known. A conventional telephone does not therefore satisfy this requirement.

Note that the requirements for the pictogram are not defined in BS EN 81-28[21], but are defined in BS ISO 4190-5: 2006[22].

7.16.7 Inspection controls

These have historically been provided on the top of lift cars to permit the lift to be moved at reduced speed in relative safety. It is now recognised that with the introduction of machine room-less lifts and an increasing drive to reduce accidents to persons working on lifts that the provision of controls in other areas of the lift may be beneficial. It is likely that changes may be made in standards within the next few years to call for inspection controls to be provided in the lift pit and at any working platform provided within the lift well. Thus a lift may have three or possibly more inspection control stations installed.

BS EN 81-1/2[4,11] already recognises the need for more than one inspection control in some situations. Where more than one inspection control is provided it needs to be electrically interlocked with any other inspection control to ensure that the operation of one device does not override an instruction from another.

7.17 Guarding

It is generally accepted that all exposed rotating parts of lifts should be guarded. The old practice of painting parts yellow being an ineffective and unacceptable solution. Amendment A3 to BS EN 81-1/2[4,11] requires fixings for guards that remain with the guard or with the item to which the guard is attached, in the event that it is removed.

This new requirement stems from the third amendment to the Machinery Directive[23] (on which the Lift Directive[1] rests) and created a discussion over what constitutes a guard. Is a car operating panel a guard? It clearly protects users from electric shock.

Covers, shields etc. designed to fulfil a protective function that may be required to be removed for maintenance are guards and will require captive fixings.

Parts fulfilling an operational function are not guards and do not require captive fixings.

As an example a wire mesh cover over a traction sheave may, depending on design need to be removed reasonably frequently (once per year) for maintenance. If this covering is removed the lift still operates as normal so it is a guard. The prime function of a car operating panel is to hold the operating buttons in place and whilst it also guards persons from shock it is not classed as a guard and the fixings do not need to be captive. A trunking cover lid could be considered as a guard but it does not need to be removed for maintenance, whereas a landing lock cover does, therefore the lock cover will requires captive fixings.

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8 Lift drives and controls

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Chapter contents

Contents continue

8 Lift drives and controls

8.1 Introduction

The objective of this chapter is to provide an unbiased guide to lift controls so that users and specifiers may compare manufacturers' products and have confidence that they are specifying the correct control equipment for each application. It is intended to help the reader to look for good and bad features and to be in a position to ask the right questions about manufacturers' products. Documentary proof of performance, reliability and control characteristics should always be requested from the manufacturer in case of uncertainty.

Until the 1980s, buildings and users have often suffered because of the incorrect application of lift products to the building. In many cases, this was due to speculative building decisions, providing less than the optimum number of lifts for the building. In other cases, the specifier has failed to take advice, or taken incorrect advice, from lift salespersons. Changes in office working practices and the cost of office accommodation have also resulted in problems. Both can lead to the building population increasing far beyond the capabilities of the existing lift control systems. In these cases, installing new computer-based equipment will normally improve the passenger-handling capacity of existing groups of lift cars. The selection of the most suitable control system for optimum performance needs to take into account the building use and also environmental performance objects.

8.1.1 Performance parameters

The controller influences the efficiency of a given group of lifts to move people. Parameters such as flight times, round trip times and interval (see section 3.5) provide a guide to the relative efficiency and these parameters can be either measured or obtained from the lift supplier. As an example, one second saved on single floor transit time (see section 3.5.9) improves the traffic handling capacity of the lift by approximately 5%.

To maximise the transportation capacity for a given size and speed of lift car, the cycle time must be as short as possible. In practical terms this means that:

— the lift should drive straight to floor level (known as direct to floor approach) without the need for a slower levelling speed to ensure accurate stopping at floor level and a short single-floor flight time

— the opening time for the doors must be short; this time may overlap with levelling

— the door open time must be optimised to the building type, size of the lift car and passenger movement; non-contact passenger detectors (see section 7.8.6) can be used to shorten the door open time and are necessary for lifts to be used by persons with disabilities as required by BS EN 81-70[1], see chapter 17

— the door closing time should be as short as possible, commensurate with the kinetic energy limitations imposed by BS EN 81[2,3] (see section 7.8.2) and passenger comfort.

These factors have important consequences for the design of lift components and control devices.

8.1.2 Operation monitoring

In the past, lift controllers have provided little information on the operational state of the lifts. This information has been typically confined to:

— lift position indication on landings and in the car

— actual and intended travel direction

— 'lift in use' indication for simpler lifts using automatic push button control.

The Lifts Regulations 1997[4] require that a new lift has a means of generating an alarm and two-way communication system that provides direct communication to an organisation capable of releasing the passengers safely. This organisation and communication must be permanently available. The organisation is typically the lift maintenance company. However, it may be a 24-hour security organization on a large industrial site. BS EN 81-28[5] is the harmonized standard that defines the requirements for the alarm equipment and management of the alarm.

Computer-based control systems have resulted in the development of more sophisticated monitoring of the state of the lift and its traffic handling efficiency. Features typically available include:

— add-on or built-in fault detection and diagnosis

— statistics on call handling and lift usage

— a summary of group waiting times and stopping accuracies

— communications capability for transmission of information to a remote point

— the ability to monitor third-party control systems from the same remote monitoring package.

— video monitor displays of the real-time operation of the lift group(s)

— voice annunciation of lift position and other messages.

Groups of lifts in busy public use, e.g. those in airports and hospitals, should always have some form of lift monitoring, either local to or remote from the building. If monitoring of small groups or individual lifts is installed for maintenance purposes, the equipment local to the lift should not be over-complex. The monitored information must be checked for accuracy and relevance. False or irrelevant information can be worse than no information at all. Current alarm systems can have integrated remote equipment monitoring capability. This allows reporting of faults and equipment condition to the maintenance organisation.

Most manufacturers have their own solutions to lift monitoring that, in the main, rely on special computer software and it is essential to consult with the potential suppliers before specifying non-standard monitoring equipment (see chapter 14). It is rarely cost-effective for manufacturers to design one-off software for individual customers. Furthermore, it may prove difficult to locate a maintenance company willing to accept responsibility for such software.

8.2 Lift controllers

8.2.1 General

The function of a lift controller is to respond to inputs and produce outputs in order to control and monitor all the operations of an individual lift car. The controller may be considered to comprise power control (i.e. motion control, door control) and traffic control (passenger demands).

The power controller must control the lift drive motion so that the lift always achieves the optimum speed for any travel distance. Uneven floor heights must not result in long periods of low speed travel when slowing to some floors. The power controller must also operate the doors and may modify the opening time and speed of the doors in response to signals from the passenger detectors.

In general, the controller inputs are:

— car calls

— landing calls (direct or from a group controller)

— door safety device signals

— lift well safety signals

— signals from passenger detection devices on car, doors and landings.

The controller outputs are:

— door control signals

— lift drive control signals

— passenger signalling (call acceptance, lift position, direction of travel indication).

The basic traffic control task of moving a lift car in response to calls is relatively straightforward. However, two factors combine to make the lift controller one of the most complex logic controllers to be found in any control situation. These are:

— control options

— fail safe operation if faults occur.

8.2.2 Lift control options

Lift control options are customer-defined modes of operation of the lift. Many options are standard and defined in the operational sequence of the lift, and are offered by all major lift manufacturers. In some circumstances, the complexity or combination of options makes the use of computer-based controllers essential. Among the most common options are:

— car preference or independent operation of one lift car

— rapid closing of doors, when a car call is registered

— reduction in door open time, when passengers are detected by interruption of the light ray or other passenger detection device

— differential door timing so that doors stay open longer at the main floor and/or vary according to the lift traffic and use by persons with disabilities

— 'door open' button

— 'door close' button

— attendant operation (becoming less common)

— recall of all or some lifts to specified floor(s) in the event of fire

— emergency power operation (the exact operational sequence is usually defined by the customer)

— bed service (for hospital lifts).

A detailed description of the operation of the particular lift manufacturers' version of these options should always be provided by the manufacturer when discussing the specification with the customer. This can avoid ambiguity and misunderstandings leading to excessive costs.

Other modes of operation may be specified by the customer, such as, for example, hall call allocation control. Where these modes are unique, it is important to note that they may require special computer software and/or additional controller hardware. The commissioning and maintenance of such special modes is not always as straightforward as that for conventional lifts. This is often due to an insufficient technical exchange between all parties during the project design stage

8.2.3 Fail-safe operation

Safety requirements are laid down in BS EN 81-1[2] for electric traction lifts, BS EN 81-2[3] for hydraulic lifts (other than home lifts) and BS 5900[6] for powered domestic home lifts. These standards require that both the lift controller and the lift must be designed so that a single fault in the lift or the controller shall not cause a dangerous situation to arise for the lift user.

Note that the safety requirements for powered domestic home lifts to comply with BS 5900 are less rigorous than those for lifts in public areas and workplaces required to comply with BS EN 81-1/2.

8.2.4 Controller cabinet and its location

The introduction of machine room-less lifts and the associated amendment A2 to BS EN 81-1[2] and BS EN 81-2[3] has fundamentally changed the design of the lift. Now it is possible for the controller to be divided into a number of components distributed around the lift installation. The major part of the controller (e.g. hoist motor drive) may be mounted in the top of the well, the pit, in an enclosure on a landing or to the side of the well. Other parts may be located on top of the car, call buttons, indicators and door operator may be intelligent and communication between all parts of the control system may be carried out using serial data transmission or even by radio or laser in some applications rather than a conventional hard-wired system. Large, high speed lifts may still use machine rooms due to the size of the hoisting machine and its drive.

The size of controller cabinets varies with complexity of the controls. Most cabinets are between 0.8 and 2.5 m high. They should be installed plumb, square and securely fixed in place. They should not be located in awkward corners or restricted spaces that may cause servicing or safe-working problems. Control cabinets should be positioned such that they are not subjected to the heat resulting from machine ventilation fans or any other direct source of heat. Lighting with an illumination of 200 lux (BS EN 81-1/2[2,3]) must be provided where work needs to be carried out on control systems and machinery should be provided and the environmental conditions required by the manufacturer must be observed.

The physical arrangement of the components within the cabinet may cause the local temperature for some components to rise above the ambient temperature in the machine room by up to 10 °C. All power resistors and high-temperature components should be mounted so as to avoid undue heating of other components. The cabinet should be designed to allow a free flow of air from bottom to top of the controller, without any fan assistance, in order to limit the internal temperature rise to 10 °C.

High humidity and rapid changes in temperature may cause condensation and these conditions should be avoided in the machine room or the machinery space. This is not a problem in most applications. However, where the environment is severe and condensation cannot be avoided, the following precautions should be considered:

— all equipment should be 'passivated' or galvanised and extra coats of paint applied

— all components and printed circuit boards should be 'tropicalised' (to avoid mould growth and damage from condensation)

— forced ventilation and temperature/humidity control of the cabinet should be considered.

8.3 Controller technology

8.3.1 General

The size of the building (i.e. number of floors) and the complexity of the lift operations required determine the technology used for the controller. Three basic controller technologies have been used:

— electromagnetic relays

— solid-state logic

— computer-based ('intelligent') systems.

Computer-based systems offer the greatest flexibility to accommodate changes in the use of the building and the requirements of the user. For this reason, it is now, by far, the most commonly-used technology. Electromagnetic relays offer the least flexibility. Electromagnetic relays and contactors are used in computer-based and solid-state logic controllers in order to satisfy the requirements of the relevant British and European safety standards[2,3,6].

8.3.2 Electromechanical switching

Electromechanical switching devices include electromagnetic relays and mechanically driven selectors. Relays are designed for low-power switching operations and contactors for higher powers. Lift selectors, mechanically driven from the motion of the lift by a tape or rope drive, may be used for low-power logic operations in lift control. Some manufacturers use tape drives for lift position indicators, even in computer-based controllers.

To maximise the reliability of the lift controller, the number of electromechanical components should be kept to a minimum. When a relay controller is 8–10 years old, the breakdown rate of the lift rapidly increases as the relays wear out. O'Connor[7] gives intermittent faults as 70% of relay failures during the wear-out phase.

Relay-based controllers have often presented maintenance problems when fitted to larger lifts and group systems (see chapter 9). Often, manufacturers do not include sufficient indicator lights to show the operational state of the relays. In cases of intermittent faults, this lack of indicators can increase repair times unnecessarily. Although the controller drawings are on site, they often do not show the actual circuits, because modifications may have been made, without the appropriate changes being made to the circuit diagrams. Updated electrical drawings are therefore essential following any subsequent controller modification.

8.3.3 Solid-state logic technology

Solid-state logic technology includes both discrete transistor circuits and integrated circuit boards. With integrated circuits based on complementary metal oxide silicon (CMOS), 12–15 V power supplies may be used, which provide high immunity to electrical interference.

Call signals and other direct current input signals are usually interfaced via passive filter circuits. Light-emitting diodes (LEDs) may be easily incorporated into the design to aid maintainability. It is still normal practice to

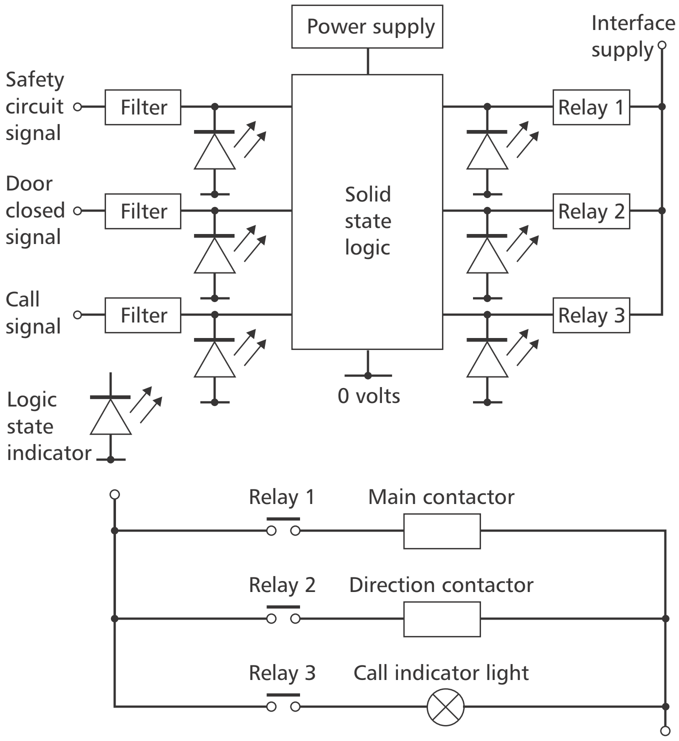


Figure 8.1 Schematic of typical solid-state logic controller

use some contactors and relays to satisfy requirements of BS EN 81-1(2) and BS EN 81-2(3) and BS 5900(6). Small cased relays may be used to interface between logic circuits and the high voltage parts of the controller and lift. Figure 8.1 illustrates the basic features.

The reliability of solid-state logic devices is dependent upon the ambient temperature, the operating point of the device (in relation to its maximum rating) and the complexity of the device. The following points should be considered to ensure maximum life:

— Increasing the ambient temperature by 25 °C increases the failure rate of a device by a factor of ten. Therefore, the lift motor room should be kept as cool as possible while staying within the minimum set by BS EN 81-1(2) and BS EN 81-2(3) of 5 °C (see chapter 12).

— Running a solid-state device at 70–80% of its maximum rating doubles its reliability compared with running at maximum rating.

Integrated circuits allow lift controllers to incorporate many lift options and are suitable for single and duplex lifts, where there is a low density of traffic.

8.3.4 Computer-based technology

Computer-based technology enables complex and adaptable functions to be performed. However, non-standard features should be avoided because of the expense involved in developing and testing special computer software. Computer-based controllers offer flexibility in the options provided and permit fine-tuning to match the building requirements. They are at present the preferred choice for lift groups of any size and for all lift traffic situations. The following features should be provided to ensure adaptability and trouble-free operation:

— isolated floating power supply for the computer (i.e. not connected to the electrical safety earth or supply common)

— power supply regulator with a high input/output voltage differential to ensure immunity from fluctuations in the mains supply

— galvanic isolation (also known as opto-isolation) of all inputs and outputs to the computer to reduce pick-up of electrical noise and possible destruction of low-voltage components

— program written in a high-level language for ease of program maintenance

— real-time operating system to control lift program execution

— diagnostic capability to monitor performance and record controller logger events to aid fault diagnosis

— visual indicators on key input and output signals to aid maintenance

— means of altering lift parameters (e.g. door times, parking floor) on site, without the use of special programming equipment or replacement programs.

The basic reliability of computer-based devices is the same as for solid-state devices. However, considerably improved reliability is achievable if the hardware and software are carefully engineered. The construction of the computer, its programming and its interface to the rest of the lift controller profoundly affect the reliability of the controller. Software also affects reliability. The use of a high-level language is essential for all but the simplest programs. It is necessary to thoroughly test new software and software modifications to ensure that any programming errors cannot cause lift malfunctions. Standardised software will ultimately ensure that optimum reliability is achieved. This also ensures that software traceability is more easily maintained than the alternative option of relying upon bespoke software.

Computer-based controllers are suitable for:

— all types of lifts

— all drive speeds (i.e. 0.5 to 15 m/s)

— lift groups of all sizes (see also section 8.6).

The group control function should have at least one level of backup to ensure continued landing call service if the main group control fails, e.g. a 'bus stop' type service.

8.3.5 Programmable electronic systems in safety related applications (PESSRAL)

The Lifts Directive(8) (see chapter 17) allows the function of safety switches to be implemented by solid state devices and software. Potentially this allows a reduction of the use of wiring in the lift. As an example, a landing lock contact could be replaced by a lock latch position sensor that communicates its state and receives its power supply by electromagnetic induction. Such a lock implementation removes the need to run high voltage power supplies to the locks. This implementation needs to have the same level of reliability and safety integrity level (SIL) at least as high as the electromechanical device that it replaces. The design, production and maintenance of these devices and systems should be rigorously controlled. Compliance with BS EN 81-1[(2)] or BS EN 81-2[(3)] as appropriate and BS EN 61508[(9)] requirements (see chapter 17) is an effective way to provide that control.

Existing installed control systems generally cannot be modified at a reasonable cost to incorporate and use PESSRAL devices.

8.3.6 Building security systems

Computer-based lift control systems using destination control and other advanced traffic controls (see chapter 9) are ideally suited to be an integral part of the building security system. Access control gates in the lobby can be linked to enter a person's destination call into the lift system. It should be noted, however, that a lift car is not an inherently secure device such as a locked door.

The use of machine room-less lifts for access direct into apartments should be avoided. It is not possible to provide effective security without the addition of a normal building door providing access to the apartment. Also, arguably, it does not comply with the requirements of the Lifts Directive[(8)] to minimise the hazards and risks of being trapped in the lift. This is due to the difficulties of providing access to the lift entrance in the apartment for maintenance and rescue.

8.4 Control of lift drives

8.4.1 General

Drives for lifts are separated into two main categories: electric traction (see section 7.2) and hydraulic drive (see section 7.3). Electric traction drives are further divided into geared and gearless drives in both synchronous and asynchronous variants (DC motors are almost never used in new lifts now). It should also be noted that hydraulic lifts also use electric motors for driving the hydraulic pump. The characteristics and applications of each type of drive vary considerably and an inappropriate drive can have disastrous effects on the reliability and efficiency of the lift installation. It may also lead to increased capital and recurrent costs for the building.

Irrespective of space considerations, the key parameters in choosing between hydraulic or electric traction lifts are as follows:

- — height of travel
- — projected number of starts per hour
- — required ride quality
- — nominal lift speed to provide an acceptable transit time between terminal floors of the building (e.g. 20–40 s)
- — number of lifts required to move the projected building population.

As a general guide, hydraulic lifts should not be specified if the number of motor starts per hour is likely to exceed 45 (or up to 60 motor starts per hour, if additional oil cooling is provided), see section 12.10.1, or if more than two lifts are necessary to move the population efficiently. This is because the temperature of the oil is very important for reliable operation and most of the energy from the motor is dissipated in the oil, causing its temperature to rise. However, it should be noted that for hydraulic lifts, which do not use a counterweight, the number of motor starts is not equal to the number of lift starts since, for travel in the down direction, only the fluid control valve is opened.

The ride quality of hydraulic lifts at high speeds is generally inferior to that of controlled electric traction drives. For goods and service lifts, however, this is of minor importance provided that levelling accuracy is not compromised.

Guidance on the selection and application of various drive systems is given in BS 5655-6[(10)]. Unlike many industrial or plant applications of motors and their solid state drives, lift applications impose heavy stresses on the equipment. Lift motors and their drives have to be capable of starting at up to 240 starts per hour under widely varying load conditions. Thus the motor and its drive can spend a large proportion of time under accelerating and decelerating load conditions. Whilst the drive's nominal rating may be the same as that for a comparable non-lift application, its overload capacity should be larger to cater for these repeated periods of acceleration and deceleration. This will ensure reliable operation is achieved from suitably sized output devices in order to cater for these conditions of changing load and speed. In addition, there is a need to be able to reverse the hoist motor torque linearly at any speed without causing an unwanted jerk to the lift car. In particular, standard industrial DC and variable frequency AC drives are unsuitable for direct application to lift hoisting applications.

A comparison of the basic electrical characteristics of electric motor drives can be made by simulation. Figure 8.2 shows the major differences such as (a) power factor, (b) kVA and (c) line current demand. The graphs shown are for a nominal 10 kW output motor under acceleration. Consideration of these for a particular building may influence the choice of drive.

8.4.2 Motor speed reference

The motor speed reference is a control signal generated by some device that indicates the speed and direction of movement of the lift. Some motor speed reference generators also provide information on the present position of the car. These signals are used to control the speed and direction of the motor to enable the lift to respond to instructions received from the controller.

Motor speed references may be divided into two categories: time-based and distance-based[(11)]. In general, provided that the motor speed is accurately controlled and stable under all likely environmental and load conditions, the choice is not critical. However, the distance-based speed reference provides better control, maximum handling capacity and in most cases superior ride comfort. In addition, the lift user benefits from 'direct-to-floor'

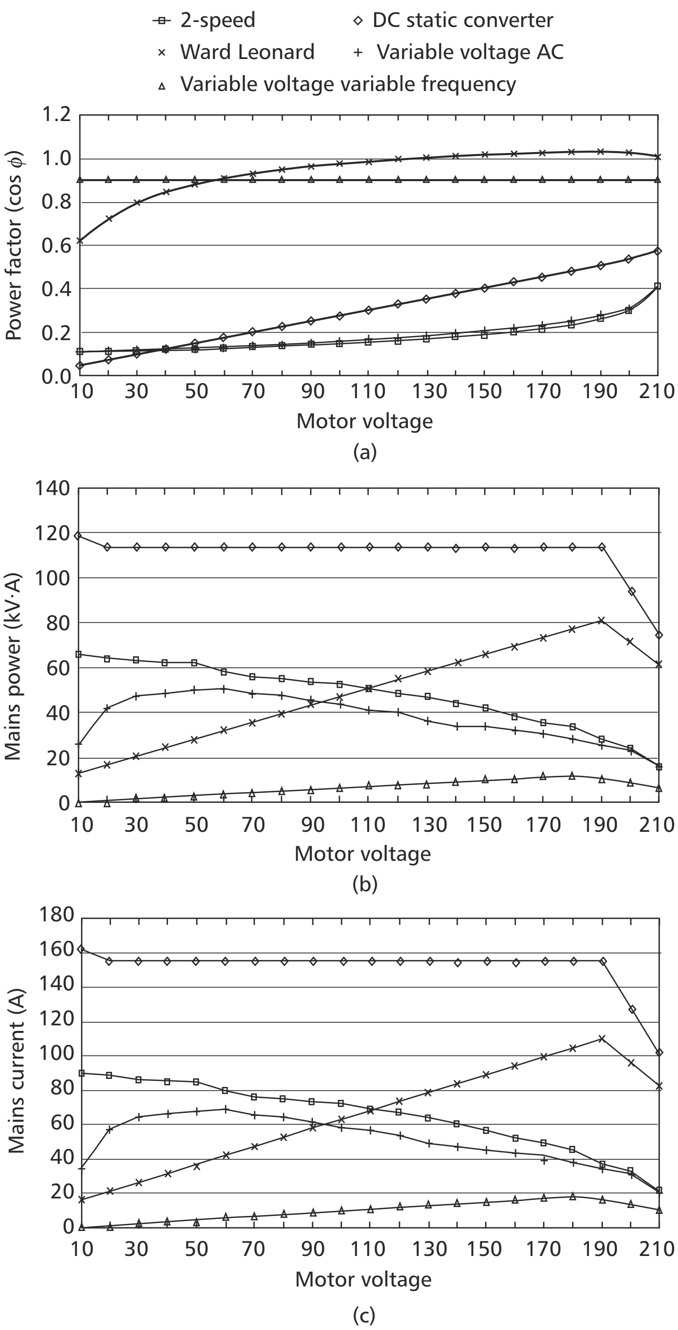


Figure 8.2 Simulation of basic electrical characteristics; (a) power factor, (b) mains power, (c) mains current

approach when a position-based speed reference system is used.

8.4.2.1 Time-based speed reference

Figure 8.3 shows a typical velocity/time graph for a time-based speed reference. The speed reference may be generated by simple analogue or precision digital computer methods in response to a lift call. It has preset acceleration and deceleration values but, often, may not have a predefined value of jerk. At the start of a run between floors the speed reference increases to the maximum speed for multi-floor runs. For one-floor runs, the speed is limited to an intermediate value determined by the shortest interfloor distance. For lifts with speeds greater than 1.5 m/s, two or more intermediate speeds may be used for two- and three-floor runs, where the lift does not reach its maximum speed.

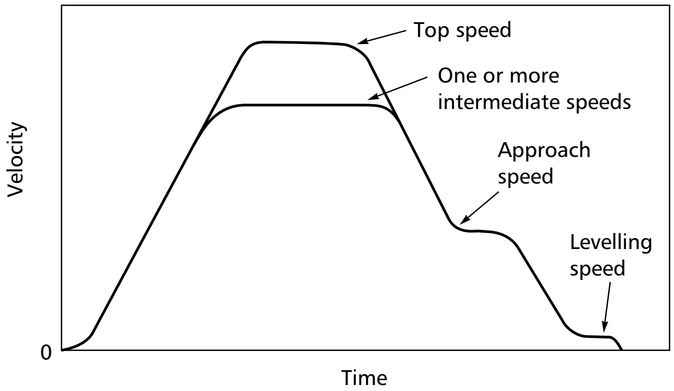


Figure 8.3 Velocity/time graph for time-based speed reference

For simple time-based speed generators, there is no feedback of lift position to the reference generator. Furthermore, since the lift position during deceleration is dependent upon the load, it is not possible for the controller to bring the lift to rest at floor level by means of constant deceleration. This difficulty can be overcome by ensuring that, as the car nears the required floor, its speed is reduced to a constant 'approach speed', typically 0.4 to 0.5 m/s, and then further reduced to a 'levelling speed' of about 0.06 m/s, just before the car reaches floor level.

The multi-step deceleration is initiated at one or more fixed points in the shaft. The speed reference causes the lift to decelerate at a constant rate, until it reaches a second point at which the approach speed is set. The lift then runs at constant speed until a third point is reached at which the speed reference causes further deceleration to the levelling speed. The lift is finally brought to a standstill, either by the brake or by electrical regeneration in response to a signal from a position sensor. Lifts using a digital time based speed reference, with a well tuned velocity control, can reduce the levelling time to less than one second. It is not uncommon for poorly adjusted lifts to run at approach and levelling speeds for four or five seconds. This will also have additional unwanted effects of energy wastage during this levelling speed process.

8.4.2.2 Distance-based speed reference

Figure 8.4 shows a typical velocity/time graph for a distance-based speed reference, also known as optimal speed reference. The acceleration and deceleration values are preset with a predefined value of jerk. These values are typically adjustable during commissioning of the lift. However it is not normal to adjust the values in, for

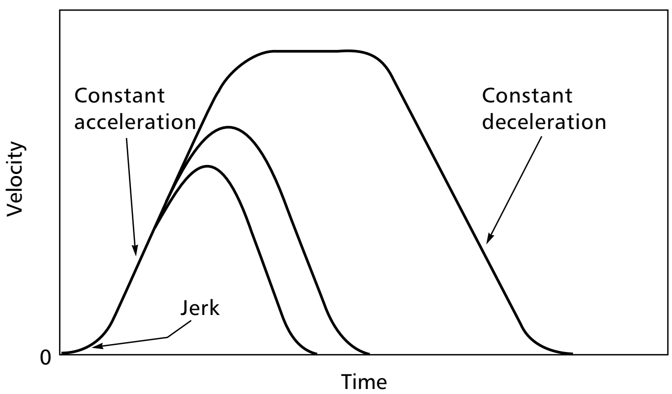


Figure 8.4 Velocity/time graph for distance-based speed reference

example, response to traffic conditions. Adjustment affects ride comfort and lift traffic handling performance.

There are no intermediate speeds used for short distance travel, where the lift cannot attain rated speed. The speed reference generator has inputs, which are dependent on lift position and velocity. These allow the reference to generate the maximum possible speed for the distance to be travelled.

For speeds of up to approximately 2 m/s, signals from devices mounted on the car or in the lift well are used to initiate deceleration. Because the speed of the lift is known at the signal point, the deceleration distance can be calculated by the speed reference generator. The start of deceleration can be immediate or delayed corresponding to the actual lift speed. During deceleration, the distance from floor level is calculated continuously and the braking torque applied to the motor is varied to maintain the lift on the required velocity distance curve.

For high lift speeds and buildings with several uneven interfloor distances, it is common to use a digital counter-based lift position and deceleration system. This technique can resolve the lift position in the shaft to an accuracy of 3 mm per count or better. The counter input is usually derived directly from a pulse generator connected to the lift or from a motor speed transducer. Typically, to correct for possible counting errors, a spatial image of the lift well is stored in computer memory and used for error correction, whenever the lift is running. Other techniques use directly coupled digital pulse encoders or resolvers. These are commonly used to determine position and for control of motor speed and load angle for variable frequency drives used with induction and permanent magnet synchronous motors.

Using the stored image of the well and information derived from it, the speed reference is continuously provided with information on the distance the lift needs to travel to the next possible stopping point. Using this information, the speed reference determines the maximum possible speed for the distance the lift has to travel. The lift is decelerated in the same way, as described above for lower speed lifts.

8.4.3 Protection against failure of feedback systems

Closed-loop drive systems operate by attempting to reduce to zero the difference between the speed reference signal and the feedback signal. Thus if a feedback device fails or becomes disconnected, the output of the drive becomes large and uncontrolled. The most vulnerable of feedback devices is usually the speed sensing device, which in some control systems is often duplicated for additional security. Monitoring circuits built into the drive compare the difference signals between the outputs of the two sensors and the speed reference. Figure 8.5 shows such a system applied to a static converter drive. The motor armature current feedback is monitored separately.

Protection against failure of feedback systems must be built into all closed loop drive systems. The protection must be fast acting and stop the lift immediately.

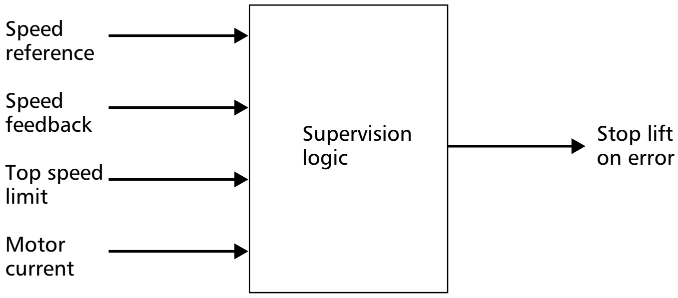


Figure 8.5 Supervision logic for closed-loop drive

8.4.4 Traction lift hoisting motor rating

For a given lift capacity and speed, the hoisting motor power can vary substantially dependant on:

- whether a gear box is used or not and, if so, its associated starting and running efficiency
- the roping arrangement of the lift, e.g. 1:1, 2:1
- the percentage of rated load counterbalanced by the counterweight
- the type of guide shoes: sliding, roller
- the type of motor, e.g. DC, AC induction, AC permanent magnet synchronous (AC PMS)
- design values of acceleration, deceleration and jerk.

To minimise the energy used by the hoisting machine, it is preferable to avoid the use of a gearbox, minimise the roping ratio, use the highest efficiency motor type (AC PMS) and use roller guide shoes. Other engineering and cost factors will affect the combination of these parameters for a particular lift design.

Modern traction lifts minimise the torque (and ampere) requirements of the motor to lift the payload by counterbalancing the mass of the moving equipment at mid-range payload. However, with a high speed lifts a significant amount of energy is still necessary to accelerate the inertia of the moving equipment and load (see section 13.3.2). When stopping the lift, the kinetic energy stored in the moving mass must be removed in order to cause deceleration. This phenomenon occurs during every start–stop cycle of the lift. What happens to the inertial energy (wasted by machine friction, or as heat in the motor, or electrical resistor bank, or reclaimed by regeneration back into utility mains) is an important factor to determine overall energy consumption (kW·h) over the course of a year and for the entire life-time span of the equipment. This becomes an increasingly important consideration with higher lift speeds as the inertial energy is proportional to the square of lift speed.

8.5 DC motor control techniques

DC gearless machines used to be the most common type of drive for lift speeds greater than 2 m/s. There are two basic methods of controlling DC motors: the Ward Leonard set and the static converter drive. Static converter drives are the most economical in operation with energy costs up to

60% less than those for equivalent Ward Leonard drives. When modernising or replacing lifts these drives are normally replaced by AC gearless machines using variable frequency drives to provide the same or superior speed control whilst using less energy.

8.5.1 Ward Leonard set

A Ward Leonard set(12) is an AC motor driving a DC generator using a mechanical coupling. Open loop control, i.e. no feedback of the motor speed to the control device, or simple armature voltage control allows tolerable performance over a 30:1 speed range. The dynamic characteristics of circuits of this type are not stable, either over time or temperature, which generally appears as variations in the slow speed approach to floor level.

The best control for DC generators is achieved by using feedback techniques to regulate the motor speed, armature current and the generator field current. This reduces the energy losses in the generator by at least 20%, and reduces the current peaks in the machines. The control of armature current ensures a stable drive, which does not drift with time and temperature. Within the limits of the generator capacity, the ride performance of the lift can be as good as that using static converter drive. Another consideration in favour of the motor–generator is that the system is inherently regenerative. In spite of the somewhat lower efficiencies, a significant amount of energy is returned to the mains supply on each deceleration phase, or with overhauling loads, without creating unwanted current harmonics.

A more detailed description of this type of drive may be found in the 2005 edition of this Guide.

8.5.2 Static converter drives

A static converter is an electronically controlled power converter which converts AC to DC and inverts DC to AC. Used with a DC motors, static converters provide high efficiency and accurate speed control without the use of a DC generator. The power losses are very low, typically less than 5%.

Lifts require a smooth, linear reversal of motor torque to obtain a good ride. The majority of drives designed for industrial use cannot reverse motor torque with the smoothness required for lifts. Hence, purpose-designed drives are preferred.

Power conversion is accomplished using bridges of thyristors or silicon controlled rectifiers. Using current lag phase displacement control, the DC output of the bridge can be varied from zero to full power, in order to drive the motor.

Dual-way static converters enable the kinetic energy of the lift to be returned to the mains supply by the process of inversion. When the motor voltage is higher than the supply, energy can be returned to the mains at high efficiency by suitably controlling the conduction angle of the bridge thyristors.

A more detailed description of this type of drive may be found in the 2005 edition of this Guide.

8.6 AC motor control techniques

The AC variable voltage drive is suitable for lift speeds up to 1.6 m/s. For speeds of 1.0 m/s or less, and small lift cars (i.e. less than 8-person), a simple AC drive without re-levelling may be satisfactory. A drive with re-levelling should always be specified for larger lift cars and higher speed applications or where levelling accuracy is important such as where small wheeled trolleys, hospital beds etc. may be used.

Compared to variable voltage control only, variable voltage, variable frequency drives provide better all-round drive performance for lift speeds from 0.4 m/s to 10 m/s and above. They give near unity power factor operation and draw lower acceleration currents (e.g. less than twice the full load current) requiring smaller mains feeders. Provided that it is correctly designed and filtered, the variable voltage, variable frequency drive produces the lowest harmonic current and voltage values in the supply of all the various types of solid-state drive.

8.6.1 Variable voltage drive with single-speed motor

There are several variations using the variable voltage technique, depending on whether the speed of the motor is controlled during all phases of the lift movement.

For low-speed, low-grade lifts (e.g. car park lifts and goods lifts) it is possible to obtain accurate and consistent stopping at floor level by controlling only the deceleration of the lift. This technique is suitable for lift speeds up to 1 m/s. Some drives of this type do not allow re-levelling.

Thyristors can be used to control the acceleration of the lift. They also reduce the voltage on the motor during deceleration and can be controlled to produce DC to obtain more braking torque if necessary. This technique is also suitable for lift speeds up to 1 m/s.

Both the acceleration and deceleration of the lift can be controlled using thyristors by reversing the phase rotation of the supply, see Figure 8.6. Due to the lower efficiency of AC phase rotation reversal for braking, the design of the control for the thyristors is critical to obtain good jerk-free torque reversal of the motor. This technique also increases motor and machine room heating compared with DC braking. This technique is suitable for lift speeds up to

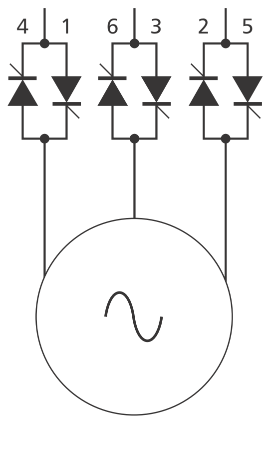


Figure 8.6 Variable voltage drive with single speed motor

1.6 m/s. However, using variable voltage to control the torque and speed of an AC motor causes a great deal of internal motor heating. In all but low traffic situations a special motor design must be employed for a successful installation.

8.6.2 Variable voltage drive with two-speed motor

In general, the low-speed windings of the motor are used as braking torque windings. The AC supply voltage to the high-speed windings is controlled using phase control by means of thyristors, see Figure 8.7. The speed of the motor is under control at all times during movement of the lift. With variable voltage control, the starting current of the motor is reduced to approximately 50% of the current drawn by the same motor running as an uncontrolled two-speed motor. During deceleration, the AC voltage is reduced and a variable DC voltage is applied to the low-speed winding to produce additional braking torque if required.

Some drives of this type limit the maximum speed of the motor to approximately 90–95% of its full load maximum speed. This is because the speed reference and deceleration control cannot deal with variations in the rated speed of the motor due to the load and bring the lift to a halt accordingly at floor level under such circumstances. The electrical efficiency of these drives is considerably reduced and heat losses are increased by limiting the top speed. The motor is working with large slip and DC power has to be applied to the low-speed winding to maintain motor control. Additionally the traffic handling capacity of the lift is unnecessarily reduced.

All drives of this type should have re-levelling and levelling accuracy of at least ±5mm under all load conditions and are suitable for lift speeds from 1.0 to 2.0 m/s.

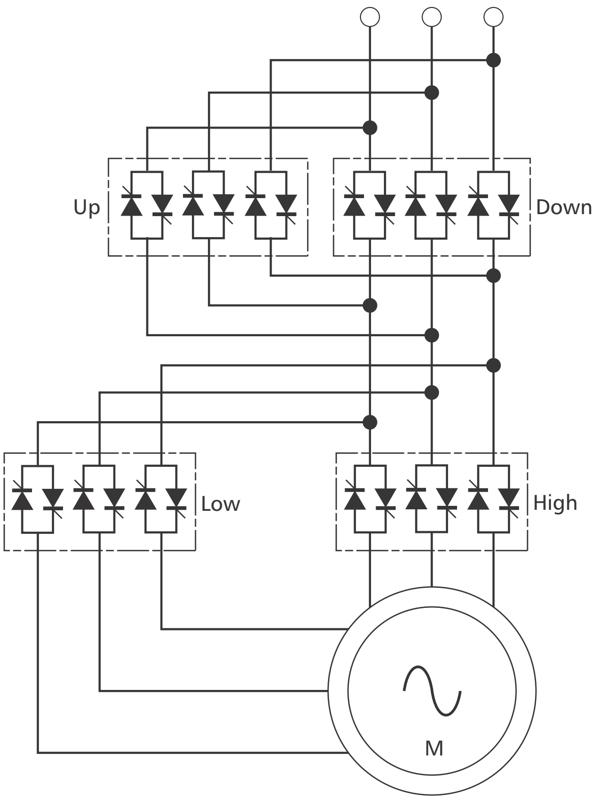


Figure 8.7 Variable voltage drive with two-speed motor

The ride comfort, levelling accuracy and traffic handling achieved using two-speed motors can be easily improved by using an electronic drive. Electronic drives are used for speeds up to 1 m/s. The peak starting currents are higher for two-speed drives. However, in low traffic situations and for some goods lifts, the extra costs of electronic drives may not be warranted.

8.6.3 Variable voltage, variable frequency drives

Variable voltage, variable frequency drives use the fundamental characteristic of the AC induction motor, i.e. that its synchronous top speed is proportional to the supply frequency. By varying the supply frequency the motor can be made to function at its most efficient operating point over a wide speed range. However, the conversion of power at a frequency of 50 Hz to power at a variable frequency suitable for the motor is a complex process, see Figure 8.8.

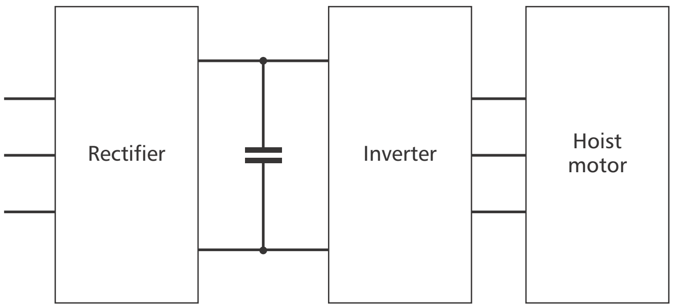


Figure 8.8 Schematic of a variable voltage, variable frequency drive

These drives provide a high power factor (i.e. >0.9) at all lift speeds and with low electricity and machine room cooling costs.

Variable voltage, variable frequency drives need only a single speed motor. Where existing lifts are being modernised, the drive may be fitted to an existing single or 2-speed motor. In such cases, the lift manufacturer must always be consulted to determine the suitability of retaining the existing motor for use with a variable voltage, variable frequency drives. In addition, a check on the motor's nameplate should be carried out to establish if the machine has a suitable insulation class rating.

Variable voltage, variable frequency drives are also used with permanent magnet synchronous motors. These motors are more efficient than induction motors and are physically more compact. This reduces the required space and floor loading in machine rooms.

For lift speeds up to 2 m/s, using gearboxes, the energy regenerated by the lift is relatively small and can normally be dissipated by a resistor. The cost of a 4-quadrant drive to regenerate power to the mains is usually not warranted.

Lifts capable of speeds up to 10 m/s can be installed using AC gearless motors, and still higher speeds are possible. In these circumstances a 4-quadrant drive is usual, regenerating energy to the mains supply, rather than dissipating it by means of a dynamic braking resistor.

'Flux vector control' is a type of variable voltage, variable frequency control system that operates in the following manner. In mathematics, vector quantities (such as force) have both magnitude and direction and may be resolved into components. In AC motors, the torque generated by the motor depends on the magnetic flux produced between the rotor and the stator. This flux is a variable quantity, the value of which may be determined using a vector diagram. Two vector quantities are controlled: the flux and the torque. The input currents representing these vectors are the magnetising current and the rotor current, respectively. Drives that control the flux are referred to as 'flux vector' drives. Digital encoders are typically used as a motor speed sensor for medium and high speed induction motor drives. Resolvers or digital encoders are generally required to measure rotor position and speed with permanent magnet synchronous motors (PMSM).

There are variations on this principle. In so-called 'sensorless' flux vector drives, computer processing is used to determine the torque and magnetising currents from the motor current, and to determine slip. Hence, the vector is calculated. This enables the motor speed sensor to be eliminated on low speed systems. (Usually, however, it is still required on medium and high speed systems in order to obtain the required accuracy of control.)

In order to provide optimum performance, the motor and drive systems need to be matched. Sensorless flux vector systems can be easily retro-fitted because the characteristics of the existing motor can be programmed into the drive and the motor does not need to be physically adapted to the encoder in every case. In effect the motor also acts as the speed sensor in this case. Furthermore, sensorless drives do not usually provide the level of performance that may be obtained from speed regulated drives with encoder feedback, or from the more sophisticated flux vector control systems.

8.6.4 Variable voltage, variable frequency drives with PMSMs

Permanent magnet synchronous motors (PMSMs) have a significant energy saving advantages over the use of induction motors. This is due to the absence of losses due to the rotor running slower than or faster than synchronous speed in most situations for an induction machine. It also does not have magnet excitation losses that are also present in the induction machine. PMSMs can easily be designed in pancake or axial forms providing a wide range of low torque, high rotational speed or high torque, low rotational speed. They cannot be run direct from a mains supply with its fixed 50 or 60 Hz frequency. A variable voltage, variable frequency drive is thus necessary and its control must be designed to ensure that the maximum safe load angle of the motor is not exceeded under all conditions.

8.6.5 Linear induction drives

A linear motor may be regarded as a conventional AC motor 'unrolled' to lie flat (see section 7.2.9). Such machines are sometimes referred to as 'flat-bed motors'. Control is usually achieved by a variable voltage, variable frequency drive as described in section 8.6.3

8.7 Control of hydraulic drives

A schematic of a typical hydraulic installation is shown in Figure 8.9.

8.7.1 Control valves

Hydraulic valves produced in the early 1970s were generally not very well compensated for control variations with car load, oil viscosity and temperature. Consequently the levelling accuracy and lift speed varied according to the load. Many modern control valve designs are fully compensated for pressure and viscosity variations and therefore provide stable characteristics over long periods. This allows higher lift speeds (i.e. up to 1.0 m/s) with accurate levelling and short levelling times.

The flow of oil is controlled either by internal hydraulic feedback (pilot valve) or by electronic sensing of the oil flow. Electronically controlled valves use proportional solenoids to control the oil flow. Electronically controlled valves are more efficient than hydraulic feedback types when operating at extremes of oil temperature.

8.7.2 Speed control

The pump motor runs only when the lift travels upwards and the pump has to lift the entire load when a counterweight is not used. The motor power is therefore approximately twice that of an equivalent electric traction lift. Star-delta starting is generally employed to prevent large acceleration currents. Usually, the motor runs at a constant speed. The oil pressure and flow to the hydraulic ram is controlled by returning oil direct to the tank, bypassing the jack.

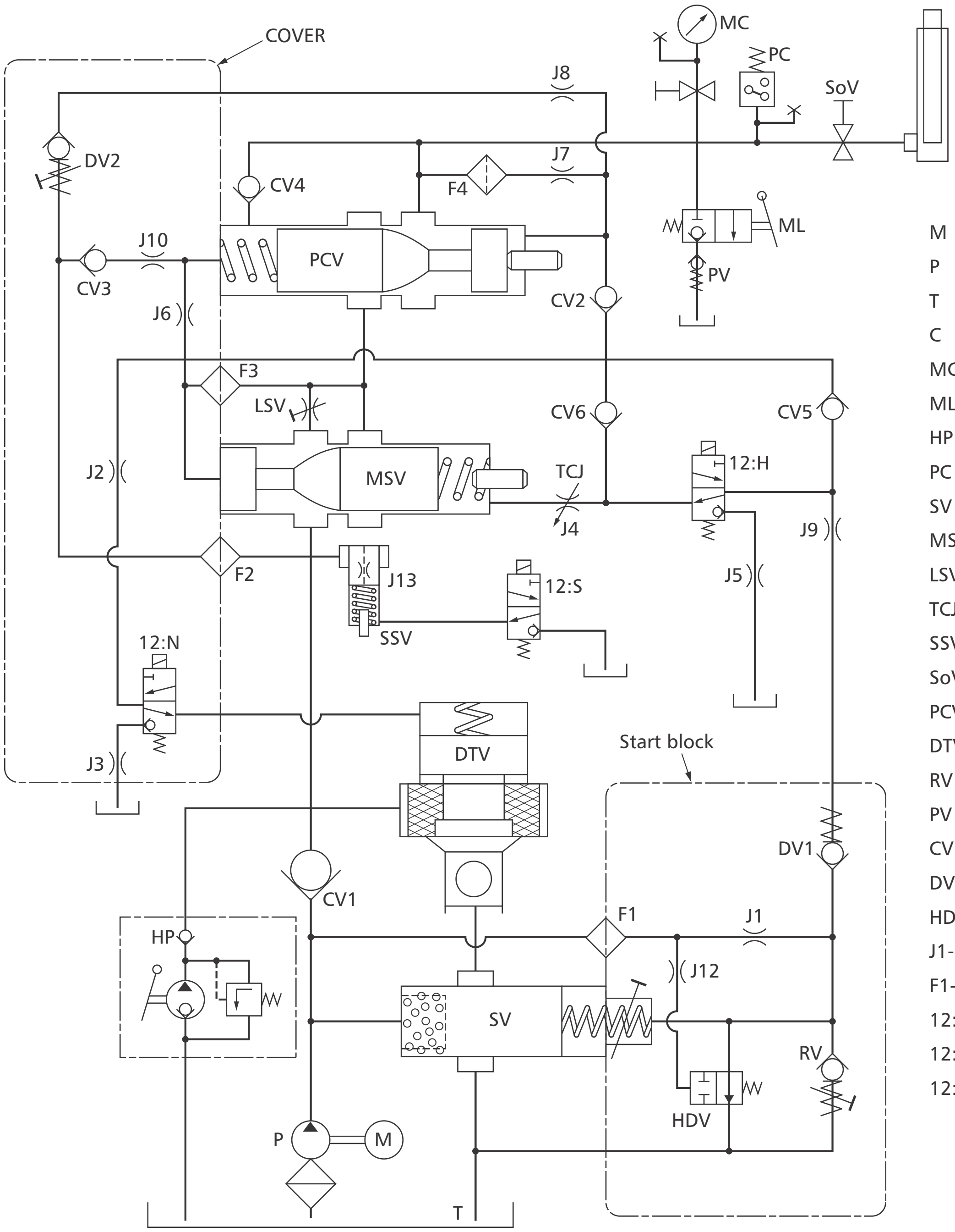
When the lift runs downwards, the control valve is opened and the lift car makes a controlled descent under the effect of gravity. The up and down speeds are generally independently adjustable on the valve block. The down speed can be higher than the up speed. This allows the average lift velocity to be higher than that provided by the pump. This reduces the round trip time of the lift and increases the traffic handling capability, see chapter 3.

Valves are rated by oil flow rate (litre/minute) and maximum top speed. Electronically controlled valves are suitable for speeds up to 1 m/s. Hydraulic feedback valves are more suited to lower speed applications, i.e. up to 0.75 m/s.

8.7.3 Anti-creep devices

BS EN 81-2[3] specifies the use of some form of anti-creep device on all hydraulic lifts. This is a safety measure to prevent the lift sinking down from floor level due to oil leakage. The anti-creep action may be 'active' whereby the lift is driven up if the lift sinks below floor level due to leakage or oil compression when a heavy load is placed in the car.

For large goods and vehicle lifts, the lift can be physically held at floor level using mechanical stops in the lift well. This is complicated, both mechanically and electrically,



M	Motor
P	Pump
T	Tank
C	Cylinder
MC	Manometer
ML	Manual lowering valve
HP	Hand pump
PC	Pressure switch
SV	Start valve
MSV	Main speed valve
LSV	Levelling speed valve
TCJ	Temp. controlled needle valve
SSV	Service speed valve
SoV	Shut-off valve
PCV	Pressure compensator valve
DTV	Down travel valve
RV	Relief valve
PV	Pressure valve (indirect drive)
CV1-6	Check valves
DV1-2	Pressure difference valves
HDV	Hydraulic delay valve
J1-13	Jets
F1-4	Filters
12:H	Pilot valve for nominal speed
12:N	Pilot valve for down travel
12:S	Pilot valve for service speed

Figure 8.9 Typical hydraulic installation

but provides a better solution for these applications than active re-levelling.

8.7.4 Hydraulic drives with energy accumulators

Devices are now available that use gas-filled energy accumulators as a means to reduce the energy consumption of the lift. During the down travel of the lift car, the potential energy of the lift car and ram are used to increase the pressure of the gas in the accumulator. This stored energy is used to reduce the energy demand on the electricity supply.

It should be noted that gas accumulators are pressure vessels and as such are subject to the Pressure Equipment Directive[13]. Lifts using pressure vessels require safety examinations of the vessels in addition to the usual examinations required for lifts.

8.7.5 Variable frequency pump motor drive

Products are now available which use a variable frequency drive to power a variable flow hydraulic pump. This decreases starting currents and reduces energy consumption compared to lifts using flow control valves. These drives may be used in combination with energy accumulators, see section 8.7.4.

8.8 Control of door operators

8.8.1 General

The door operator (see section 7.8) and its control system (see Figure 8.10) must meet the following requirements:

— the opening and closing speeds must be independently adjustable

— for high-performance lifts, the opening and closing speeds must be automatically adjustable according to the prevailing traffic conditions at the floor

— safety edges must be fast acting and tolerant of mechanical impact; remote sensing edges (i.e. electronic) are inherently better than mechanical edges in these respects.

Optical (i.e. photocell) or other passenger/object detection devices may be used to modify door control. Additionally, they can be used in conjunction with a load sensor to prevent nuisance car calls.

Advanced opening is a time-saving feature widely used in office buildings to improve performance, see section 3.5.12. This allows the doors to commence opening once the car speed is below 0.3 m/s and the lift is within the door zone (typically ±100 mm, maximum ±200 mm). However, the advance opening door opening action can be disturbing to elderly users and may not be suitable in some buildings.

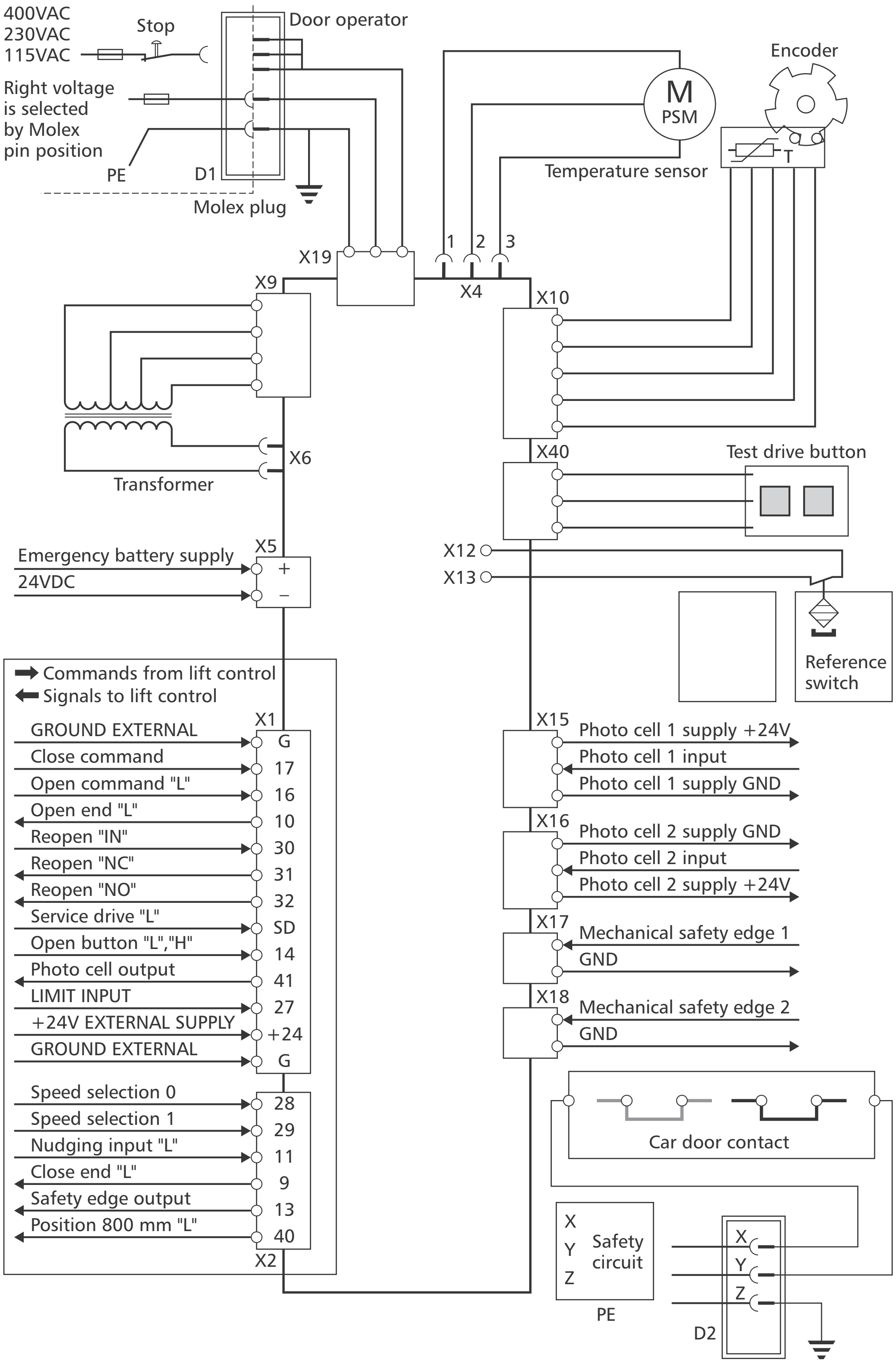


Figure 8.10 Door operator and control system

8.8.2 Control of DC door operators

Two methods have been in use for many years:

— resistance control of motor field and armature

— saturable reactor control.

These methods control the door velocity depending on the position of the doors in relation to the open and closed positions. DC motors are often provided with additional velocity control to provide a smooth stop at the extremes of travel of the doors.

Position sensing is normally by limit switches. It is difficult, and almost impossible economically, to vary the door speeds in response to prevailing lift traffic conditions using commands from the controller. This is a major limitation to obtaining maximum handling efficiency in large lift groups with heavy traffic.

Some manufacturers have introduced electronic speed control of the motor. Control of deceleration is by limit switches. The speed reference is usually time-based. This removes the need for banks of resistors and makes the door operator easier to set up, the electronics merely replacing the resistors. Unfortunately many of these operators still retain sinusoidal mechanical linkages. The bearings in these mechanisms are subject to very high peak loading if the doors are reversed during closing or stopped by the safety devices. These sinusoidal mechanisms are not used in new lift applications, However they are used in lift modernisations for reasons of cost and equipment compatibility.

The motors typically used for modern door operators are low voltage (e.g. 24 volt) using electronic control of speed, torque and door position. This provides good performance with a compact door operator design.

8.8.4 Control of AC door operators

Simple AC door operators do not have speed control, and the motor runs at a constant speed. The door motor may be designed to run safely, when stalled with the full supply voltage applied. Constant speed door operation is suitable for narrow doors and where traffic is low so that the limited speed does not restrict lift performance.

8.8.5 Electronic control of AC door operators

AC variable voltage door operators typically use a single speed motor. Braking torque and direction is controlled by reversing the phase rotation of the supply. This technique is satisfactory with low-power motors. The speed, position of the doors and motor torque can be controlled using closed-loop feedback. The feedback signals are monitored and compared with reference signals. If there is loss of, or large errors in, the feedback signal the door drive is stopped. Variable voltage variable frequency drives are also now being used for door operators. These provide a higher electrical efficiency than variable voltage drives and also potentially lower noise operation.

Logic circuits built into the door operator control the speed reference so that the doors always follow a distance-based velocity curve. This safely minimises opening and closing times and prevents high acceleration forces on the doors. Logic circuits can also control the reopening of the door in response to safety signals. For example on a 1200 mm entrance, the doors open only to 800 mm in response to the first reopen signal. This minimises the door operation time to maintain the maximum possible traffic handling capability. Additionally, the lift controller can, as an option, modify the door speeds and open times in response to changes in the level of traffic.

The more advanced electronic controlled operators, using velocity and position closed-loop control, are suitable for both general use and for demanding applications. In modernising a lift system, electronic operators, used in conjunction with good group control and lift motor control, can produce dramatic increases in the traffic handling capacity of the lift group (typically 30–40% improvement).

8.9 Electromagnetic compatibility, environment and reliability

The use of solid state drives and computers in lifts requires more attention to these aspects than was necessary previously. The Electromagnetic Compatibility Directive(14) requires, in general terms, that equipment shall not generate interference that can damage or cause malfunctions in other equipment and shall be immune or respond to interference in a way which is not hazardous. The harmonised product standards for lifts and escalators are BS EN 12015(15) (emission) and BS EN 12016(16) (immunity), see chapter 12. All (new) equipment should be compliant with these standards. Note that due to the distributed layout the lift and escalator equipment in the building (i.e. parts of a lift are on each floor) it is not meaningful to make compliance tests on site.

Of particular importance in the construction of the equipment is the design and installation of the electrical earthing both internal to control cabinets and external, including the coaxial termination of screened signal and power cables.

The environment must be controlled to ensure that the storage and operating temperature and humidity limits are not exceeded. The performance and reliability of the equipment is adversely affected by operation outside of its design parameters. Such operation may cause breakdowns and adversely affect warranties.

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9 Lift traffic control

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Dr Richard Peters (Peters Research Ltd.)

Chapter contents

Contents continue

9 Lift traffic control

9.1 The need for lift traffic control

Individual lift control is a basic necessity and, as such, was present from the very beginnings of lift usage. Early systems used 'car switch' controls, in the car operated by an attendant, to move and stop the lift at the various landings. The introduction of automatic motion control eliminated the car switch, but the attendant remained to collect and transport intending passengers. The early group traffic control systems were human dispatchers, sometimes called 'starters', who stood in the main lobby during morning up-peak and using various signalling techniques, informed the in-car attendants where to stop their lifts. When multiple lifts were installed to serve the same set of floors, it was quickly realized that efficiency could be enhanced by coordinating the behaviour of lifts in a group, resulting in the concept of group traffic control.

After the Second World War, automatic systems utilising relay logic were designed which dispatched individual lift cars in a group from terminal landings separated by a time headway. They picked up any landing calls encountered in their path. These relay-based systems were eventually developed to operate 'on-demand' and only react to the registration of landing calls. As time passed, these relay-based systems gave way to hybrid relay/electronic controllers and eventually to programmable logic controllers (PLCs) and microprocessor-based systems.

The development of fully automatic pushbutton (FAPB) controls has almost completely eliminated the use of an attendant in the car and a dispatcher on the main landing, and thus allowed passengers to 'drive' the lifts themselves. The attendant is only retained in exceptional cases, e.g. where there is a security issue, customers' or builders' beneficial use prior to handover, or to provide a special service to VIPs.

The overall control of lift systems presents two different engineering challenges:

- First, some means of commanding a lift car to move in both up and down directions and to stop at a specified landing should be provided, i.e. motion control.
- Second, to serve passenger demands (landing and car calls) and for a group of lifts to work together in order to make efficient use of the individual lifts in the group, i.e. traffic control.

The first challenge is concerned with drive systems and drive control, which is discussed in chapter 8. The second challenge is concerned with (passenger) traffic control and is the subject of this chapter.

Both control systems are often found in the same cabinet and thus have become known collectively as the 'controller'. Another term sometimes used to describe the traffic controller is 'dispatcher' — an echo from history. Different types of traffic controllers are described in BS 5655-6: 2002[4].

Appropriate automatic traffic control systems can enable a single lift, or a group of lifts, to operate at high efficiency, provided the equipment is well designed, properly installed and adequately maintained. Often the individual controller is referred to as the 'lift (or car) controller' and the traffic controller is referred to as the 'group controller'. This chapter provides guidance on the traffic control of single lifts, and for lift groups through legacy systems, based on relay logic, to modern day systems, utilising microcomputers.

In the discussions, the various types of passenger demand (up-peak, down-peak, mid-day and interfloor traffic) are mentioned. These terms are fully discussed in chapter 3.

9.2 Single lift traffic control

There are many lifts installed as single units in buildings such as hotels, small offices, car parks, museums, railway stations, schools etc. They should respond to the registration of landing calls and the resulting registration of car calls. Where a single lift is proposed, purchasers should consider which control system would suit their purpose from those described below.

9.2.1 Single call automatic control

The simplest form of automatic lift control is single call automatic control. Single pushbuttons are provided on the landings and a button for each floor in the car. This form of control is also termed non-collective or automatic pushbutton (APB) control.

The passengers operate the lift by pressing landing and car buttons. Car calls are given absolute preference over landing calls. Once a passenger in the car presses a car call pushbutton corresponding to the required destination floor, the lift moves directly to this floor bypassing any intermediate floors. When a landing call pushbutton is pressed and the lift is free, the call is immediately answered. If the lift is in use, a landing signal indicates 'lift busy' and a new landing call can only be registered when the lift is no longer in use.

This type of control is suitable only for short travel passenger lifts serving up to four floors, e.g. in small residential buildings with a light traffic demand. It provides a very low carrying capability, as most of the time the lift carries a single passenger. It can also produce long passenger waiting times, owing to the many trips that bypass passengers on the intermediate landings. This type of automatic pushbutton control is, however, suitable for goods lifts, particularly when a single item of goods can fit in the lift at one time.

9.2.2 Collective control

The most common form of automatic control used today for a single lift is collective control. This is a generic designation for those types of control where all landing and car calls made by pressing pushbuttons are registered and answered in strict floor sequence. The lift automatically stops at landings for which calls have been registered, following the floor order rather than the order in which the pushbuttons were pressed. Collective control can either be of the single button, or of the two pushbutton types.

9.2.2.1 Non-directional collective

Non-directive collective control provides a single pushbutton at each landing. This pushbutton is pressed by passengers to register a landing call irrespective of the desired direction of travel. Thus, a lift travelling upwards, for example, and detecting a landing call in its path stops to answer the call, although it may happen that the person waiting at the landing wishes to go down. The person is then left with the options either to step into the car and travel upwards before going down to the required floor; or to let the lift depart and re-register the landing call. Owing to this inconvenience, this type of control is only acceptable for short travel lifts.

9.2.2.2 Down collective (up-distributive, down-collective)

Despite the disadvantages expressed in 9.2.2.1, single pushbutton call registration systems may be adequate in buildings where there is traffic between the ground floor and the upper floors only and no interfloor traffic is expected, e.g. car parks, public high-rise housing, flats. Retaining the single pushbutton on the landing, a suitable control system is the down collective control (sometimes called up-distributive, down-collective) where all landing calls above the ground are understood to be down calls. A lift moving upwards only stops in response to car calls. When no further car calls are registered, the lift travels to the highest landing call registered and travels downwards, answering both car and landing calls in floor sequence.

9.2.2.3 Full collective (directional collective)

The two pushbutton full collective control (also designated directional collective control) provides each landing (except terminal landings) with one 'up' and one 'down' pushbutton, and passengers are requested to press only the pushbutton for the intended direction of travel. The lift stops to answer both landing calls and car calls in the direction of travel, and in floor sequence. When no more calls are registered in the direction ahead of the lift, the lift moves to the furthest landing call in the opposite direction, if any, and answers the calls in the new direction. This control system is suitable for single lifts or duplexes (two lifts) serving a few floors with some interfloor traffic. Typical examples are small office buildings, small hotels and blocks of flats.

Directional collective control applied to a single lift car is also known as simplex control.

The system can be applied to two or three interconnected lifts to work as a team, where a fully configured group control is not appropriate. Two lifts are termed a duplex and three lifts a triplex. Full collective control is the simplest form of group control.

9.3 Purpose of group traffic control

A single lift may not always be able to cope with all the passenger traffic in a building. Where a number of lifts are installed together, the individual lift control mechanisms should be interconnected and there should also be some form of automatic supervisory control provided. In such a system, the landing call pushbuttons are common to all the lifts that are interconnected, and the traffic supervisory controller decides which landing calls are to be answered by each of the individual lifts in the group.

The function of efficiently distributing landing calls to individual lift cars in a group is basically the same for both large and small groups. Thus, a 2-car lift group can benefit from the use of group control as much as an 8-car group. This is called group traffic control, which can be defined (see Appendix A1: Glossary of terms) as:

> 'number of lifts placed physically together, using a common signalling system and under the command of a group traffic control system.'

The purpose of group control is to allocate (or assign) the landing calls in an optimum way to the various individual lifts in the group. The term 'optimum' is difficult to define. Equally difficult is 'What to optimise?'. Some group control algorithms seek to optimise a specific metric while others seek to balance multiple metrics within acceptable ranges. A number of possibilities have been suggested, for example:

- minimise passenger waiting time
- minimise system response time (i.e. the time between the registration of the call until it is answered; this is equal to the waiting time of the first passenger who registered the call)
- minimise passenger journey time (also called time to destination)
- minimise the variance (in statistical terms) in passenger waiting time (or system response time)
- maximise the handling capacity
- minimise the energy consumption
- reduce 'bunching' (see Appendix A1: Glossary of terms).

Various traffic control algorithms have been developed to achieve some of the above goals and if there is a specific requirement for one of these this should be written into any specification and discussed with the potential suppliers at the design stage.

The definition of a traffic control algorithm is:

> 'a set of rules defining the traffic control policy, which is to be obeyed by the lift system, when a particular traffic condition applies.'

Most group traffic control systems provide more than one traffic algorithm to allocate lifts to calls. The control system adopts the appropriate algorithm according to the intensity of passenger demand, and the mix of the traffic (incoming, outgoing and interfloor, see section 4.3.2). The most advanced traffic algorithms learn repeating traffic patterns for themselves, and adapt their strategies dynamically without the need for time clocks or manual settings.

A simple controller would not be suitable for a busy office building. The most advanced systems may not represent value if installed in a building with minimal demand. Thus at an early stage the expected or predicted type of traffic demand should be established in order to match a suitable traffic controller to the demand. A supplier may be able to indicate the category in which their equipment falls.

For any traffic algorithm to be effective, it requires certain information about the building and lift system to be input to the controller, see Figure 9.1. The more data that are available, the greater opportunity the algorithm has to optimise performance. The basic data are:

— number and position of served floors
— all the landing calls
— number of cars, and their current position
— status of each lift car (i.e. moving up/down, door status, car load, in/out of service etc.)

Further improvement to the performance of the system may be achieved if the following variables are also input and learnt by the group controller:

— all the car calls registered in the lifts
— a means of determining if a travelling car can slow down in time to stop for a floor it is travelling towards
— type of prevailing traffic or the time and date if traffic pattern is being learnt

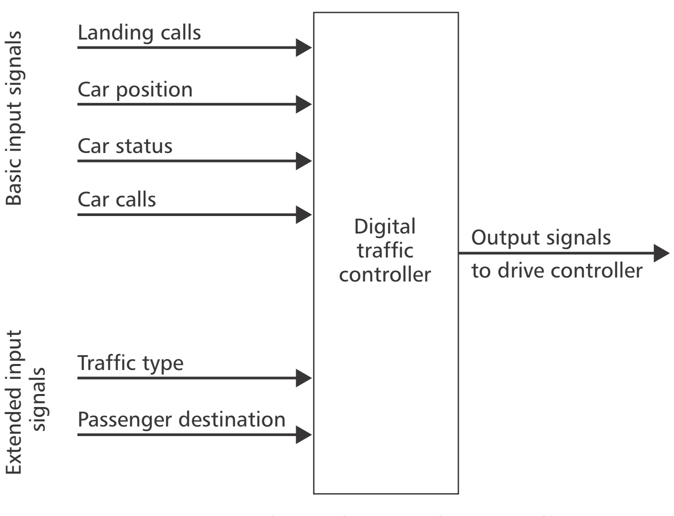


Figure 9.1 Basic schematic of signal flow in a lift group traffic controller

— the destination of each passenger prior to boarding the lift (as in hall call allocation systems (see section 9.4.2.3).

As a general rule, the more information about the lift system that the group controller has access to, the better the performance of the group controller in allocating calls and optimising the relevant parameter or combination of parameters (e.g. passenger waiting time).

9.4 Types of traffic control algorithm

The traffic control system complexity depends not only on the number of available control programs, but also on the complexity of the algorithms themselves. A lift system with a large variety of control algorithms is not necessarily the best system, as some problems may arise in the transfer of control from one algorithm to another, as an effective redistribution of lifts takes some time, making response to transient changes in traffic requirements very difficult to achieve consistently.

Lift group control systems respond to the necessity of providing efficient control of a group of automatic lifts servicing a common set of landing calls. The main goals are to provide the maximum handling capacity and the minimum waiting and travelling time of passengers, whilst using the most economical installation. The criteria are to determine the best allocation of landing calls and to select the best lift car to serve the particular landing call. Various algorithms have been developed throughout the decades.

9.4.1 Legacy traffic control systems

When modernising a lift installation, the existing traffic controller may be considered for replacement, often due to reliability or maintainability issues. It is important that the replacement traffic controller, which might almost certainly be microcomputer based, can perform as well, or better, than the system it replaces. The systems developed and installed a quarter of a century ago were all based on relay logic or primitive programmable logic controllers (PLCs). This does not mean the control algorithms provided were in any way significantly inferior to those available today. In general, these legacy traffic controllers concentrated on dealing with the most significant traffic pattern of the day, namely up-peak. The exception to this philosophy was the dynamic sectoring system (see section 9.4.1.4). It is important to understand these legacy controllers when choosing a replacement.

There were four basic (generic) types of traffic controller developed by the proprietary and independent manufacturers. These are briefly described below. A fuller description can be found elsewhere[1,3].

9.4.1.1 Nearest car

The simplest type of group control is the directional collective control described in section 9.2.2.3. It is suitable for a group of two or three lifts, each operating on the directional collective principles and serving seven or so floor levels. The assignment of lifts to landing calls is achieved by the 'nearest car' control policy.

A single landing call system with one 'up' and one 'down' pushbutton at each landing, except for the terminal landings is required. The nearest car traffic control system is expected to space the lifts effectively around the building, in order to provide even service, and also to park one or more lifts at a specified parking floor, usually the entrance lobby floor (main terminal). Other features, which might be included, are the bypassing of landing calls when a lift is fully loaded.

Car calls are dealt with according to the directional distributive control principles. Landing calls are dealt with by reversal at lowest down and highest up calls. Thus the lift answers its car and landing calls in floor sequence from its current position and in the direction of travel to which it is committed.

The only group traffic control feature contained in this simple algorithm is the allocation of each landing call to the lift that is considered to be the best placed to answer this particular call. The search for the 'nearest car' is continuously performed until the call is cancelled after being serviced.

9.4.1.2 Fixed sectoring; common sector system

A fixed sectoring common sector control system can be devised for dealing with off-peak traffic and can be complemented with special features to cater for heavy unbalanced traffic. The system divides a building zone into a number of static demand sectors (Figure 9.2) equal to the number of lifts. Note that a building zone is a number of floors served by a group of lifts. Zones can be adjacent to the main terminal (low zone) or above the low zone (high zones). A sector includes both the up and down landing calls at the floors within its limits. A lift is allocated to a sector if it is present in that sector and the sector is not committed to another lift. Fully loaded lifts are not considered for assignment.

An assigned lift operates on the directional collective principle within the limits of its range of activity. The de-assignment of a lift from its sector takes place when the lift leaves the sector. A lift picks up calls ahead when travelling in either direction, even if it is not assigned to the sector.

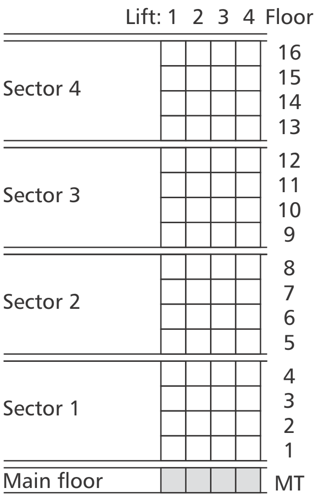


Figure 9.2 Illustration of the fixed sectoring of a building zone

The system, by distributing the lifts equally around the building, presents a good performance under balanced interfloor traffic. It also performs well for up-peak and unbalanced interfloor traffic conditions. It lacks a proper procedure to cater for sudden heavy demands at a particular floor. Under heavy down-peak traffic conditions, poor service may be provided to the lower floors of the building owing to problems in recycling the lifts to unoccupied sectors.

9.4.1.3 Fixed sectoring; priority timed system

A fixed sectoring system can also allocate the lifts on a priority timed basis. The landings in the building zone served by the group of lifts are grouped into up and down sectors. Each sector is timed as soon as a landing call is registered within its limits. The timing is measured in predefined periods of time, designating the priority levels. The system is unique among the classical traffic control systems as it considers time when making an assignment. The other algorithms only consider position.

The assignment of lifts to the sectors takes into account the number and positions of the available lifts and the sector priority levels. A lift is available for allocation when it has completed its previous assignment and has dealt with all the car calls that have been registered. The sector with the highest priority is the first to be allocated a lift.

The control system provides a good up peak performance. Its down-peak performance is very good, especially under very heavy traffic conditions. The interfloor traffic performance is fair, but not as good as can be obtained from dynamic sectoring.

9.4.1.4 Dynamic sectoring system

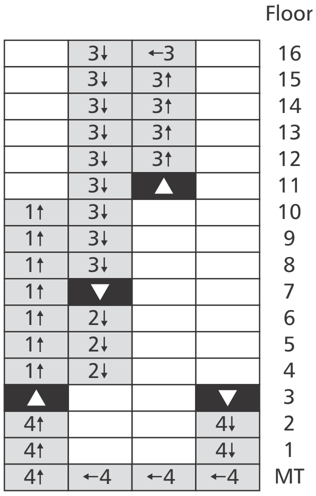
The dynamic sectoring group supervisory control system provides a basic algorithm and is suitable to deal with light to heavy balanced interfloor traffic. It is complemented by a number of other control algorithms to cater for unbalanced traffic conditions.

The basic dynamic sectoring algorithm groups landing calls into dynamic sectors. The position and direction of each lift defines the dynamic sector, see example definitions of sector boundaries shown in Figure 9.3. Each lift answers the landing calls in the sector 'ahead' of it. In parallel with the basic traffic algorithm, another dynamic sectoring algorithm is provided to insert free lifts ahead of lifts serving a large number of floors (e.g. sector 3 in Figure 9.3) or a large number of calls registered in their dynamic sector.

The dynamic sectoring system provides a very good performance for up-peak and interfloor traffic conditions, but a poor performance for down-peak.

9.4.2 Modern traffic control systems

The concept of centralised supervisory control systems for buildings, known as a building management system (BMS) using digital computers, is well established. As part of the



Dynamic sector allocation shown is:

- DS1: floors 4–10
- DS2: floors 6–4
- DS3: floors 12–16–8
- DS4: floors 2–MT–2

Figure 9.3 Illustration of the dynamic sectoring of a building zone

comprehensive information system for a whole building, it includes facilities such as employee identification, security control, fire control, environmental control, water treatment, data logging etc. It is not sensible to include the task of lift traffic control in any centralised building control system. Thus, a lift should normally have all aspects of its traffic and drive control managed independently of other building systems. In some installations, security systems are used as part of the mechanism to call lifts; in these cases, great care should be made to ensure the systems' fast and reliable integration.

The opportunity exists with a computer to program complex tasks to assist the call allocation process, which are impossible to achieve with fixed program systems. This might be considered to lead to truly optimal traffic control. However, humans (passengers) are involved and they expect certain rules to be obeyed. In summary these are:

— *Rule 1*: car calls must always be served.

— *Rule 2*: a lift should not reverse its direction of travel until all calls in that direction have been served.

— *Rule 3*: a lift should stop at a passenger destination floor (it should not pass it).

— *Rule 4*: passengers wishing to travel in one direction should not enter a lift committed to travel in the opposite direction.

— *Rule 5*: a lift with passengers in the car should not stop at a floor where no passengers wish to enter or leave the car.

Absent-minded passengers could infringe rule 4, but its likely violation can be reduced by effective signalling (indicators, lanterns and gongs). Rule 5 could be violated by the passengers, either in the car or on the landing, accidentally or deliberately, registering incorrect calls.

There are three basic (generic) types of traffic controller developed by the proprietary and independent manufacturers. These are described below. A comprehensive description can be found elsewhere[1,3]. Selection of the traffic control system can have significant negative consequences, if incorrect, and independent advice may be needed for complex projects.

9.4.2.1 Estimated time of arrival (ETA)

An estimated time of arrival (ETA) digital computer-based traffic control system allocates lifts to landing calls, based upon computed car journey times, i.e. how long a lift takes to arrive. Early systems of this type, developed in the 1970s, substituted relay or solid state fixed logic by a truly programmable computer. This technique was an obvious one to use once programming facilities were available. The ETA technique remains the underlying basis of many computer based systems on the market. The quality of the estimation can be improved by use of artificial intelligence (AI) techniques, see section 9.5.1.

The ETA control system can be expected to provide a good up-peak performance. By declaring the main terminal floor as a parking and priority floor, cars can be sent down to deal with the incoming traffic. The system is not, however, particularly suitable for down-peak traffic. Under light to medium balanced interfloor traffic conditions, the system behaviour is very similar to a dynamic sectoring system, and good performance is to be expected.

A variation[17] of ETA is estimated time to destination (ETD). This system not only estimates the time to arrive and pick up the intending passenger(s), but also the time to take them to their destination. The system takes into account the commitments an arriving car has in terms of landing calls already allocated and the current car calls it should honour. AI techniques can be used to improve the estimations.

9.4.2.2 Quality of service equalisation

The stochastic control algorithm[8] aims to provide an even service to all floors, where every landing call is given a fair consideration. This means that the landing call that has been waiting the longest should be given higher priority. The effect is to give a more even and more consistent service to passengers by trading the instant response calls to reduce long wait calls.

Enhancements to the ETD[17] algorithm are suggested that apply a similar strategy to stochastic control, recognising that passenger satisfaction is not simply a function of providing the lowest overall average waiting time or time to destination. Optimisation algorithms can be adjusted to target any required goal, including a greater consistency in waiting time.

Prioritising long wait calls is a valid strategy, but should be applied with caution during busy periods as it reduces handling capacity. If passenger demand exceeds the reduced handling capacity, the system may overload, leading to unacceptable waiting times for all passengers.

9.4.2.3 Hall call allocation (HCA) control

It would be much more useful if the traffic controller knew the intended destination of each landing call. This information can be obtained, for example, by replacing the conventional up/down buttons (Figure 9.4(a)) by a panel of passenger destination buttons at each landing similar to the keypad on telephones (Figure 9.4(b)) or even by touch screens. Hall call allocation(10) (also known as destination control) gives the opportunity to track every passenger from landing call registration through to his or her destination.

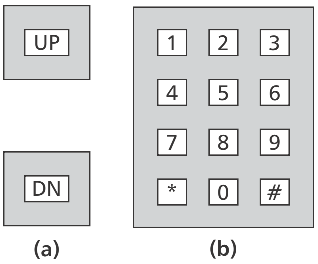


Figure 9.4 Illustration of hall call allocation landing registration panel; (a) conventional, (b) key pad

The basic system works(3,15) by the algorithm allocating each new passenger call, as it is registered, to each car in turn and evaluating the cost of each allocation. The allocation giving the lowest cost is then adopted. Suitable cost functions are, for example, passenger average waiting time, passenger average journey time or a combination of both. For periods when a boost in handling capacity is not required, a significant reduction in time to destination can be achieved with minimal impact on passenger average waiting time(17).

During up-peak, passengers can be grouped to common destinations as there are large numbers of them. The individual waiting time may increase, the travel time may decrease, and there would be an overall reduction in journey time. During down-peak, there is little advantage as the destination floor is known. During reasonable levels of balanced interfloor traffic, there is little advantage as most landing calls and car calls are not co-incident. However, during an up-peak with some down travelling traffic, or a down-peak with some up travelling traffic, or during mid day traffic, there are benefits.

The advantages of the system are:

— passengers do not need to translate their intention to travel to a specific floor into a request for an up or down command

— passengers do not need to rush to the lift whose hall lantern is on as they stand by the pre-assigned lift

— the supervisory system receives full information regarding the destinations of all passengers and thus it can make more intelligent decisions

— handling capacity is increased when there is an opportunity to group passengers travelling to the same floors, e.g. during up-peak

— reductions in the passenger time to destination are possible.

The disadvantages of the system are:

— the passenger waiting time may increase

— each passenger should register a call

— passengers cannot register destination calls in the car

— increased cost of call station fixtures

— possible passenger misunderstanding of the system

— possible abuses by passengers registering more than one call each

— allocations have to be made immediately and are fixed.

The ‘positive’ concept of using a cost function as a performance index can be transposed into a ‘negative’ concept of penalty functions in order to promote higher efficiency. An example of a penalty function is the rejection of an allocation which introduces an additional stop.

The HCA system is often used to boost(13) the performance during the up-peak period in buildings where there is inadequate provision of lifts. Unfortunately, it does not significantly change the performance during other traffic conditions, see section 3.13.

If the boosted handling capacity is temporarily insufficient, some HCA systems may refuse to make an allocation requiring the passenger to ‘try again later’. These refusals are very frustrating for passengers and should be avoided if at all possible. If refusals are disallowed, there are some instances where transporting passengers in the wrong direction (section 9.4.2, Rule 4) cannot be avoided. This is a rare occurrence in a well-designed system unless the provision of lifts in the building is inadequate.

If not addressed within the algorithm, HCA can perform worse than a conventional system with landing buttons when it is itself overloaded. This is because systems that operate a booking system to map the load of the car can result in a situation where they have no choice but to allocate a passenger to the only car with a space.

Some suppliers offer a mixed system with a full call registration station at the lobby and other principal floors, and two button stations at all other floors. This approach can yield cost savings, particularly for modernisations if the existing two button stations can be interfaced with the new control system. Mixed landing and destination call systems provide the same up-peak boost as HCA. However, they require a car call station in the car, which is susceptible to abuse if passengers at the ground floor join the next car to depart rather than the car allocated by the traffic controller. This abuse can be discouraged by temporarily disabling the car call buttons until a landing call above the main terminal is answered.

9.5 Advanced group traffic controller features

9.5.1 Use of artificial intelligence in group traffic control

The engineering goal of artificial intelligence (AI) is to solve real-world problems using ideas representing knowledge, using knowledge, and assembling knowledge-based systems. Generally, the application of AI techniques to lift systems has not been shown to bring significant increases in handling capacity. However, where the traffic demand is less than the capacity of the lift installation, AI techniques do improve overall performance.

A number of AI techniques have been applied to lift traffic control, and some manufacturers claim they are advantageous. A summary of the most common systems is given below.

(*a*) *Expert system control*: the philosophy of supervisory control based on traffic sensing and rule-based expert systems was developed in the 1990s. The system was implemented using standard packages, built on a spreadsheet in the first instance. Simulated input traffic was generated and dynamically linked to the simulator, showing car movements. An expert system linked to the traffic sensing system continuously calculated optimal car movements.

(*b*) *Fuzzy control*: the application of fuzzy logic(12,16) on elevator systems was first achieved in Japan where the appropriate rule was selected immediately after any hall call button was pressed. A fuzzy logic dispatching system reduces waiting time by operating in an active mode. The dispatcher uses fuzzy rules based on past experience to predict how many people may be waiting for elevators at various times of the day, rather than simply reacting to calls. When several fuzzy features are included in the dispatching decision process, the result is a more effective approach to elevator dispatching than systems based on conventional digital logic.

(*c*) *Artificial neural network control*: artificial neural networks(9) have been used to select the appropriate traffic patterns so that the traffic control module could choose the best hall call assignment algorithm. A destination-oriented car allocation service has also been developed to improve services during rush hours.

(*d*) *Optimal variance method*: a statistical approach involving variance analysis has been adopted where the variance of hall call response time could be decreased by computerised elevator dispatch systems utilising cost function minimisation. The idea is to improve the variance performance by sacrificing the mean response time to a small extent.

(*e*) *Genetic algorithms*: emulating animal genetics and based on the concept that the fittest individuals survive, genetic algorithms(19) can be used to search for a global optimisation of lift service times.

9.5.2 Methods of detecting traffic patterns and the incidence of peak traffic

Until the 1980s, office working hours were relatively stable. Incoming and outgoing traffic peaks could be predicted and simple time clocks used to switch the mode of operation of the group control. The installation of analogue computer circuits to measure the number and direction of landing and car calls provided additional discrimination. Changes in working practices to more flexible and staggered office hours defeat these simple strategies for handling peak traffic. Also, building population densities have often increased beyond the original designed capacity of the lifts using non-computer-based systems. For these reasons, it has become necessary to enable the controller to detect the type of traffic prevailing. The techniques described below should be discussed with any prospective supplier.

— *Load weighing devices*: in most cases, these devices give the estimated weight in discrete steps of full load, and give a rough estimate of the number of passengers. The conversion process from measured weights to passenger numbers assumes a fixed weight figure per passenger, which could vary widely owing to the differing weights of passenger groups (adults, children, etc.) and other disturbances (e.g. passengers carrying objects, or pushing trolleys, etc.).

— *Photocell signals*: this method is used to identify the number of passengers leaving or entering the car. In cases where the lift responds to both a landing call and a car call, it is difficult to distinguish between in-going and out-going passengers.

— *Pressure sensitive device*: this can be a platform switch or pressure sensitive pad on the floor of the car, which determines the number of passengers.

— *Imaging systems*: these use artificial intelligence techniques to identify the number of passengers.

9.5.3 Data logging

Data logging is essential in facilitating routine maintenance (see chapter 14). Before any action of the traffic control algorithm is performed, information reflecting the current status of every car within the system should also be retrieved. This relies on an advanced digital monitoring system.

All modern controllers provide various degrees of data logging. The owner should have access to all operational data in a form which allows its analysis and presentation. At the very least, all data concerned with failures and faults should be available. Additionally, dependent on the size of the installation, data should be accessible to the owner regarding performance. These data should comprise performance data such as door times, dwell times, system response times, out-of-service times etc. A prospective supplier should be asked exactly what can be made available to the owner.

In addition to remote status monitoring, a diagnostic system should be provided on intensive traffic installations to allow proactive preventive maintenance procedures to be put in place by the installation maintainer. The system should detect failure symptoms, which would not be noticed even by a skilled maintenance technician. It has been found that small abnormalities in some equipment can cause serious problems when amplified by factors such as wear and deterioration.

9.5.4 Centralised and distributed control and back-up

There is a vast amount of data to collect and process with the modern lift installation. As there are a number of lifts in the group, there are a number of methods by which the data, including landing calls, are collected and processed.

A dedicated group controller can be employed which collects the data and allocates landing calls to a lift according to a certain algorithm (see Figure 9.5). The disadvantage of this method is that the group controller (typically an industrial computer) may need extra space and, if it fails, it jeopardises the whole system. For this reason, installations utilising a group controller should include a backup system in buildings where failure would be catastrophic, e.g. in a high-rise group.

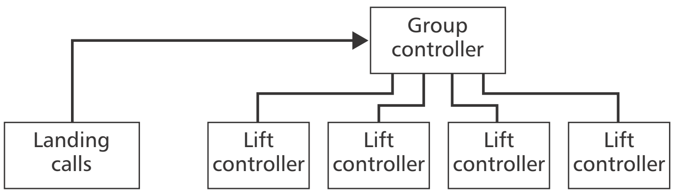


Figure 9.5 Dedicated group controller

An alternative is the master-slave configuration, in which there is no separate group controller hardware (see Figure 9.6). In this configuration, every lift controller is also capable of acting as the group control. Each lift controller receives all information about new landing (or destination) calls over a network. The lift controller performs it own calculations, providing a bid for the call according to the traffic control algorithm. The master lift control compares the bids and awards the call. If the master lift fails, one of the other lifts automatically takes over the group control functions.

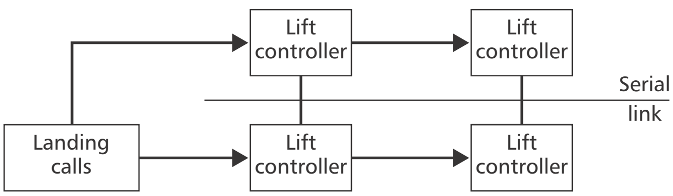


Figure 9.6 Master–slave configuration

Some suppliers opt for a hybrid of the systems shown in Figures 9.5 and 9.6, with a dedicated group controller, and a back-up on the lift controller boards in case the group controller fails.

With computer-based systems it is relatively simple to provide back-up to normal operation to accommodate failures in the controller that would otherwise cause complete loss of lift service. The first level of group control back-up, however, should never be a 'bus service' where landing calls are ignored and the lifts move continuously between floors, stopping at each floor to pick up any waiting passengers. Back-up service of this kind is inefficient and gives very poor lift service to the building.

It is advisable for a prospective purchaser to determine with their supplier the type of data and control configuration to be supplied.

9.6 Other features of group traffic control systems

There are a number of other features that lift group control systems might provide such as up-peak service, down-peak service, load bypass, heavy demand floors, lobby floor preference service, parking policy, car preference, fire service etc.

These features are not always necessary or appropriate in many cases. They should be decided at the time of specifying the system to be installed and then discussed with prospective suppliers. Additional costs may be incurred for some of the advanced features.

9.6.1 Load bypass

When a lift fills to its capacity it should not stop in response to further landing calls, as such stops would be useless and particularly annoying to the passengers already in the lift. A load weighing system is usually available to prevent this. As indicated in section 3.5.5, larger lifts cannot accommodate the rated capacity as indicated in the standards. For example, if the load detection for a 2500 kg lift were to be set to 60%, this would equate to 1500 kg. However, from Table 3.1 a 2500 kg can accommodate only 23.8 passengers. The real 60% value would be equivalent to 60% of 23.8 persons, i.e. 1071 kg. It is important that the load bypass detection is set correctly (see section 9.8 for an example).

9.6.2 Up-peak service

Most lift group control systems detect and take special action for up-peak traffic conditions. Whilst the up-peak condition applies, as soon as a lift discharges its last passenger on its way upward, as long as there are no down or interfloor calls assigned to the lift, it returns to the main terminal floor.

There are several up-peak detection mechanisms. A common method is based on weighing devices installed in the car floor or by measuring the motor load current as an indicator of loading. When heavily or fully loaded lifts leaving the main terminal floor are detected, the up-peak control algorithm is either selected for a specific time period or until the detected condition has changed. A variation of this method, which is able to cater for slight up-peak situations, detects a lift car load at the main terminal in excess of a predefined level, say 50% or 60% (*warning*: see section 9.6.1 above.) For a certain period of time, a parking call is set up at the main terminal to ensure that a lift is available there as soon as possible. Another method counts the car calls registered and, when a predetermined number are registered, initiates the up-peak algorithm.

A more sophisticated approach employs an up/down logic counter which increments, when loads are above a predefined level, and decrements for loads below this level. Additionally, the counter decrements on a timed basis, say every 60 s or so, to ensure that the up-peak algorithm is switched off quickly as the up-peak traffic diminishes.

Some systems limit the service to up and down landing calls above the main terminal during up-peak. During up-peak any passenger wishing to travel up from floors other than the main terminal floor should have little difficulty, as the lifts are frequently stopping at the floors, whilst travelling upwards, to discharge passengers. However, passengers wishing to travel down may find a restricted service or no service at all during the 10–15 minutes of heavy up-peak demand. This strategy should be applied with caution. It may increase the handling capacity of the system, but at the expense of very poor performance for outgoing and (down) interfloor traffic, which in modern buildings is a significant part of the traffic demand during the up-peak period, see Figure 4.10.

9.6.3 Down-peak service

Group control systems frequently include a means to detect down-peak traffic situations, employing similar methods as those used for up-peak detection, but considering heavy loaded lift arrivals at the main terminal floor. Whilst the down-peak condition applies, these systems restrict the service provided to any up traffic and cancel the allocation of lifts to the main terminal, whilst the traffic condition lasts.

Unlike up-peak, where the lifts start and finish their round trips at the main terminal, during down-peak lifts can start their journey anywhere in the building before travelling to the main terminal. If the lifts are commanded to travel to a high call reversal floor, the lower floors may be starved of service as cars can arrive (or pass by) fully loaded. One system which avoids this groups the down landing calls into sectors and assigns lifts to serve call groups in the sectors in a 'round robin' fashion.

9.6.4 Heavy demand floors

Heavy floor demands can occur, for example, at the closing of a meeting or lecture. It is then justifiable to bring extra lifts to the floor to deal with such peaks of demand.

A simple method is to detect at individual floors that a fully loaded lift has left that floor and a new landing call has been registered within, say, 2.0 s for the same direction of travel. The traffic controller can then send free lifts to this floor.

Where controllers use sector-based algorithms, the number of landing calls in each sector can be evaluated and compared with the average number of landing calls per sector. A particular sector exceeding the average value by more than a predefined quantity can be set up as a heavy traffic sector. Extra lifts can then be brought to this sector, bypassing the landing calls at other sectors.

9.6.5 Lobby and preferential floor service

The lobby or main terminal floor in a building is normally of great importance, owing to the steady flow of incoming passengers and/or outgoing passengers during some periods of the day. Preferential service is usually provided for these passengers by parking a lift at the main terminal prior to any other sector. The lobby floor preferential service implies that a slightly poorer service is provided to the remaining floors in the building. This feature is highly undesirable under certain traffic conditions, such as down-peak.

A feature called 'director' or 'VIP' service gives special service to floors where senior executives or directors are located. The lift system can be made to recognise landing calls at such floors and to treat them with higher priority. Alternatively, key operated switches may be available at these preferred landings or destination entry devices may accept VIP codes, which cause a lift to travel direct to the executive floor bypassing all other landing calls, or a lift may be completely segregated out of the bank of lifts for directors' service. It is obvious that this sort of preferential treatment can seriously affect the efficiency of the service as a whole, and it should be avoided whenever possible.

9.6.6 Parking policy

Under light to medium traffic conditions, a lift frequently has no calls to answer. The lift is then free for further assignments and, if no further demand exists, it might be parked at its current position, or at a convenient floor, or in a sector in the building zone. The parking procedure is mainly intended to distribute the lifts evenly around the building. A proper parking policy is essential for good lift system performance, particularly in tall buildings. At the design stage, a suitable number of floors, in addition to the main terminal floor, should be identified where the lifts may be parked. These could include, for example, basement areas, leisure, restaurant and facility floors.

9.6.7 Car preference service

When a lift is taken out of normal passenger control to be exclusively operated from the inside of the lift, it is said to be in car preference service (also known as independent service), emergency service or hospital service.

One method is to make the transfer by a key operated switch in the lift, which causes the doors to remain open until a car call is registered for floor destination. All landing calls are bypassed and car position indicators on the landings for the lift are not illuminated. The removal of the key, when the special operation is complete, returns the lift to normal control.

Another method is for the authorised user to enter a code and/or other security device into a destination entry device which can then prompt the user to select which car is to be put into independent service.

Car preference may be useful to give a special personal service, or for an attendant to have complete control of the lift, whenever it is required. A typical example is in hospital buildings, where lifts for carrying beds and stretchers require the provision of a car preference switch.

9.6.8 Fire and evacuation service

Some lifts may be designed as firefighters lifts (to BS EN 81-72[(6)]) or the older (now obsolete) 'fireman's lifts' and special recall features are provided. Some lifts may be designated as evacuation lifts provided to allow the safe egress of persons with mobility problems. These are complex areas (see chapter 6) and expert assistance should be sought. BS EN 81-73[7] defines the behaviour of a lift in the event of fire.

9.6.9 Other facilities

Some lifts may be designated to provide service to persons with disabilities to BS EN 81-70[5] (see chapters 6 and 11). This is also a complex area and expert assistance should be sought.

The provision of suitable indicators, lanterns and gongs to indicate lift arrivals and direction at landings, their direction and floor indication in the car and other landing and in-car announcements are important to ensure improved passenger communication. These can require special interfacing to the group control system.

Another useful feature is the provision of anti-nuisance devices to ensure that a lift does not answer car calls, if it is empty. This avoids unnecessary car trips and stops due to a practical joker who registers car calls, sometimes pressing or touching all the car pushbuttons when leaving the lift.

Other features that improve the efficiency of people movement which should be considered are:

— adjustable car and landing call door dwell times

— differential door timing

— limiting the number of door re-opening sequences on the re-registering of a landing call at a floor where a lift is about to depart

— adjustable sound levels on gongs at all floors and in-car voice announcements

— easily seen and brightly illuminated position indicators on landings and in the back and the front of the car

— advanced door opening at landings

— multiple car operating panels (COPs) in large lifts

— combining security checks and lift service requests in hall call allocation systems.

Early call announcement (ECA) is a feature popular in some Asian countries. With ECA, the assignment of a lift to a landing call is immediate and fixed. This allows the gong and directional indicator of the assigned car to be announced immediately. The traffic control system cannot change its assignment when other passengers introduce new calls; this degrades service. However, early announcement of the call helps efficient loading as passengers have more time to reach and stand in front of the assigned car.

9.7 Effect of traffic control algorithm on traffic design

9.7.1 Introduction to up-peak boosters

Chapters 3 and 4 indicate traffic design methods to size an installation to meet the expected passenger demand. Chapter 3 dealt with methods that are independent of the traffic control system used. The simulation methods outlined in chapter 4, however, allow an actual traffic control system to be simulated against a defined passenger demand.

Owing to the fact that the up-peak traffic has, in the past, usually been the most demanding type of traffic for lift systems, most traditional algorithms are built around that type of traffic. Moreover, much of the terminology and the methodology used in lift design still rely on the concept of meeting a heavy up-peak influx over a period of five minutes by circulating lifts at the main terminal, delivering the passengers and returning the lift to the main terminal. Nowadays the lunchtime period is often the most severe traffic condition.

Sometimes the traffic designer specifies too few lifts, or the architect is unable to provide sufficient space for the number of lifts required, or the building population increases and the installed lift system cannot handle the up-peak traffic demand. Several techniques[2] are available to improve the up-peak handling capacity of an installation, which are sometimes called up-peak 'boosters'. The main techniques available are up-peak subzoning, up-peak sectoring and hall call allocation (destination control) and these are available from many manufacturers. Discussions should be carried out with the manufacturers at the design stage in order to determine the most suitable type for a particular installation.

9.7.2 Up-peak boosting by subzoning

In subzoning systems, the building zone is divided into two subzones and the lift group is divided into two subgroups for the duration of the up-peak period. The cars are permanently allocated to a subzone and passengers are directed to the subgroup which serves their floor by illuminated signs. The subzones may not contain equal numbers of floors, nor may equal numbers of lifts serve each subzone, see Figure 9.7. The technique works well with at least six lifts in the group and is available from a number of lift manufacturers.

9.7.3 Up-peak boosting by sectoring

Up-peak subzoning can be extended by dividing the building into more than two sectors to provide an up-peak sectoring traffic control system[11]. The number of sectors can be made equal to (or slightly less than) the number of lifts. Each sector generally contains the same number of floors, except the highest may have less floors and the lowest may have more floors. The number of floors in each sector is small, e.g. 3/4/5, and consequently the round trip time is reduced and the handling capacity increased. An

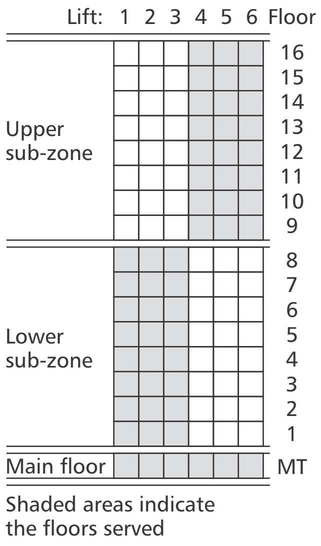


Figure 9.7 Illustration of up-peak subzoning

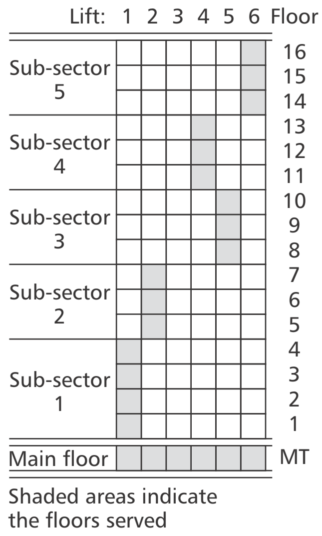


Figure 9.8 Illustration of up-peak sectoring

illustration of the up-peak sectoring system is shown in Figure 9.8.

Lifts controlled under an up-peak sectoring traffic algorithm are not permanently assigned to a specific sector. As lifts arrive at the main terminal floor they serve, the sectors in a strict 'round robin' fashion. Passengers normally have to wait longer for service, but the group interval is smaller. Passengers are directed to lifts serving their floors by destination signs above the lifts. These have to be continually scanned by the passengers until they find a lift serving their desired destination. Where there are more lifts than sectors, it allows some lifts to be travelling back to the main terminal as the others travel up the building. One lift manufacturer formerly proposed this system with mixed results.

9.7.4 Up-peak boosting by hall call allocation

Boosting up-peak performance by basic hall call allocation traffic control (destination control), available from a number of manufacturers[13], has been discussed in section 9.4.2.3.

A further technique with hall call allocation is to use dynamic subzoning. Here the building is divided into two subzones similar to subzoning described above. The boundary of the subzones can change according to the demand to each of the subzones, determined by the individual car loadings. The intending passengers may be unaware of the changing boundary, as they are always told at call registration which lift they are to travel in.

9.7.5 Boosting summary

Up-peak boosters can increase[2] the up-peak handling capacity by approximately:

- 15% using up-peak subzoning
- 40% using up-peak sectoring
- 15% using basic hall call allocation
- 50% using hall call allocation with dynamic subzoning.

However, it is not possible to obtain something for nothing and the increase in handling capacity is usually offset by longer passenger waiting times, but not necessarily longer times to destination.

Boosters improve the overall performance of an installation for up-peak, either by increasing the handling capacity with longer passenger waiting times, or by improving the passenger waiting times for the same number of passenger arrivals. However, such techniques do not generally improve the performance of the other major traffic conditions. Their performance may stay the same. Up-peak 'boosters' have to be used carefully and independent expert advice should be sought if such a system is considered.

Calculation methods are available[3] to analyse the four up-peak booster techniques described above and the other traffic conditions[1]. These are, however, only indicative and a better evaluation of the performance of an installation can only be obtained by the use of simulation techniques (see chapter 4). Many manufacturers claim the application of the AI techniques described in section 9.5.1 enhance installation performance for the other traffic conditions. These claims should always be checked by simulation at the design stage. This is a complex area and independent advice may need to be sought.

9.8 Design case study

This case study illustrates how the handling capacity of a lift installation can be increased to meet the changed specification of the occupier.

9.8.1 Background

A developer speculatively built an office block on the assumption that a cellular office layout would be fitted. The building comprised 16 floors above the ground floor with a total net internal area of 14 000 m^2.

The original lift system was to be designed to the criteria of a 15% percentage arrival rate, a 30 second average interval, and an occupational density of 14 m^2 net internal area per person. Thus the design population was 1000 persons (i.e. 14 000 ÷ 14) and the 5-minute peak arrival rate was 150 persons (i.e. 1000 × 0.15). The lift system specified comprised six lifts, with 1275 kg rated load, 2.5 m/s rated speed and provided a handling capacity of 147 persons/5-minutes at an interval of 22 seconds. Although the handling capacity is just short of that required, the interval is considerably better. The building was to be constructed to accommodate this lift installation.

During construction, a tenant became interested in the building, but only if an open plan office arrangement could be accommodated. The tenant measured the net usable area (NUA), i.e. the rentable space, as 12 000 m^2 and intended an occupation density of 9 m^2 NUA per person. This implied a design population of 1333 persons (i.e. 12 000 ÷ 9). However, a more likely peak arrival rate of 13% was proposed. This requires a lift system handling capacity of 173 persons/5-minutes (1333 × 0.13). Would the lifts cope with the increased demand? The answer is no as the new demand is approximately 16% larger than the core was designed to handle.

9.8.2 Boosting the lift capacity

It was not possible to add an extra lift and so another solution had to be sought. The extra handling capacity during the morning peak can only be obtained if an up-peak booster is applied. Section 9.7 suggested that up-peak boosters can increase the up-peak handling capacity by between approximately 15% and 50%.

Any of the up-peak boosters can provide a 15% increase and of these the up-peak subzoning system is probably the simplest to adopt. The next question is: should the subzones contain equal numbers of floors, or equal numbers of lifts? The six lifts are arranged as three opposite three, leading to the consideration that, during subzoning operation, they can be easily presented to intending passengers by indicators placed over each sub-group of three lifts. In any case, a two-lift group would provide a very poor interval and, in the event of the failure of one, would only leave one lift to serve that subzone. Changing the number of floors per subzone also provides a finer adjustment. The next question is: how many floors should be contained in each subzone?

The logical split would be 8 floors by 8 floors, but it should be remembered that the upper subzone lifts have further to travel before reaching their first served floor than the lower subzone lifts, thus increasing their round trip time and reducing their handling capacity. Table 9.1 summarises three subzone schemes and compares them to the original design (row 1).

The 8/8 split provides the required handling capacity (173) precisely, but there is a considerable mismatch of percentage population served (15.1% to 10.7%). The 9/7 split nearly provides the 13% percentage arrival rate value and only just misses the handling capacity target (167). The final 10/6 split shows deterioration in all criteria. The 9/7 split is preferred even if the intervals (35 s and 46 s), as would be expected with only three lifts, are poor. The subzoning solution with a 9/7 split is not ideal, but does provide nearly the handling capacity required.

To implement this solution, the traffic controller should detect the onset of the up-peak condition and then split the control system into two groups of three lifts serving the designated floors. Passenger information displays would need to be illuminated to inform passengers on which side of the lift lobby to stand, in order to travel to their destination. The service may not be ideal, but the tenant's requirements are almost achieved. Note, however, that the ability to serve mid-day and down-peak traffic has not been enhanced to serve the increased population.

9.9 Installation case study

This case study illustrates how a traffic controller can be designed correctly but so badly set up that the installation performs badly.

9.9.1 Background

The building was occupied by a single tenant with a daily population of 1800–1900 persons attending on a flexitime regime. There were 17 floors designated Basement, Ground and Floors 1 to 15, with a restaurant at Floor 1 and office services in the basement.

The lift installation was provided by a reputable, major manufacturer with extensive experience of traffic control algorithms. The lift installation comprised eight, 1250 kg (16-person) lifts with a rated speed of 2.5 m/s and good dynamic performance.

Table 9.1 Comparison of three subzone schemes with underlying installation

Number of floors served	Floor number	Number of lifts	Population served (person)	Handling capacity	Population served (person/5-min)	Interval (s)
16	1–16	3	1000	147	14.7%	22
8	1–8	3	667	101	15.1%	32
8	9–16	3	667	72	10.7%	46
Scheme 1: 8/8 split			Total:	173		
9	1–9	3	750	95	12.7%	35
7	10–16	3	583	72	12.3%	46
Scheme 2: 9/7 split			Total:	167		
10	1–10	3	833	91	10.9%	36
6	11–16	3	500	72	8.6%	46
Scheme 3: 10/6 split			Total:	163		

The building tenant complained that the lift installation was performing badly in the building they occupied. Complaints presented included:

During the morning arrivals:

(*a*) the lobby 'backed-up' with waiting passengers

(*b*) some cars could only load 10 persons before the overload operated

(*c*) loaded cars did not immediately leave the lobby but continually opened and shut their doors

(*d*) some lifts stopped on the way up for landing calls despite being full

(*e*) when lifts stopped at a floor and no one entered, or left, the lift did not close its doors for eight seconds

(*f*) when lifts stopped at a floor and a person entered, or left, the lift did not close its doors for eight seconds

(*g*) 'up-travelling' passengers entered cars which did not travel up, but down to the basement.

During the evening departures:

(*h*) lifts arrived at the ground floor with only 5–6 persons exiting

(*i*) long waits were reported at lower floors (Floor 4 reported 10 minutes).

During the mid-day period:

(*j*) lifts rarely called at Floor 1.

Generally:

(*k*) passengers hesitated when entering and leaving a car, delaying the journey.

9.9.2 Complaint resolution

On investigation it was found that many of the traffic controller features were incorrectly set. The installation maintainer was asked to attend to the following items:

— The load weighing system for each lift should be calibrated. The lifts are 1250 kg so the overload setting would be 1375 kg. This would deal with complaint (*b*).

— The load bypass should be set to 750 kg (60%). This means that when more than 10 persons of average weight are in the car then the lift does not stop for any further landing calls. This would deal with complaint (*d*). Complaint (*h*) is resolved by the combination of a well calibrated load weighing system (item 1) and correctly set load bypass (item 2).

— The current door dwell times should be reduced and all lifts should present the same times. Car call dwell times should be set to 2.0 s and the landing call dwell times to 5.0 s. This would deal with complaint (*e*).

— The differential door times should be set to 0.5 s. This would deal with complaint (*f*).

— The lift doors should re-cycle only once, in order to allow additional passengers to enter, after the first closure of the doors prior to departure. This deals with complaint (*c*).

— The lifts should be parked whenever they become idle in an even distribution around the building. Two lifts should always be directed to be present at Ground. One lift should be parked at Level 1. The remaining lifts should be parked at Levels 3, 6, 9, 12 and 15. This would improve the situation with complaints (*i*) and (*j*) out of peak times.

Further actions to deal with complaints (*a*), (*i*) and (*j*), i.e. to increase the handling capacity and overall efficiency, would be:

— each door operator should be individually adjusted to the contract values of door operating times

— each drive system should be individually 'tuned' to achieve the contract flight times

— the up-peak and down-peak thresholds (complaint (*i*)) should be set at three cars leaving/arriving at the ground floor 60% full

— the traffic controller should not accept any calls registered on the car operating panel 'behind the car' (i.e. car calls for floors already passed); alternatively, at the reversal floor any outstanding car calls remaining should be cancelled.

Complaint (*g*) can be dealt with by providing large, high illumination direction lanterns, loud gongs on the landing and direction arrows in the back of the car visible from the landing.

Complaint (*k*) can be dealt with by providing large floor indicators in the cars, audible floor announcements and large visible floor identification signs on the landings visible for the cars.

9.10 Improvement verification case study

A lift installation has been modernised. There have been a number of enhancements, including the application of HCA (destination control) utilising an ETD optimisation algorithm[18]. The client requires the improvements to be quantified so that a report can be presented to the tenants.

The installation includes a data logger that tracks the full life cycle of every destination call starting when it is registered, recording the passenger waiting time when the allocated car arrives, and the time to destination when the journey is complete.

The passenger demand reported by the data logger, see Figure 9.9, can be used as an input to a simulation program.

The simulation program can be used to demonstrate consistency between the simulation and the installed system. If the simulation program also included a model of the old control algorithm, it could be used to demonstrate the performance of the old system with the current demand. The results are plotted in Figure 9.10.

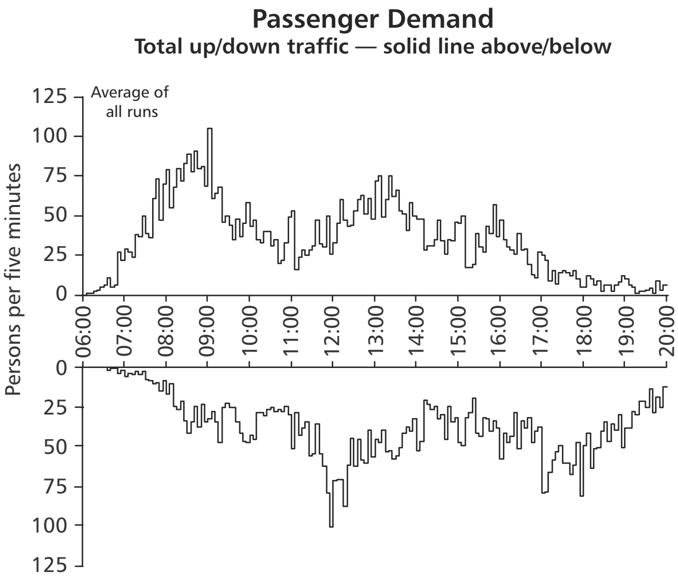


Figure 9.9 Estimated passenger demand for one working day based on data logger record

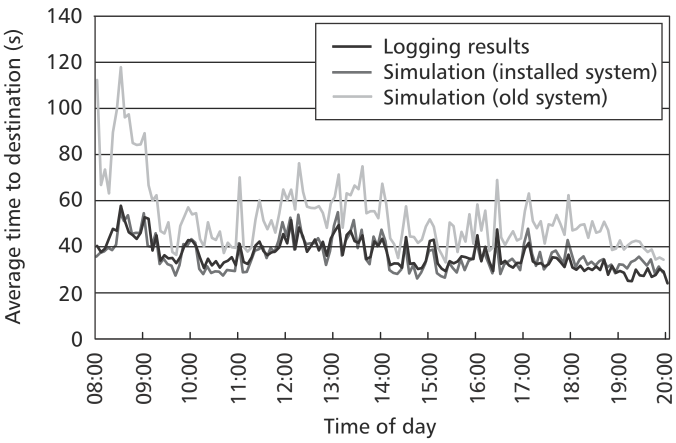


Figure 9.10 Comparison of performance using both data logging and simulation

Daily reporting of passenger demand and lift performance is generated automatically allowing the lift company and building owner to monitor the installation closely. This allows them to act immediately if quality of service deteriorates for any reason other than an increase in passenger demand.

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10 Escalators and moving walks

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Chapter contents

10 Escalators and moving walks

10.1 Introduction

Escalators have been in public use since the turn of the 20th century and their derivative, the pallet based moving walk, since the 1950s. Escalator applications range from low-rise installations to accommodate a small change in level within a storey of a building to high-rise installations found in locations such as deep underground railways. Inclined moving walks are found in retail premises and transportation facilities, where trolleys need to be accommodated. These two pieces of equipment are installed into a structural opening provided in the building. Horizontal moving walks are typically found in transportation facilities such as airports and/or retail environments. Horizontal moving walks are installed along wide corridors generally with a fixed walkway alongside. A general arrangement of a typical escalator is shown in Figure 10.1.

With few exceptions, escalators and moving walks are installed for use by the general public of all ages. Therefore, great care must be taken to ensure compliance with all the safety and operating requirements. These are covered in BS EN 115: 2008[(1)] and BS 7801: 2004[(2)]. Escalators and moving walks are unsuitable for the conveyance of wheelchairs, prams, pushchairs etc., as the risks are considered to be too high. The transportation of shopping/baggage trolleys is not recommended by BS EN 115-1: 2008.

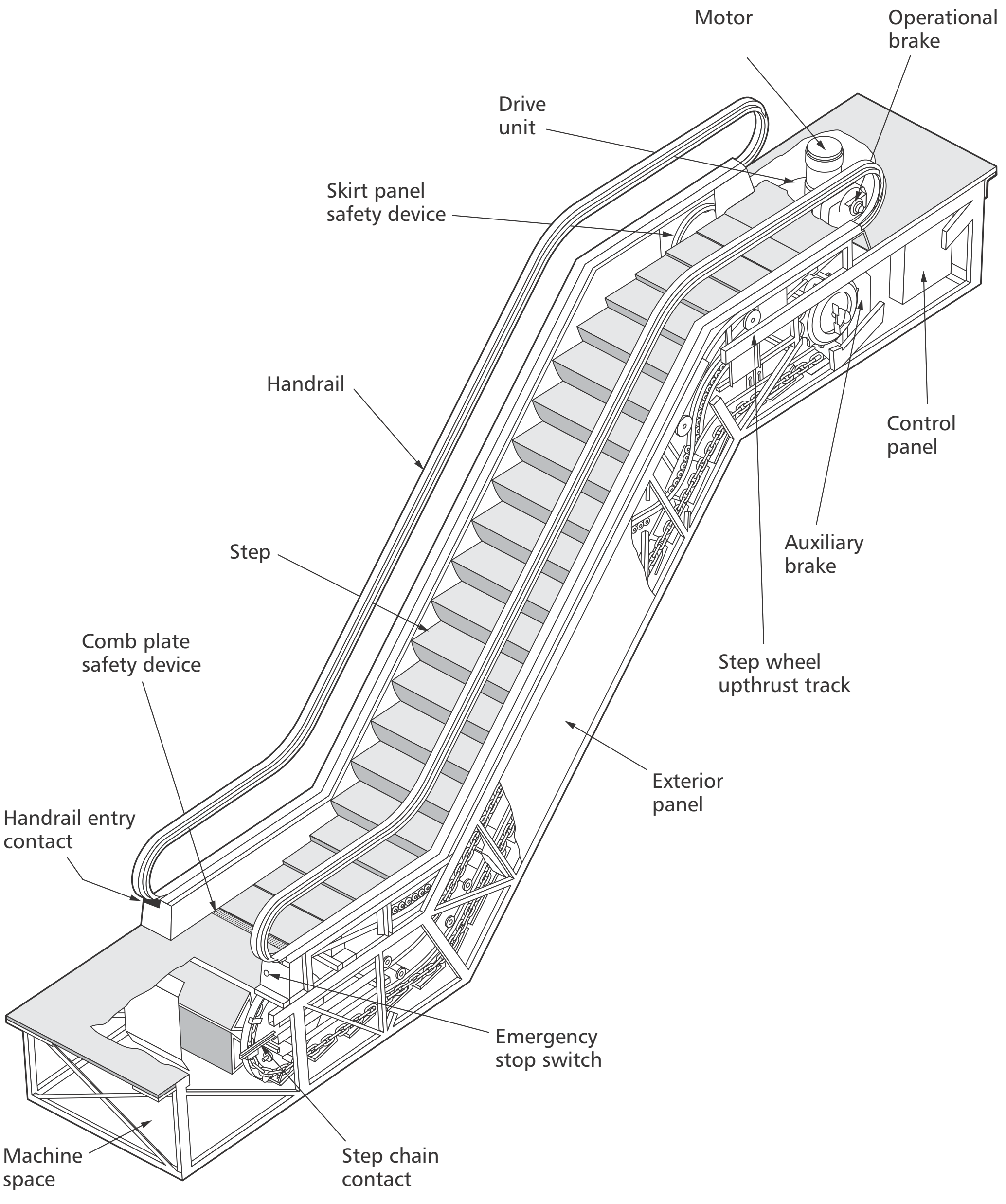

Figure 10.1 General arrangement of a typical escalator

10.2 Definitions, commonly available equipment and duty

10.2.1 Definitions

BS EN 115-1: 2008[1] defines these devices as follows:

— *escalator*: power driven, inclined, continuous moving stairway used for raising or lowering persons in which the user-carrying surface (e.g. steps) remains horizontal

— *moving walk*: power driven installation for the conveyance of persons in which the user-carrying surface remains parallel to the direction of motion and is uninterrupted (e.g. pallets, belt).

Note: the term 'passenger conveyor' has been discontinued in favour of the term 'moving walk' although some older standards still use the redundant term.

Escalators and moving walks are machines under the Machinery Directive[3] enacted as the Supply of Machinery Regulations 2008[4] and as such the CE-marking is carried out by the supplier by compliance to a harmonised standard or to an EC type examination certificate obtained from a notified body for model equipment. However, before first use, an escalator or moving walk should be tested using BS 5656-1: 1997[5].

10.2.2 Commonly available equipment

There are two types of escalator equipment available. The compact escalator is the most common, where all the drive machinery is located within the truss (structural framework). The remote drive escalator is less common and is typical of underground railway systems. Here the drive machinery is located external to the truss in a separate machine room

Escalators and moving walks are factory built equipment and their characteristics can be closely defined. The most commonly available equipment is as follows:

(*a*) Escalator:

— *Speeds*: 0.5 m/s (also 0.65/0.75 m/s)

— *Inclination*: 30° (an inclination of 35° is permitted for rises <6 m and rated speeds <0.5 m/s, however 35° is not permitted in America or Australia)

— *Step width*: 600/800/1000 mm

(*b*) Moving walks:

— *Speeds*: 0.5/0.65/0.75 m/s

— *Inclination*: 0°, 6°, 10°, 12°

— *Pallet width*: 800/1000/1400 mm for inclinations ≤ 6°; 800/1000 mm for inclinations >6°.

Note 1: the maximum inclination of 12° for inclined moving walks was established as the largest safe inclination that most persons could stand on and walk on without overbalancing.

Note 2: some moving walks up to an inclination of 6° may be adapted to permit the safe transportation of shopping and baggage trolleys.

10.2.3 Duty

According to BS 5656-2: 2004[6]. The design of escalators and moving walks falls into four distinct duty categories, as shown in Table 10.1.

Table 10.1 Duty categories of escalators and moving walks

Duty category	Typical usage (passengers per day)	Typical locations
1 Light	Up to 3000	Shops, museums, libraries and leisure facilities
2 Medium	Up to 10 000	Department stores, shopping centres, regional airports and regional railway stations
3 Heavy	Up to 20 000	Major railway and metro stations, major international airports and critical locations such as underground railway systems
4 Intensive	Over 20 000	Ditto

The differences in cost between the categories are significant and care must be taken in assessing the demand, in order to make an appropriate selection to meet the needs of a specific location. When deciding the duty category, account should be taken of:

— the peak demands that might be made on the equipment

— the number of passengers using the escalator or moving walk per day.

BS EN 115-1: 2008[1] defines a public service escalator/moving walk. The definition is based on up to 140 hours per week service hours with a load reaching 100% brake loading. This type of equipment would fall into duty categories 3 or 4 in Table 10.1.

10.3 Principal components

Figure 10.1 shows a cutaway view of a typical escalator, showing the passenger and machine sides of the equipment. The machine side is completely enclosed within a steel structure commonly known as the truss.

On the passenger side the machine covers are fitted over the machine spaces at the top and bottom of the escalator. The upper machine space, called the drive station, contains the drive machinery and the lower machine space is the return station. As a boarding passenger passes over the machine covers onto the first escalator step the handrails become available on the top of the balustrade running in the same plane as the steps and at the same speed. The interface between the stationary machine covers and the moving steps is protected by a comb plate, which is intended to prevent any entrapment by deflecting

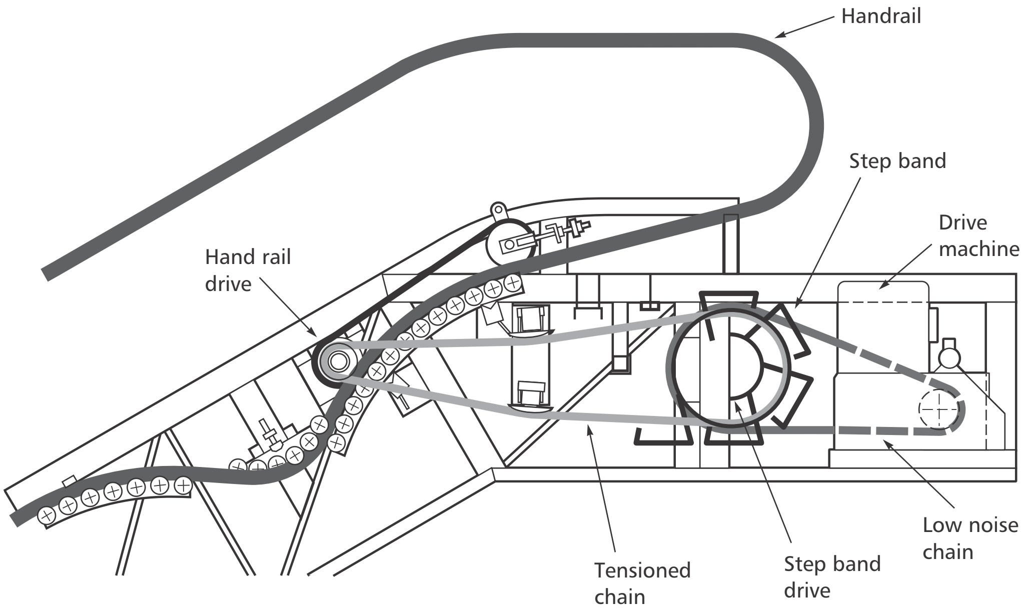

Figure 10.2 Principal components of an escalator drive system

any intruding material, object or passenger body part. Several flat steps then present themselves to the boarding passenger before the escalator rises, or falls, according to whether it is an up escalator or down escalator.

In general, the more flat steps that are available the easier and safer it is for passengers to adjust their balance from a walking movement to a transported movement. Five flat steps are considered adequate in most locations — space and cost are important considerations. At the bottom of the skirt panels, deflector devices are fitted to deflect any material, object or passenger body parts from being drawn into the gap between the moving step/pallet and skirt panel. Another safety device protects the entry and exit points of the handrail as it appears/disappears into the truss. Stop switches for emergency situations are provided at suitable positions along the length of the escalator.

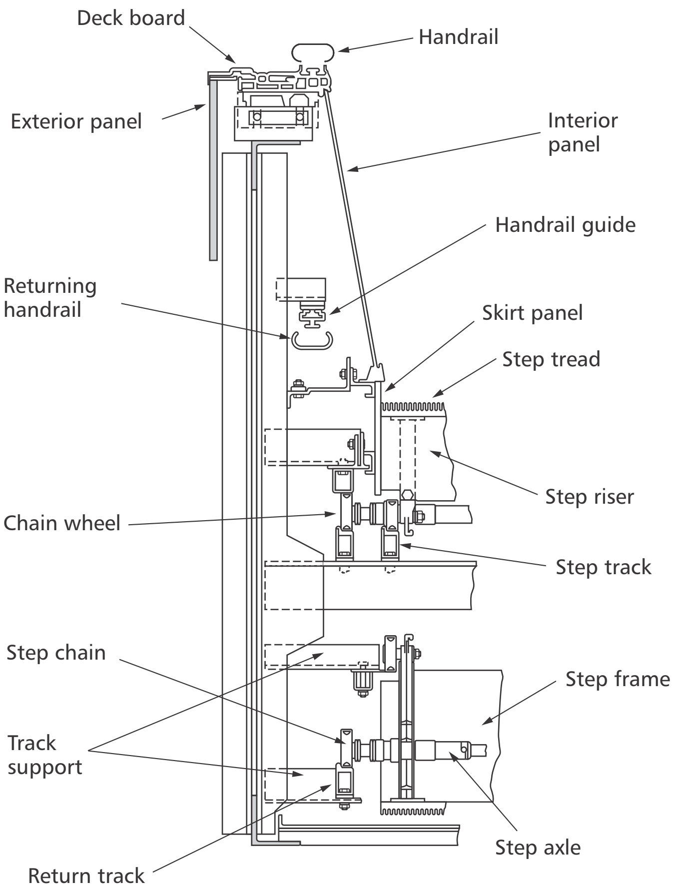

Figure 10.3 Balustrade; section view

Some of the machine side components, such as the drive unit, operational and auxiliary brakes, together with other safety devices, are also indicated in Figure 10.1. The principal components of machine side are shown in Figure 10.2. In this example, the drive machine is situated outside of the step band to allow ease of maintenance. Power transmission from the machine to the main drive of the step band is normally via a chain. The handrail is driven from the main drive via an automatically tensioned chain. The handrail drive is designed to ensure synchronous handrail and step band speeds. Figure 10.3 provides a balustrade section view, illustrating the relationship of all the components.

The main components of the step and step chain are illustrated in Figure 10.4. Each step is located by an axle. The intermediate wheels ensure that the load is distributed evenly around the curved track section from the incline to the upper landing.

10.4 Installation planning

10.4.1 Specifying the equipment

Although an escalator or moving walk is factory-built equipment there is a large amount of information that needs to be exchanged. General guidance is given in BS 5656-2: 2004[(6)] on the procedure and overall chronological sequence to be adopted in obtaining an installation that is satisfactory from the aspects of operation, safety and maintenance. This code of practice also provides guidance on the exchange of information between the purchaser and the escalator/moving walk supplier. A series of checklists for the various tender documents is given in Annex B to BS 5656-2, detailing the initial exchange of information prior to and at the time of the tender and the contract inclusions and exclusions.

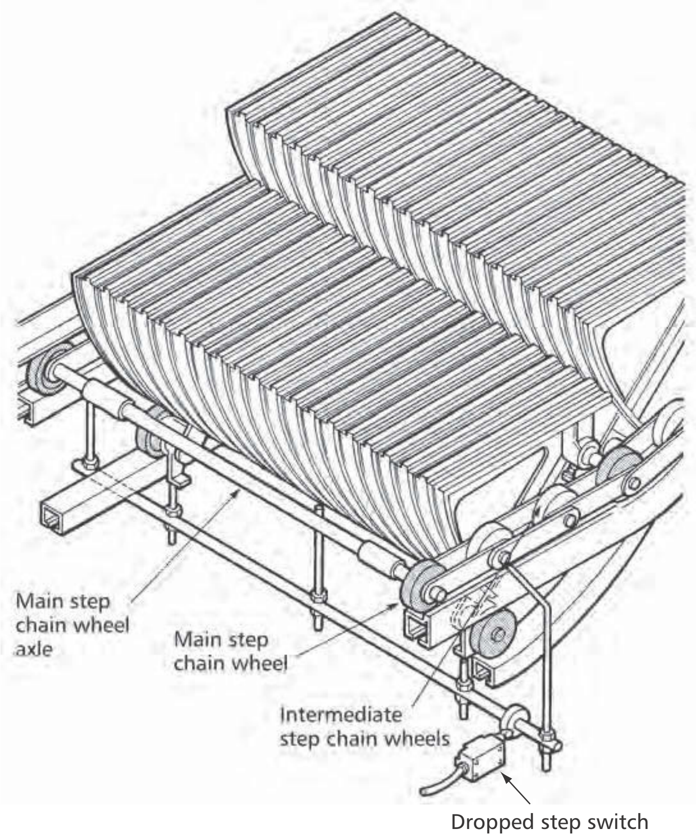

Figure 10.4 Escalator step and step chain details

Specialist advice should be sought at the design stage, where unusual environments are likely to be encountered, for example:

— potential exposure to weather
— low/high temperatures and or high humidity
— hosing-down for hygiene or decontamination
— corrosive/dusty atmospheres
— the need for quiet operation
— vandal-prone installations
— the transportation of shopping/baggage trolleys (moving walks only).

The installation of equipment in these environments will increase the cost owing to the complications involved.

It should be borne in mind that the design, installation and maintenance of escalators and moving walks is always subject to risk assessments being carried out and their installation will be subject to the Construction (Design and Management) Regulations 2007[7] ('CDM Regulations').

10.4.2 Traffic sizing

The number, speed, step/pallet width to meet the expected traffic demand can be determined using the procedures and information in sections 2.4.4, 2.4.5 and 2.5.11.2.

10.4.3 Location

The location of escalators and moving walks is fully discussed in section 2.6.3. Care must be taken to ensure that the alighting areas are not obstructed either by fixed furnishings or by alighted passengers, whose departure from the alighting area is also obstructed or the succeeding area is too small. The full traffic function must be considered particularly in intensive traffic locations. Particular care should be taken not to obstruct the unrestricted area according to BS EN 115-1: 2008[1], where successive escalators and moving walks are installed.

Clear areas are specified in BS EN 115: 2008 and particular attention is drawn to clause 7.3 of BS 5656-2: 2004[6] where specific risks associated with the environment are considered.

10.4.4 Aesthetic design

Unlike lifts, escalators and moving walks are not enclosed and most of the equipment is in the view of the public. They offer considerable scope to the designer for the imaginative use of glass, cladding and polished metal finishes. Careful design of the lighting may also enhance the appearance. However, consideration must also be given to the following:

— Designs that create voids at the sides of the equipment or gaps between equipment, such as where equipment is located in atria, should be avoided where possible (but managed by design risk assessment as a minimum) as these present a risk of falling or entrapment to users.
— Coloured handrails require regular cleaning, using special materials, at least every two weeks if the appearance is to be preserved. Black handrails are less attractive but more practicable for public usage.
— Where glass balustrades are installed close to a wall, rubbish will collect in the space between the wall and the balustrade. This will be difficult and expensive to remove.
— Stainless steel does not suffer damage by scratching from shoes, luggage etc. and is therefore an appropriate material for intensive duty applications. For aesthetic reasons, the grain of patterned materials should be considered.
— Ambient temperature can affect passenger comfort and handrail reliability.
— In some recent designs, the moving equipment is observable through glass cladding. This is very effective when the escalator is lit internally, but the difficulties of cleaning the glass (externally and internally) and the equipment must be considered.
— Some manufacturers have developed curved escalators (see Figure 10.5).

10.4.5 Safe use of escalators and moving walks

The following are some of the safety features that should be included to assist passengers in their safe use of modern escalators and moving walks:

— *Yellow lines on steps*: the border of the step is painted with a yellow line. This enables visually impaired passengers to see the step border and

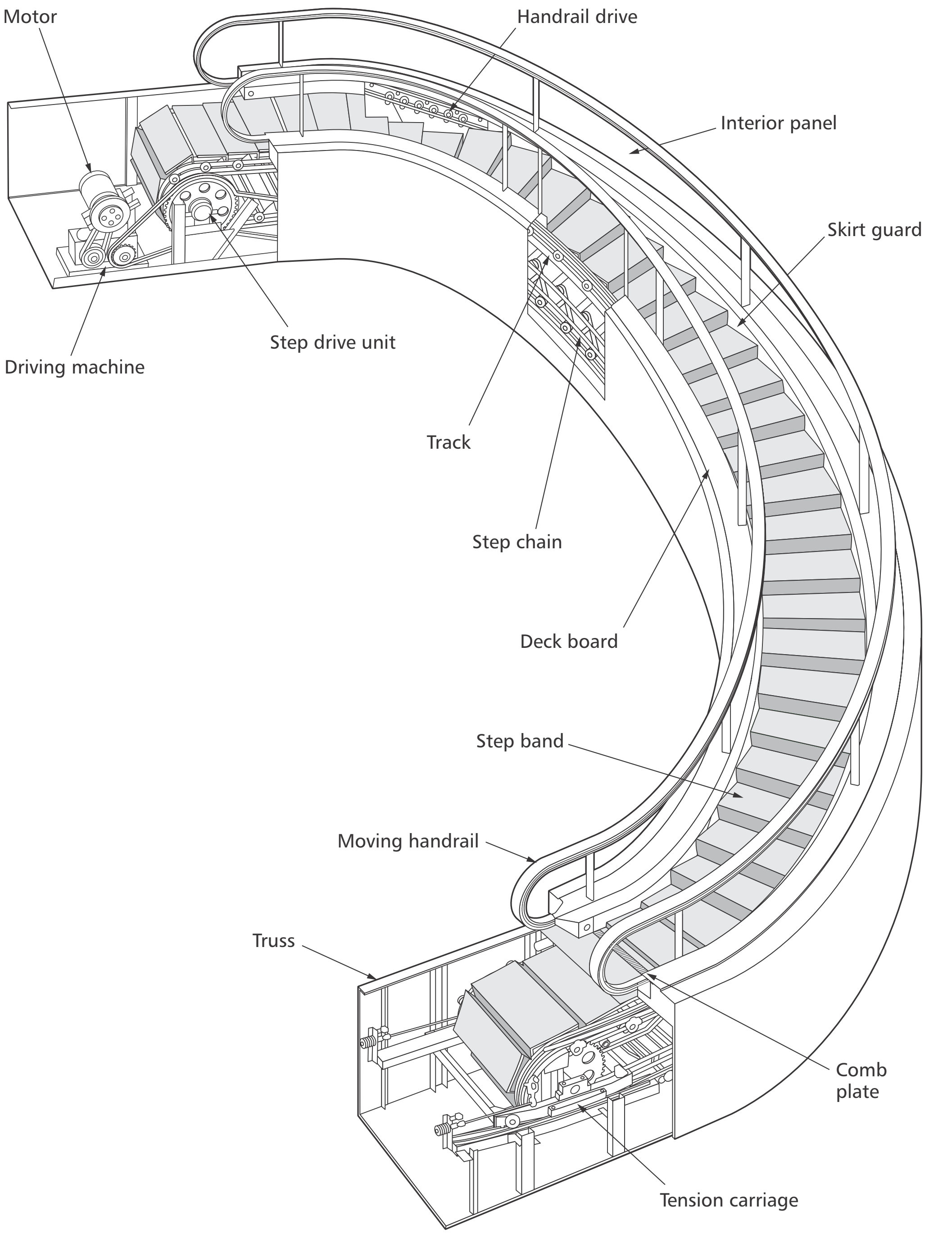

Figure 10.5 Curved escalator

encourages passengers to keep their feet away from the step sides.

— *Brush guards*: installed above the edges at the sides of the step, and fixed to the skirting. They are effective in reducing passenger entrapments. Brush guards are not recommended on moving walks where trolleys are used as they present a hazard.

— *Yellow spots on handrails*: these help visually impaired passengers see the moving handrail.

— *Lighting*: adequate permanent lighting at the landings of at least 100 lux.

— *Safety signs and warning notices*: must be to Annex C of BS 5656-2: 2004[(6)].

— *Guards*: end barrier, intersection, outer decking, etc.

— *Angle of inclination of balustrade panels*: should be greater than 25° and preferably greater than 27° to discourage children from climbing on the panels.

— *Guard rails*: the guard rails connecting to the escalator/moving walk should be a similar height to the handrail height of the equipment or higher where there is a risk of falling into voids.

— *Use as fixed stairs*: escalators are unsuitable for use as fixed stairs and should not form part of an emergency exit route.

It is strongly recommended that persons using escalators or moving walks do not do so for the movement of goods and materials, and that when work is undertaken in the environment around the escalator that ladders, scaffolds etc. are not placed on them.

An assumption has been made that persons using escalators and moving walks are able to do so unaided. However, they are also likely to be used by persons with a range of disabilities. Factors to be considered are:

- speed
- step/pallet width
- inclination
- number of horizontal steps at landings (escalators only)
- handrails
- surface finishes
- controls
- lighting
- signs and information
- landings clear space
- guarding
- environmental surroundings such as mirrors, advertisements
- use of trolleys (moving walks only).

Chapter 10 of BS 5656-2: 2004[(6)] gives specific recommendations and guidance intended to assist persons with disabilities. These recommendations can also improve the level of safety of other users and improve circulation efficiency.

Where shopping/baggage trolleys are to be transported special measures should be put in place. The moving walks should be designed to accept the shopping/baggage trolleys to be used, such that they can be automatically locked into a safe position. The unrestricted area should be extended to 5.0 metres and additional emergency stop switches placed approximately two metres before each comb intersection. BS EN 115-1: 2008[(1)] does not recommend the use of trolleys on escalators.

For moving walks the rated speed for inclinations greater than 6° should not exceed 0.5 m/s and be fitted with an upper and lower transition curve.

10.4.6 Machine rooms

Machine rooms are required for remote drive escalators. Many of the requirements are similar to those for lift machine rooms. Section 5.4 of BS 5656-2: 2004[(6)] provides guidance.

10.4.7 Electrical supply and electromagnetic compatibility

The supplier should provide details of the full load current, the starting current and its duration, the maximum permissible voltage drop etc. in order to enable the size of the main supply cable to be determined. The electrical installation should conform in all respects to BS 7671[(8)] (the IEE Wiring Regulations).

The main supply from the intake room should be separate from other building services. A temporary electricity supply may be required during the installation and its characteristics should be the same as those of the permanent supply. BS 5656-2: 2004[(6)] gives further details.

The electrical installations should be in accordance with BS EN 12015[(9)] and BS EN 12016[(10)] to ensure electromagnetic compatibility (EMC). Certain locations, e.g. railway systems, have specific EMC requirements.

10.4.8 Noise

The location of escalators or moving walks should be such as to cause minimum noise disturbance, although no equipment can be totally silent or vibration-free in operation. The design of the building is significant in noise and vibration reduction. The walls, floor and ceilings of machinery spaces and machine rooms should be designed to substantially absorb the sound. Beams and structural members should not penetrate into occupied areas. If there is any doubt about the equipment then a similar installation should be checked. If the escalator or moving walks is required to operate to specific requirements, this should be agreed at the contract stage. Specialist advice may need to be sought.

10.4.9 Fire protection

When fire protection systems such as smoke detectors, sprinklers and shutters are required by the relevant fire authority, the owner should provide such equipment and any necessary interfaces and arrange for the system to be tested.

Where sprinklers are used special consideration should be given to specifying the appropriate IP rating of equipment that would be affected by water from the sprinklers.

Fire shutters are provided by specialist subcontractors. When such devices are installed it is necessary for the escalator or moving walks supplier to include control interfaces to ensure their correct and safe operation.

10.4.10 Installing equipment

Generally an escalator or moving walk is delivered and installed as a single unit. This allows for maximum pre-assembly and testing at the factory, including running-in, and will ensure rapid and efficient installation on site. A typical one-piece escalator unit may be more than 16 m long, 1.6 m wide and 3 m high, and weigh up to 9000 kg. Thus careful planning is essential if costly installation difficulties are to be avoided. Therefore consideration must be given to the following:

- A clear, straight access route onto and across the site must be provided. Normally this should be at least 3 m wide, with a minimum vertical clearance of 3.5 m.

  Note: the 3.5 m dimension can be reduced for the installation of moving walks.

- Police approval will be needed if unloading is to be carried out on a public highway, including a possible road closure application that may take weeks to organise due to the need for public consultation.

— Consideration must be given to permitted floor loadings along access route.

— Suitable hoisting points must be provided.

Early planning is essential, particularly in the case of installations in existing buildings.

10.5 Drive systems, energy usage and safety devices

10.5.1 Motor sizing and selection

The sizing of the drive motor depends on a number of factors:

— vertical rise of escalator or travel distance of a moving walks

— escalator or moving walk equipment efficiency

— efficiency of gearbox

— running speed

— angle of inclination of escalator or moving walks

— number of passengers assumed to occupy a step/pallet

— rise of each escalator step.

For an escalator, the required power from the motor depends on nine parameters:

— rise, R_e (m)

— escalator efficiency, η_s (%)

— gearbox efficiency, η_g (%)

— speed, s (m/s)

— inclination, θ (degrees)

— number of passengers, n

— passenger mass, m (75 kg)

— step riser, R_s (m)

— handrail power, p_h (W)

The output power, P (kW) required for the motor is given by:

$$P = \frac{[s\, m\, g\, n\, (R_e / R_s) \sin \theta] + p_h}{\eta_s\, \eta_g \times 1000} \tag{10.1}$$

10.5.2 Methods of starting

The majority of systems currently employ induction motors in the drive systems of escalators and moving walks. The drive motors are controlled and started by one of the following systems.

Direct-on-line start (or star-delta)

A star–delta starter is used to start the system and the motor is then directly connected to the supply during service. For maintenance speed, a second slow speed winding in the motor is used, which usually achieves one quarter (25%) of the normal running speed. The motor has two sets of windings, each with a different number of poles (in the ratio of 4:1). The main disadvantage of direct-on-line, or star–delta, systems is the large in-rush current during start-up (up to seven times the full load current for direct-on-line and up to 3.5 times the full load current for star–delta), the mechanical shock to the equipment components, the very poor power factor at light loads and poor speed control. These systems are less used nowadays, having been replaced by solid state electronic drives, but are inexpensive to purchase and maintain and appropriate where equipment is switched on/off infrequently.

Inverter (VVVF) drives

There are two types of VVVF drive: fully rated with regenerative capability or fully rated with dynamic braking resistor.

A VVVF drive with dynamic braking resistor uses a fully rated inverter system to start the system and then drive it up to the full speed. Then either the inverter carries on driving the motor or a contactor is used to bypass the inverter. The disadvantage with the former method is that on a heavily loaded downward moving escalator excess generated energy is wasted through the braking resistor, while the disadvantage of the latter is the high changeover current and the resulting jerk in the motor at the moment of changeover.

A feature of VVVF drives is that the speed can be varied to suit a number of different applications, such as a low speed for inspection and maintenance, very low speed for releasing trapped objects from the comb, reduced speed during periods of low or no usage. This has the advantage of reducing the power consumption as well as reducing the wear. The use of an inverter allows imperceptible acceleration and deceleration between the low speed and the running speed.

The advantages of VVVF drives are that they give a very smooth start (reducing the mechanical shock to the equipment components), they run at a very good power factor (even under no load) and they reduce the starting current to around 1.5 times the full load current. Another advantage is that there is no need to use a pole changing two-speed motor to achieve maintenance speed, as this can be done via the inverter. The main disadvantages of VVVF drives are that they occupy more space, need extra maintenance (the capacitors in VVVF drives have a limited lifetime), and generate extra heat that needs to be removed from the machinery space.

Soft starters

Soft starters employ power electronics (usually three pairs of back-to-back thyristors) to bring the system up to full speed, after which the thyristors are bypassed by a contactor that puts the motor direct-on-line. The in-rush current is about 1.5–2.5 times the full load current.

However, for maintenance speed, there still is a need for a pole changing, two-speed motor. These systems are simple and provide a smooth start, but have a very limited functional capability compared to VVVF drives.

10.5.3 Modular escalator drives

A problem with escalator traffic is that it varies widely during the day. There are periods in the day when no one uses the escalator at all, although the escalator has to be kept running. At other times of the day, during peak periods, the escalator is heavily loaded. The motor has to be sized to cope with the maximum demand. This results in the fact that during low usage periods, the motor will running very lightly loaded. This is undesirable, as the efficiency of the system is very low under these conditions. As an answer to this problem, some companies have developed a modular drive system that employs two or three motors coupled to the same gearbox. This type of drive system is particularly appropriate for intensive duty underground railway and other transport system. The control system detects the level of loading and operates as many motors as is needed. In this way the efficiency of the system is kept high and the power factor does not drop to unacceptable levels. It also allows energy reduction, improved efficiency and extended life for the motors.

10.5.4 Energy usage

Manufacturers can provide figures for the energy consumed by an escalator or moving walk. Chapter 13 gives information regarding the energy consumption of escalators and moving walks. The type of operating control employed has an effect on energy usage. There are three types of control option: continuous, variable speed and on-demand.

Continuous operation

The escalator or moving walk operates continuously at a single speed with the starting and stopping carried out manually.

This type of operation would be suitable for locations where there are continuous traffic flows.

Variable speed operation

A common method used to reduce losses is the reduction in the speed of the escalator or moving walk during periods of inactivity. The change of speed is initiated by the use of a passenger detection system such as pressure mats, photocells or passive infrared beams. The equipment reverts to its highest speed when sensors (e.g. switches under mats at landings, photo-sensors on newels etc.) are activated by passengers on the approaches. The advantage of a system that reduces the speed rather than stopping the escalator is that passengers are aware of the direction of travel of the equipment when approaching, and there is no risk that they would think that the equipment is out of service.

When the equipment changes speed after periods of low passenger activity, it is important that the transition be smooth in order to prevent passengers from falling. An advantage of VVVF drives is that they provide a very smooth transition between speeds.

This type of operation would be suitable for locations where there are periods of time when there is no passenger demand.

On-demand start

The escalator or moving walk is available for use in either direction of travel and automatically starts operating as a result of passenger demand. After a period of no passenger flow the equipment stops automatically. The starting is initiated by the use of a passenger detection system such as pressure mats, photocells or passive infrared beams. A system has to be provided to manage the direction of operation.

This type of operation would be suitable for locations where there are long periods of time when there is no passenger demand and can cater for either direction of travel.

10.5.5 Safety devices

Although modern escalators and moving walks employ electronic control, the safety line is still retained. All electrical safety devices are wired in series, forming the so-called 'safety line' or 'safety chain'. All safety devices should act directly on the final contactors, as stipulated in BS EN 115-1: 2008[1].

The concept of a separate safety line is important in escalators because it removes the safety-critical elements

Table 10.2 Items causing automatic stopping of the escalator

Description	Safety device	Self-resetting
No control voltage		•
Earth fault in electrical safety device circuit		•
Motor overload	•	
Motor windings over-temperature		•
Overspeed	•	
Unintentional reversal of direction	•	
Operation of auxiliary brake	•	
Breakage or elongation of step etc.	•	
Reduction of distance between stations	•	
Entrapment of foreign bodies at comb	•	
Stopping of succeeding escalator	•	
Operation of handrail entry guard	•	
Operation of sagging step detector	•	
Broken handrail	•	
Missing step detection	•	
Brake not lifting	•	
Handrail speed defect	•	
Open inspection cover		•
Exceeding stopping distances	•	
Installation of hand winding device	•	

from the electronic programmable systems and puts them in a separate, hard-wired configuration.

Each component monitoring a safety function is called a safety device. Table 10.2 shows all the functions causing automatic stopping of the escalator. Some of them are not safety devices. Moreover, some of them need to be reset before the escalator can be re-started.

Today, escalators and moving walks are generally controlled by microprocessor and solid state devices, replacing the relay controllers used in the past. These programmable electronic devices should provide the same level of safety and in the case of failure, the system should always revert to a safe state.

10.6 Ride quality of escalators and moving walks

ISO/CD 25744: *Escalator and moving walks – measurement of ride quality*(11) was circulated for comment at the time of publication of this Guide. It sets out the methodology for the measurement and reporting of escalator and moving walk ride quality. It does not propose quality values, but does provide a definitive method of determining acceleration, sound levels and vibration.

10.7 Existing escalators and moving walks

There are over 75 000 escalators and moving walks in use, almost 50% of which were installed over 20 years ago. The forthcoming BS EN 115-2(12) will provide an authoritative reference on reducing risks and how to bring existing equipment to an acceptable standard. Readers of this Guide are reminded of their duties under legislation.

References

1 BS EN 115-1: 2008 + A1: 2010: *Safety of escalators and moving walks. Construction and installation* (London: British Standards Institution) (2008/2010)

2 BS 7801: 2004: *Escalators and moving walks. Code of practice for safe working on escalators and moving walks* (London: British Standards Institution) (2004)

3 Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast) ('The Machinery Directive') *Official J. of the European Union* **L157** 24–86 9.6.2006 (2006)

4 The Supply of Machinery (Safety) Regulations 2008 Statutory Instruments 2008 No. 1597 (London: The Stationery Office) (2008)

5 BS 5656-1: 1997: *Safety rules for the construction and installation of escalators and passenger conveyors. Specification and proformas for test and examination of new installations* (London: British Standards Institution) (1997)

6 BS 5656-2: 2004: *Escalator and moving walks. Safety rules for the construction and installation of escalators and moving walks. Code of practice for the selection, installation and location of new escalators and moving walks* (London: British Standards Institution) (2004)

7 The Construction (Design and Management) Regulations 2007 Statutory Instruments 2007 No. 320 (London: The Stationery Office) (2007)

8 BS 7671: 2008: *Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition* (London: British Standards Institution) (2008)

9 BS EN 12015: 2004: *Electromagnetic compatibility. Product family standard for lifts, escalators and moving walks. Emission* (London: British Standards Institution) (2004)

10 BS EN 12016: 2004 + A1: 2008: *Electromagnetic compatibility. Product family standard for lifts, escalators and moving walks. Immunity* (London: British Standards Institution) (2004/2008)

11 ISO/CD 25744: *Escalator and moving walks — measurement of ride quality* (committee draft) (Geneva, Switzerland: International Organization for Standardization) (2010)

12 prEN 115-2: *Safety of escalators and moving walks. Rules for the improvement of safety of existing escalators and moving walks* Draft for comment 09/30192761 DC (London: British Standards Institution) (2009)

11 Transportation facilities for persons with disabilities

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11 Transportation facilities for persons with disabilities

11.1 Access for everyone

> 'Accessibility enables people, including persons with disability, to participate in the social and economic activities for which the built environment is intended.'
> (from BS EN 81-70[1], Annex A)

Transportation systems in buildings should provide independent and equal access for everyone. This chapter provides general guidance. It cannot be specific and attention is drawn to the references for further information. Expert assistance may be needed to deal with particular situations.

In general, facilities designed to permit their use by disabled people assist able bodied people in their use. BS 8300: 2009: *Design of buildings and their approaches to meet the needs of disabled people. Code of practice*[2] gives valuable general guidance. Building Regulations Approved Document M: *Access to and use of buildings*[3] recommends that planning applications include an Access Statement* to indicate how people access any new building or extension to an existing building and this should indicate any provision of building transportation systems.

Appendix A3, section A3.5 provides a list of relevant standards.

11.2 Disability or impairment?

Many people suffer from a disability (see BS EN 81-70[1], Annex B), or impairment. Examples include the following:

(*a*) *Physical disability*: people who are unable to use stairs, or negotiate a (step) change in level due to:

- a temporary mobility impairment, e.g. a broken leg
- a permanent mobility impairment, e.g. loss of the use of a lower limb
- limited range of movement and weight-bearing ability, e.g. due to arthritis
- reduced strength and endurance, e.g. as a result of a heart or lung complaint.

(*b*) *Sensory disability*: people who have sensory limitations due to:

- poor vision
- impaired balance
- impaired hearing.

(*c*) *Intellectual disability*: people who have cognitive impairments due to:

- learning difficulties
- intellectual deterioration.

The motor and sensory abilities in a population can vary over a wide range. Transportation facilities in buildings are likely to be used by persons with a range of disabilities. Some individuals, in particular older people, may have more than one impairment. Some individuals are not able to use transportation facilities unaided and rely on assistance/support being provided by a companion or carer. Some individuals can be handicapped by objects they are carrying, or be responsible for other persons, which can also affect their mobility. The extent to which an individual is incapacitated by impairments and encumbrances often depends on the usability of the equipment provided. The most important issue to take into account during the selection and installation of transportation equipment is their safe use by all persons.

11.3 Summary of the Disability Discrimination Act 1995

The Disability Discrimination Act 1995[5] (DDA) and its subsequent amendment[6] gave disabled people new rights in such areas as access to goods, facilities and services. The Act requires goods and services to be accessible to disabled people in virtually all non-domestic environments. This is mainly concerned with the removal of physical barriers to the free circulation of all people.

From 1st October 2004, businesses and service providers had a duty, to make 'reasonable adjustments' to the physical features of their premises in order to overcome barriers to access. Service providers have a duty to consider the use of premises by people with mobility, visual, hearing, speech and dexterity impairments as well as those with learning difficulties and mental health disabilities. 'Reasonable adjustments' may take account of:

- practicality
- financial and other costs
- disruption
- resources available
- availability of financial assistance.

Lifts, lifting platforms, stairlifts, escalators and moving walks are examples of 'physical features'. The Disability Rights Commission has published a number of codes of practice relating to duties applicable under the Disability Discrimination Act 1995.

* Access Statement: achieving an inclusive environment by ensuring continuity throughout the planning, design and management of buildings and spaces. (Equality and Human Rights Commission[4])

'Barriers to access' are also physical features to the building that reduce its accessibility to all people. Examples include:

— small changes in level of less than a storey (up to 3 m)
— larger changes in level of one or more storeys (over 3 m)
— inadequate width of doors
— insufficient manoeuvring space.

In new buildings these 'barriers' should be designed-out. In existing buildings an Access Statement[(4)] should indicate that reasonable provision is being made and, if not, why not.

11.4 Building Regulations Approved Document M

The Department for Communities and Local Government (CLG) publishes Approved Documents to provide practical guidance to the requirements of the Building Regulations 2000[(7)]. There is no obligation to apply the guidance if the relevant requirements for access can be met in some other way. The argument supporting any alternative solution to Approved Document M[(3)] should be made in the Access Statement[(4)]. Approved Document M: *Access to and use of buildings*[(3)] (ADM) (also known as 'Part M'), came into effect on 1st May 2004. It is in the hands of many professionals (architects, developers, designers, surveyors, chartered engineers etc.), who faithfully follow its guidance. Amongst its guidance (on steps, ramps, stairs, handrails, lobbies, sanitary accommodation etc.) vertical circulation is discussed in clauses 3.17–3.49 for 'buildings other than dwellings' and in clauses 9.6–9.7 for dwellings (which includes buildings containing flats).

Note that a new edition of Approved Document M is likely to be published in 2010.

ADM states that 'the objective is for people to travel vertically and horizontally within buildings conveniently and without discomfort in order to make use of the facilities'. The services provided should accommodate all disabled people not simply those with a mobility problem. ADM ranks the equipment provision in public buildings with the order of preference: passenger lifts, lifting platforms, wheelchair platform stairlifts as follows:

— For all public buildings, a passenger lift is the most suitable form of access.
— For public buildings where the site or location is unsuitable for a passenger lift, a vertical lifting platform may be used.
— In exceptional circumstances in an existing public building, where the site or location is unsuitable for a passenger lift or lifting platform, a wheelchair platform stairlift may be used.

A passenger lift is the most suitable means of vertical access for all and should be provided wherever possible. However, given the space constraints in some buildings, it may not always be possible to install the type and size of passenger lift that would be suitable for use by all mobility-impaired users and alternatives may need to be provided. The case for using each lifting device should be argued in the Access Statement[(4)].

For buildings containing flats, ADM recommends that passenger lift access be provided.

11.5 Equipment selection to meet user needs

The selection of the equipment to meet the needs of disabled people should be carefully considered to ensure that it is appropriate and meets the needs of the user(s). The following identifies some important considerations.

11.5.1 Existing and future user needs

When selecting a lift, lifting platform or stairlift, both the existing and the future needs of the user(s) should be considered. This is important in a domestic environment, as people age and become less capable, or where a disability becomes more severe. Therefore, the installation of a seated stairlift might be unsuitable, should the user later become dependent on a wheelchair. In non-domestic environments, the use of the building can change significantly over its life, thereby affecting the facilities to be provided.

11.5.2 Rated load

If a lifting device is not dedicated to a particular user the future loads may be difficult to predict. When considering such loads consideration should be given to whether a travelling companion (attendant) is to be accommodated, what type of wheelchair might be used and if any medical or other equipment is to be carried.

The following are minimum rated load recommendations:

— 630 kg for passenger lifts (BS EN 81-70: 2003[(1)])
— 450 kg for passenger lifts for a lone user without an attendant (BS EN 81-70: 2003[(1)])
— 205 kg for a lone user, either standing or in a type A wheelchair on a lifting platform (BS 6440: 1999[(8)])
— 280 kg for a type A or type B wheelchair user with an attendant on a lifting platform (BS 6440: 1999[(8)])
— 250 kg for a lone wheelchair user on a wheelchair platform stairlift (BS EN 81-40: 2008[(9)])
— 115 kg for a seated or standing lone user on a stairlift for private domestic use: BS EN 81-40 2008[(9)]).

11.5.3 User position

An ambulant disabled person may stand or sit and may be using a walking aid. It should be noted that some users with walking aids cannot easily turn through 180°. Other users may be seated in a wheelchair. It is important to ensure that the user(s) can be safely transferred on and off the lifting device.

Note that chair and standing platform stairlifts are unsuitable for use in public situations.

11.5.4 Entrance facilities

Access to and from the lifting device together with manoeuvring space at the entrances of the lifting device should be carefully considered. Manual or automatic operation may need to be available for doors, wheelchair stairlift barriers, folding platforms and barriers or gates to open lifting platforms. Full platform guarding to provide safe and secure travel for both wheelchair and standing users should be provided for all lifting devices in public access situations.

11.5.5 Control devices

Consideration should be given to the position, type and number of controls that would suit users with differing disabilities.

For lifting platforms, control devices should generally conform to the requirements of Part M(3), and the requirements of prEN 81-41(10) for enclosed lifting platforms and to BS 6440: 1999(8) for non-enclosed lifting platforms.

For stairlifts, control devices should conform to the requirements of BS EN 81-40: 2010(9).

Specially adapted operating devices, switches and sensors may be required to suit individual users. Dual controls to the platform may be required in certain situations. A key switch, electronic card or similar means may be necessary to restrict the use of the lifting device to authorised users in some environments.

For passenger lifts, BS EN 81-70 provides guidance on control devices and signals, including keypads and extra large control devices, see Appendix 11.A1.

11.5.6 Location

The proposed location of the equipment should be checked for suitability, for example:

— the installation of a stairlift does not obstruct normal activities in and about the building

— the location and proposed supporting structure will be strong enough to support a lifting device

— there is an unobstructed manoeuvring space of 1500 mm by 1500 mm (public access) or 1200 mm by 1200 mm (private domestic use), or a straight access route at least 900 mm wide.

11.5.7 Duty cycle

The anticipated maximum number of journeys per hour for a passenger lift is unlikely to be a problem as most passenger lifts are capable of 90 starts per hour. For lifting platforms and stairlifts, the anticipated maximum number of journeys per hour should be agreed between the purchaser and the supplier. Care should be taken to ensure the equipment is fit for its purpose with respect to the anticipated duty cycle.

11.5.8 Alarm system

New passenger lifts are fitted with an alarm system that connects to a rescue service. Existing passenger lifts without a remote alarm system should be considered for upgrading. On fully enclosed lifting platforms, users should have available a device which allows two-way voice communication.

11.5.9 Type of wheelchair

Consideration should be made to the type of wheelchair that is likely to require transportation, whether it is a manual wheelchair to BS EN 12183: 1999(11), or a Class A, B or C electric wheelchair to BS EN 12184: 1999(12).

The minimum sizes of lifting devices required to meet these requirements are given in section 11.7.3.

In some locations, such as shopping centres, specially adapted electric wheelchairs are available, with baskets at the front and rear, that can have a combined length of over 1700 mm. These are larger than the standard sizes indicated above and appropriately sized lifting devices should be provided.

11.6 Environmental considerations

The environment in which a lifting device is installed should be carefully planned. Below are some considerations (reference should be made to Building Regulations Approved Document M(3) and BS 8300: 2009(2) for specific detail):

— signs indicating the location of a lifting device should be clearly visible in all buildings

— signs should identify each floor; these should be designed to contrast visually with the surroundings and be easily seen from the lifting device

— stairs should always be provided as an alternative means of vertical access designed to suit ambulant disabled people and those with impaired sight

— ramps of suitable gradient may be appropriate on an internal circulation route if a change of level is unavoidable

— the location of lifting platforms and stairlifts should not restrict the means of emergency access or egress

— equipment should be easily accessible for maintenance of lifting platforms and stairlifts

— fully enclosed lifts should be provided with audible and visual indication of their arrival at a landing, both in the car and on the landing

- materials should not be used in the surroundings or in the equipment that are likely to cause allergic reactions, e.g. metals (nickel, chromium, cobalt), plastic wallpapers, thick carpets etc.
- adequate lighting (>50 lux) should be provided on all routes accessing lifting devices
- adequate lighting (>50 lux) should be provided in all lifting devices
- reflective surfaces should be avoided
- colour/tone contrasting surfaces should be employed, e.g. to distinguish landing and lifting device floors and entrances
- landing and lifting device floors should have similar surface characteristics, e.g. texture, frictional (non-slip) characteristics.

11.7 Equipment provision

It is not intended in this section to repeat the provisions of Approved Document M[3] or to recite parts of the applicable standards. This section concentrates on the selection, location and installation of the equipment to provide transportation facilities for disabled people.

11.7.1 Provision to the Machinery Directive or the Lift Directive

New passenger lifts should be in compliance with the Essential Heath and Safety Requirements (EHSRs) of the Lifts Regulations 1997[13] enacting the European Lifts Directive[14]. Because lifts are classed as special machinery the EHSRs of the Supply of Machinery Regulations 2008[15] also apply, where appropriate. The usual route to achieve conformity is for the installer to provide a lift that is suitable for use by disabled people, by compliance with the relevant harmonised standards. Alternatively, an EC-type examination certificate can be obtained for a model lift from a notified body.

All new passenger lifts should bear CE-marking applied by the installer before they are placed in service. At the same time a test document is completed and a copy may be provided to the owner/operator together with a declaration of conformity. A suitable test document is BS 8486-1/2: 2007[16,17].

Lifting platforms and stairlifts are classed as machines and should comply with the Supply of Machinery Regulations 2008[15] under the European Machinery Directive[18]. As these lifting devices transport people, there are particular Essential Health and Safety Requirements (EHSRs) indicated in chapter 6 of the Machinery Directive. The main characteristic that distinguishes a lift under the Machinery Directive from lifts under the Lifts Directive is the rated speed, which should not exceed 0.15 m/s.

To comply with European directives a CE-mark should be applied by the manufacturer against a model approval certificate. All the applicable product standards require a test and examination document to be completed by the supplier immediately on completion of the installation and before first use. It is recommended that a copy of this document is given to the owner/end user together with the operating instructions.

11.7.2 Passenger lifts

Passenger lifts are the preferred lifting device under Approved Document M[3]. The applicable standards for passenger lifts are:

- BS EN 81-1: 1998[19] for electric traction lifts
- BS EN 81-2: 1998[20], including amendments A1, A2 and A3, for hydraulic lifts

plus:

- BS EN 81-28: 2003: *Remote alarms on passenger and goods passenger lifts*[21]
- BS EN 81-70: 2003: *Accessibility to lifts for persons including persons with disabilities*[1]
- BS EN 81-71: 2005: *Vandal resistant lifts*[22]
- BS EN 81-72: 2003: *Firefighters lifts*[23]
- BS EN 81-73: 2005: *Behaviour of lifts in the event of fire*[24].

The passenger carrying unit is a car completely enclosed by walls, floor and roof, running in a well enclosure that may be totally or partially enclosed. The entrance doors may be manually or automatically operated, although the latter are more suitable for use by persons with disabilities. The passengers can select their destination on the car operating panel after which no further passenger actions are required.

Where a single lift is installed, it would be wise to ensure that it complies with all the relevant standards for use by persons with disabilities. Where more than one lift is installed, reasonable provision should be made and not all the lifts need be suitable for such use. However, best practice would be to provide as much flexibility of use as possible.

The dimensions of passenger lifts are defined in BS EN 81-70: 2003[1]. The smallest suitable size is 1000 mm by 1250 mm (minimum rated load of 450 kg), which can accommodate a single wheelchair, without a companion. A summary of other suitable car dimensions and rated loads is given in Table 11.1.

Figure 11.1 illustrates the main dimensions and features of a passenger lift to meet the requirements of BS EN 81-70. Although the clear opening width of the entrance doors is shown as 800 mm, this is a minimum and larger openings, e.g. 900 mm should be considered.

Existing lifts may have been installed to earlier versions of EN 81, or even BS 2655 and BS 5655. To meet the requirements of the Disability Discrimination Act 1995[5,6], some or all lifts in a building may need to be upgraded. Full compliance with BS EN 81-70 may be impossible. For example, it may not be possible to position the car operating panel 400 mm from a return wall. In such cases 'reasonable provision' should be made to comply as closely as possible. To show due diligence, the reasons for any deviations should be recorded in the Access Statement[4].

Table 11.1 Lift car dimensions

Type	Minimum car dimensions*	Accessibility level	Remarks
1	Load: 450 kg Car width: 1000 mm Car depth: 1250 mm	Accommodates one wheelchair user	Type 1 ensures accessibility to persons using a manual wheelchair described in BS EN 12183[11], or electrically powered wheelchair of class A described in BS EN 12184[12].
2	Load: 630 kg Car width: 1100 mm Car depth: 1400 mm	Accommodates one wheelchair user and an accompanying person	Type 2 ensures accessibility to persons using a manual wheelchair described in BS EN 12183[11] or an electrically powered wheelchair of classes A or B described in BS EN 12184[12]. Class B wheelchairs are intended for some indoor environments and capable of navigating some outdoor obstacles.
3	Load: 1275 kg Car width: 2000 mm Car depth: 1400 mm	Accommodates one wheelchair user and several other users. It also allows a wheelchair to be rotated in the car	Type 3 ensures accessibility to persons using a manual wheelchair described in BS EN 12183[11] or an electrically powered wheelchair of classes A, B or C described in BS EN 12184[12]. Class C wheelchairs are not necessarily intended for indoor use but are capable of travelling over longer distances and navigating outdoor obstacles. Type 3 provides sufficient turning space for persons using wheelchairs of classes A or B, and walking aids (walking frames, roller frames etc.).

* Car width is the horizontal distance between the inner surfaces of the structural walls, measured parallel to the front entrance. Car depth is the horizontal distance between the inner surfaces of the structural walls, measured perpendicular to the width.

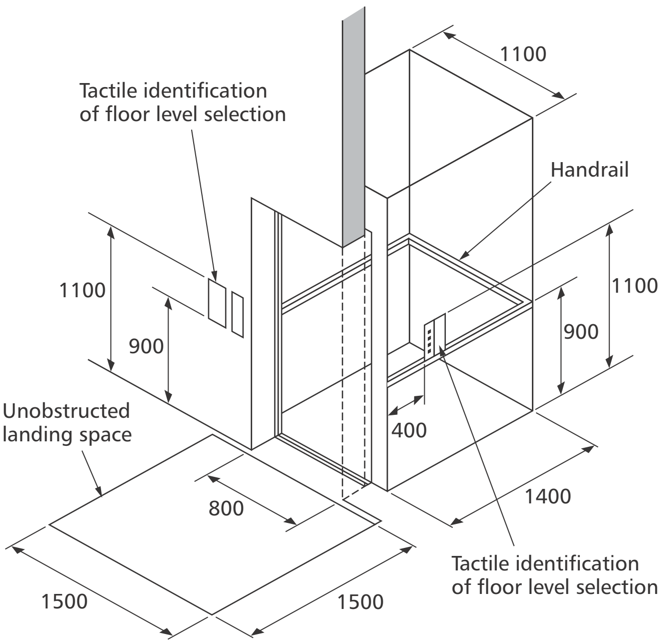


Figure 11.1 Principal features of a passenger lift for use by persons with limited mobility

It should be noted here that existing lifts do not have to be retrospectively upgraded to the latest lift standards. However, BS EN 81-80: *Rules for the improvement of safety of existing passenger and goods passenger lifts*[25], which is not a harmonised standard, draws owners attention to the importance of reviewing the safety of existing lifts.

11.7.3 Lifting platforms

Where passenger lifts cannot be installed then a lifting platform may be considered. Lifting platforms can be installed with a minimal loading demand and structural alterations on a building. This is an advantage for installations into new and existing buildings.

Standards applicable to vertical lifting platforms are:

— for lifting platforms with enclosed liftways: prEN 81-41: *Vertical lifting platforms intended for use by persons with impaired mobility*[10] (under development and yet to be published)

— for lifting platforms with non-enclosed liftways: BS 6440: 1999[8].

Due to the restricted operating speed of lifting platforms, consideration should be given to a maximum travel distance of 10 m.

Lifting platforms have a maximum rated load of 500 kg.

Lifting platforms are designed particularly to transport wheelchairs. This determines the minimum platform sizes as given in prEN 81-41[10] and BS 6440: 1999[8]; these are summarised in Table 11.2.

The maximum platform area that is permitted is 2.0 m^2, excluding hand rails.

For lifting platforms with straight on/off configuration doors/gates should have a minimum 800 mm effective clear width. For lifting platforms with adjacent entry configuration (minimum useable platform size 1100 mm by 1400 mm) doors/gates should have a minimum 900 mm effective clear width.

Lift operation controls has been a topic of much discussion. The Supply of Machinery Regulations 2008[15] (which implement the Machinery Directive[18]) now confuses the situation as regards controls at landing and in the carrier. Section 6.2 clearly indicates carrier controls should be of the 'hold to run' type, whilst section 6.4.2 has a requirement which, in order to comply and not leave the carrier stranded between floors, requires that non-hold to run controls should be used at landings. As far as users with disabilities are concerned, the operation of lifts is made much easier through the use of non-hold to run controls. It is recommended that non-hold to run controls are used throughout providing that the design of the machine and its application does not decrease the operational safety. Where, for example, the product is used in a school environment or an open public area without any key locking then the inherent safety of hold to run controls should be adopted at all control stations without exception (even though this may be considered contrary to the Machinery Directive) .

The lifting platform should only be allowed to travel under the direct control and sight of the operator, this is particularly important with non-enclosed lifting platforms.

Carrier and landing call stations should be positioned such that the centreline of the lowest button is a minimum of 900 mm from the floor and the highest button is a maximum of 1100 mm to its centreline above the floor. All controls should be located to give a minimum lateral space between the centre lines of any buttons to a corner in the platform or outside the landing of 400 mm from any return wall (reference prEN 81-41[10]). Currently these control requirements are not aligned with those in Approved Document M[3].

There are six common types of drive system. These are rack and pinion, rope or chain, screw and nut, friction/traction, guided chain, and hydraulic. The most common types used are hydraulic, and screw and nut.

11.7.3.1 Lifting platforms with enclosed liftways

The minimum dimensions of enclosed lifting platforms are given in Table 11.2.

Figure 11.2(a) illustrates a lifting platform where there is a total enclosure at the lower level and a full enclosure at the upper level, and Figure 11.2(b) shows a partial enclosure at the upper level. The height of the upper enclosure including the door is dependent on the travel. For up to three metres travel, the height of the enclosure and door should be at least 1.1 m and, for travel over three metres, the height of the enclosure and door should be at least 2.0 m (reference prEN 81-41[10]).

Consideration should be given to the use of powered doors (which, if used, causes the position of the landing call station to be remote from the door). Vision panels are required on all doors; the size and design of the glazed area may be influenced by factors such as modesty screening, visual impairment, aesthetics and fire protection requirements.

If the lifting platform penetrates a fire separation barrier, the liftway enclosure may require fire protection. This is normally constructed by others in the form of an additional external shaft or shell to the liftway to give the required fire rating. The external shell requires careful detail of the closing to the fire door frame of the liftway enclosure together with other unprotected areas of the liftway enclosure.

11.7.3.2 Lifting platforms with non-enclosed liftways

Non-enclosed lifting platforms are often installed to overcome changes in level, with a travel distance that is no more than 3.0 m. Non-enclosed lifting platforms have the benefit of minimal impact on the building design, preventing the lift dominating the built environment whilst being obvious in its presence for those who need to use it. They are quickly and simply installed with a minimum of disruption to existing buildings.

These platforms can be used by all manner of persons, handicapped in the use of other vertical circulation devices (stairs, ramps etc.) for many different reasons (e.g. physical handicap, objects being carried, responsible for others etc.). It should be recognised that the designed solution may need to provide safe access onto and from the lift as well as transit between levels for all these conditions, many of which may be unforeseen. The design of the lift should take into account all conceivable impairments, encumbrances and situations which could be foreseen.

Table 11.2 Minimum dimensions of lifting platforms

Principal use	Minimum useable plan dimensions (width × depth)
Type A and B wheelchairs with an attendant and adjacent entrances	1100 mm × 1400 mm
Type A and B wheelchairs with an attendant	900 mm × 1400 mm
Lone user, either standing lone or in a type A wheelchair	800 mm × 1250 mm

Note: for non-enclosed lifting platforms, the minimum width of 800 mm may be reduced to 750 mm

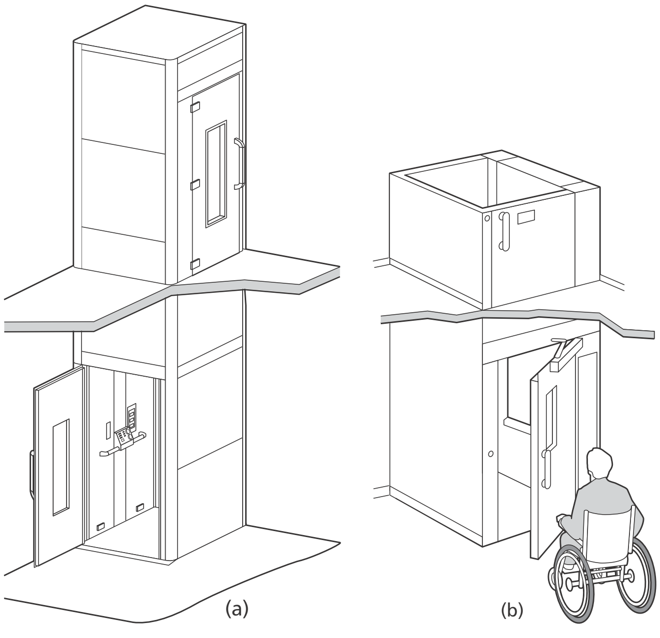


Figure 11.2 Illustration of a lifting platforms with (a) fully enclosed liftway (b) partially enclosed upper enclosure

Attention should be paid to the safe running clearances required to the platform as detailed in BS 6440: 1999[8].

Public access situations

The minimum dimensions of non-enclosed or partially enclosed lifting platforms are given in Table 11.2.

Figure 11.3 illustrates two examples of lifting platforms with non-enclosed liftways.

The platform construction should include 1100 mm high protection on all sides including access sides. On platforms travelling over 1 m, the platform protection should be in-filled such that it does not allow a 100 mm sphere to pass through any openings in the guarding. Upper level protection should consist of an interlocked imperforate gate to a height of 1100 mm. Adjacent balustrades should be designed to close to the gate frame without leaving any gaps greater than 100 mm.

Domestic situations

Where the non-enclosed lifting platform is to be used in a domestic environment for an identified wheelchair user then protection to the platform should be as follows:

— for travel up to 500 mm, access and non-access sides that are not protected by a flush full height adjacent surface should be protected from wheelchair roll-off by a minimum 100 mm high guarding

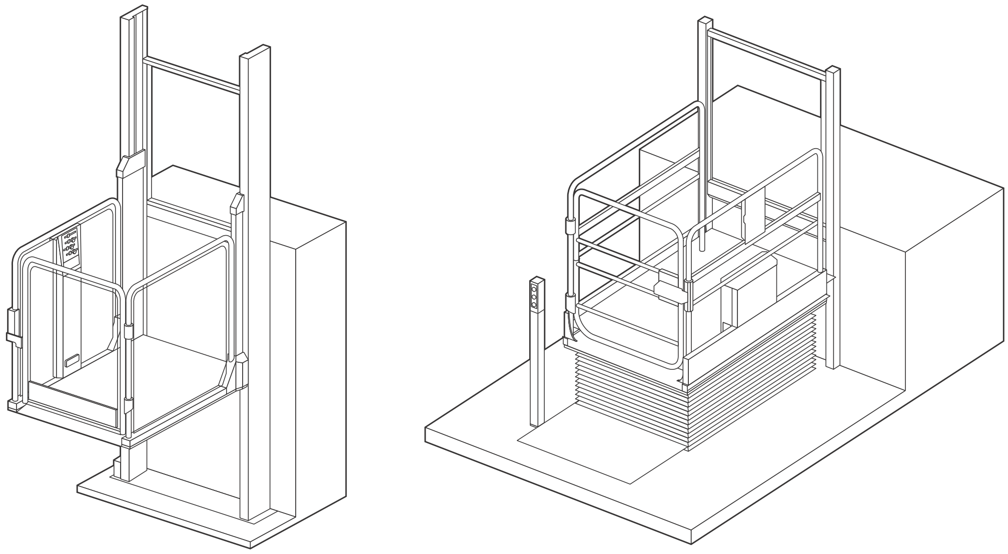
— for travels between 500 mm and 1000 mm, non-access sides which are not protected by a smooth full height adjacent surface should be protected with a 900 mm high guard rail; lower access sides should be protected by a minimum 100 mm high guarding.

The above two options require that the user is seated and that the lift is protected against unauthorised use by some form of key locking.

For travels above 1000 mm protection to access and non-access sides of the platform should be as for public access situations.

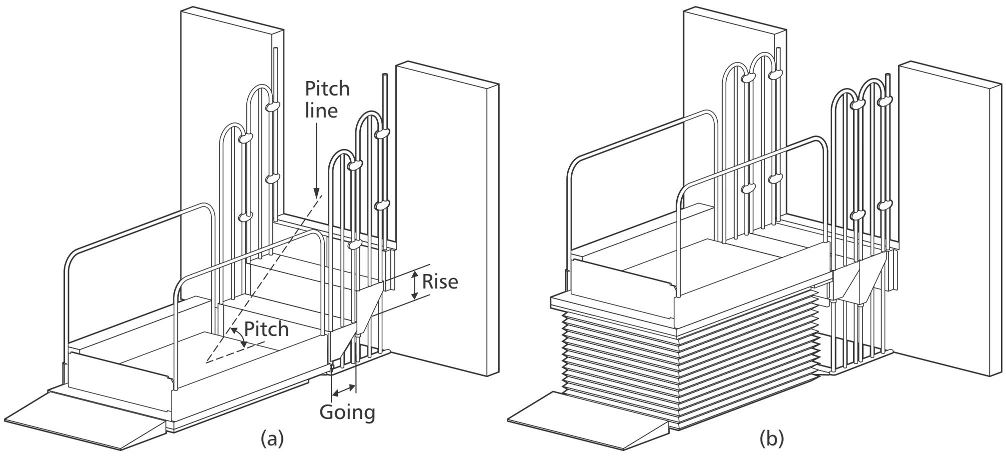
Note: the smooth full height adjacent surface should be a minimum of 1100 mm above the upper landing level.

The lower level guarding to the platform access sides often folds down to provide part of an access ramp.



(a) (b)

Figure 11.3 Lifting platforms with non-enclosed liftways; (a) cantilever type with under-surface protection, (b) scissor type with bellows protection



(a) (b)

Figure 11.4 Lifting platform with bridging step system; (a) lower position, (b) raised position

Upper level protection is required when the step height from the lifting platform floor and the upper landing is greater than 220 mm. This protection can either consist of an upper level gate, or a bridging step system (see Figure 11.4).

11.7.4 Domestic 'through the floor' lifting platforms

With today's enlightened emphasis on design in the home for lifetime living, the use of a through the floor lift enables users with many disabilities to continue to enjoy their own home environment. The flexibility of design of the wheelchair through the floor lift means that it can be used by a semi-ambulant user (fold down seat) providing wheelchair lifting facility later in the user's life. Smaller car sizes are available for seated only users with no wheelchair requirements.

Where stairlifts are unsuitable due to the staircase space and geometry, or where the user's disability makes the use of a stairlift impracticable (e.g. the user is wheelchair dependent), the through the floor lift provides an excellent alternative. Through-floor lifts are for seated use only, the seat being provided by either a wheelchair or integral seat (fold down or fixed) a variety of carriage sizes are available to suit either seated or wheelchair users.

These lifts provide the following benefits:

- small 'footprint'
- no enclosure, giving optimal space utilisation; the lift can be parked at the opposite floor to that being used, thus freeing-up circulation space
- minimalistic design
- low cost in use
- simplicity of operation
- maintains user's independence and dignity.

The applicable standard for vertical lifting platforms for domestic use is BS 5900: 1999[26].

BS 5900 specifies requirements for the design, construction, and installation of powered domestic lifts that are designed for use by persons with impaired mobility travelling between fixed floor levels in private dwellings. It applies to lifts that serve two floors only and that have partially enclosed cars without lift-well enclosures.

The lifting platform can have a rated speed up to 0.15 m/s and a maximum rated load of 500 kg. The size of the lifting platform is not defined, except that its width should not be less than the clear entrance width. The clear entrance width is a minimum of either 500 mm to accommodate a standing or sitting person, or 650 mm to accommodate a wheelchair. The most common type of drive is direct acting hydraulic which has many inherent safety features.

The passenger carrying unit is a partially enclosed car that runs in a totally open space, see Figure 11.5. It has many safety features that make it, by design, as safe as an enclosed car.

A key factor in the specification of both lift type and controls is the capability of the user. Advice is often provided by healthcare professionals on both the current and future needs of the user. It is important that this consideration is made at the outset of specifying the equipment. A variety of control systems are available to suit the broad range of needs in the disabled community. Simplicity without compromising safety should always be adopted, to which end 'push and go' controls lend themselves in many situations.

11.7.5 Stairlifts

Another popular aid in overcoming obstacles to vertical circulation are stairlifts. There are three types of stairlifts: wheelchair platform, chair stairlifts and standing (perch) stairlifts, see Figure 11.6.

The wheelchair stairlift is suitable for use in both public and domestic environments whereas the chair and standing stairlifts should only be used in domestic situations.

The applicable standard for stairlifts is BS EN 81-40: 2008: *Safety rules for the construction and installation of lifts. Special lifts for the transport of persons and goods. Stairlifts and inclined lifting platforms intended for persons with impaired mobility*[9].

A stairlift runs up the side of a stairway and care should be taken neither to obstruct normal circulation on the stair for other users nor to obstruct the means of escape in an emergency. Stairlifts can follow the contour of the stairwell and can be provided with extended travel at the ends of the stair to enable easy boarding/alighting and parking. Alternatively a swivel seat can assist the safe transfer of the user on and off the stairlift. Most stairlifts provide travel across one flight of stairs, but some

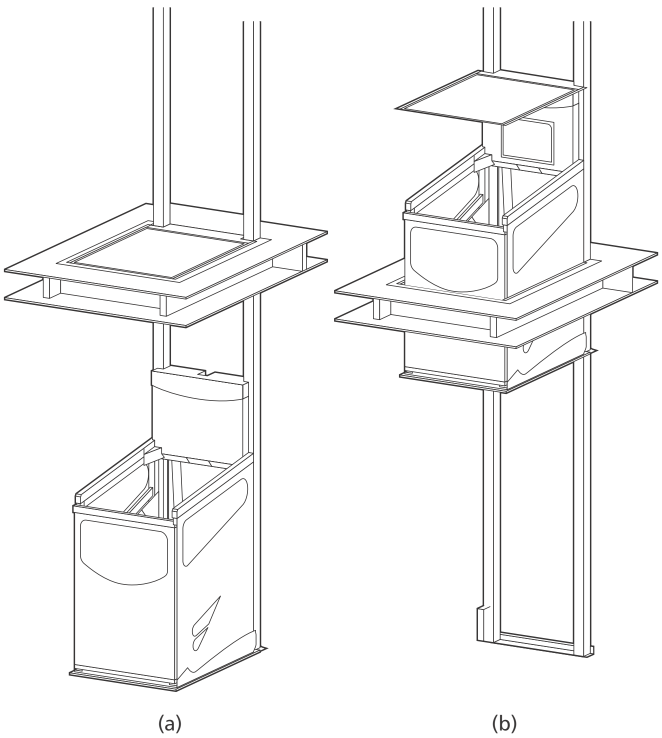


Figure 11.5 Illustrations of a domestic lifting platform

stairlifts, particularly in private dwellings, cover several flights. Boarding/alighting points are usually provided at each landing.

Chair and standing stairlifts place only a small load on the building structure and can be installed relatively inexpensively. Wheelchair platform stairlifts require more consideration on the structural implications due to the higher imposed loads. The maximum rated speed of all stairlifts is 0.15 m/s and should always be equipped with hold to run controls.

Six types of drive systems are available: rope suspension, rack and pinion, chain, screw and nut, friction/traction, and ball and rope.

Wheelchair platform stairlifts

Wheelchair platform stairlifts are the last choice lifting device under Approved Document M in public buildings, see Figure 11.6(a).

The platform size when installed in buildings with public access is required to be 800 mm wide by 1250 mm long. For installations in private dwellings the width can be reduced to 700 mm. Their location should be chosen carefully (see section 11.5.6).

Wheelchair platform stairlifts are designed for a minimum rated load of 250 kg/m^2 of the clear loading area.

Stairlifts for seated persons

Stairlifts for seated persons have a rated capacity for one person, i.e. a rated load not less than 115 kg. A range of dimensional adjustments to the stairlifts various components are available to suit the user, see Figure 11.6(b).

Stairlifts for standing persons

Stairlifts for standing persons, see Figure 11.6(c), have a rated capacity for one person, i.e. a rated load not less than 115 kg. The minimum dimensions of the platform are 325 mm by 350 mm. These lifting devices are only suitable for private dwellings.

11.8 Escalators and moving walks

Lifts are the preferred method of vertical travel for wheelchair users and persons with assistance dogs, but wheelchair users can generally use horizontal moving walks and inclined moving walks with an inclination of up to 6°, either unaided or with a companion. Moving walks with inclinations greater than 6° and escalators are not suitable for use by persons with assistance dogs (unless the dogs are carried), or by wheelchair users. Their use in this way is unsafe for the disabled user and is a risk to able bodied users travelling with them. Signs should be provided to indicate the location of alternative facilities, which should be situated nearby.

Escalators can be used safely by many persons with disabilities. Some guidance is given in BS 5656-2[27].

11.9 Egress for persons with disabilities

A great deal of attention has been paid to making buildings accessible to everyone and enable circulation around the building (see chapter 2), but little attention has been given to how to enable people to escape in an emergency. In the UK, lifts should not be used for escape from fire, regardless of lift type or building height. The able bodied use the escape stairs provided. In well managed public buildings, people with disabilities are recommended to assemble in 'refuge spaces' placed on or close to each floor, and await rescue. Rescue may then be manually achieved using an evacuation chair. In domestic situations, it may be necessary that an upper level room is specified to form a refuge.

The only lifts in a building that can be used during a fire are the specially designed firefighting lifts to BS EN 81-72: 2003: *Firefighters lifts*[23] and evacuation lifts to BS 9999: 2008: *Code of practice for fire safety in the design, management and use of buildings*[28]. See also chapter 5, section 5.9.2 and chapter 6, section 6.5.

BS 9999: 2008 deals with such elements as refuges, stairways, ramps, lifts, signs and the use of lifts to evacuate people with disabilities. A firefighting lift can be used, under the supervision of the building management, to

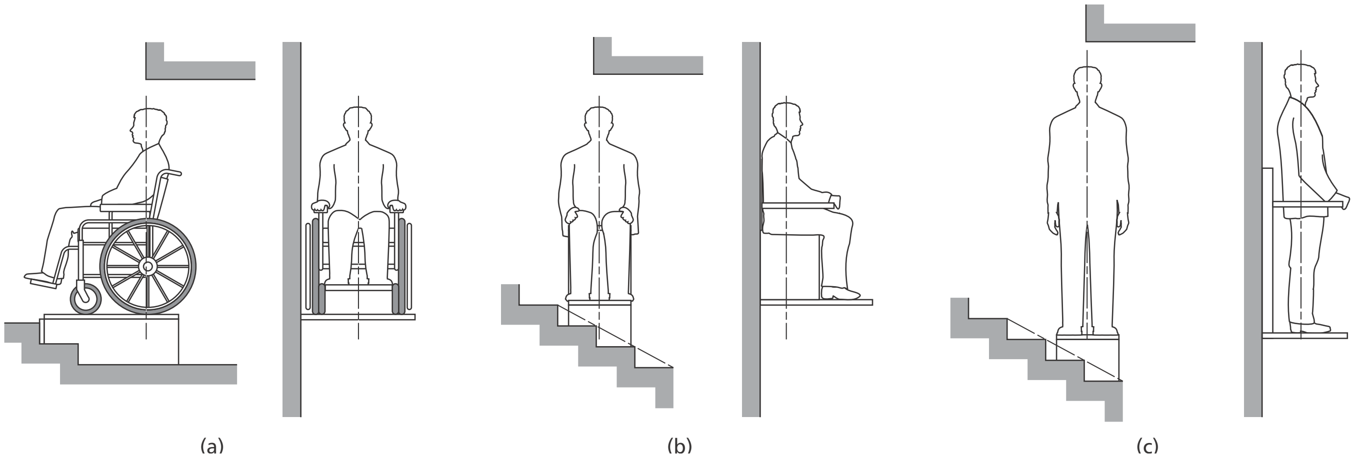


Figure 11.6 Types of stairlift; (a) wheelchair, (b) seated, (c) standing

evacuate people with disabilities until the arrival of the fire service, who may then assume responsibility for the evacuation of any remaining persons.

Evacuation lifts are being provided to BS 9999 in many public facilities such as sports stadia, entertainment centres, public halls etc., where large numbers of people with disabilities are expected. The lift should be used routinely as a passenger lift (not for goods) and should always be available. The specification for an evacuation lift is similar to, but not the same as, a firefighting lift. For example, an evacuation lift cannot be used as a firefighting lift.

In private domestic dwellings, where a through the floor lift is installed, the upper level refuge should have the integrity of its fire protection preserved, no matter where the lift is parked.

11.10 Selection of lifting devices

Table 11.4 provides a summary of the different types of lifting devices available for the transportation of people with disabilities. It is recommended that the detailed text in this chapter be consulted and that the appropriate standard(s) be obtained when considering a specific design. Specialist assistance may be necessary.

References

1 BS EN 81-70: 2003: *Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts. Accessibility to lifts for persons including persons with disability* (London: British Standards Institution) (2003)

2 BS 8300: 2009: *Design of buildings and their approaches to meet the needs of disabled people. Code of practice* (London: British Standards Institution) (2009)

3 *Access to and use of buildings* Building Regulations Approved Document M (London: NBS/RIBA Enterprises) (2004) (available at http://www.planningportal.gov.uk/england/professionals/buildingregs/technicalguidance/bcaccesstopartm/bcapproveddocuments10) (accessed July 2010)

4 Disability Rights Commission *Access Statements: Achieving an inclusive environment by ensuring continuity throughout the planning, design and management of buildings and spaces* (London: Disability Rights Commission) (2004)

5 Disability Discrimination Act 1995 (London: Her Majesty's Stationery Office) (1995) (available at http://www.opsi.gov.uk/acts/acts1995/ukpga_19950050_en_1) (accessed June 2010)

6 Disability Discrimination Act 1995 (Amendment) Regulations 2003 Statutory instruments 2003 No. 1673 (London: The Stationary Office) (2003) (available at http://www.opsi.gov.uk/si/si2003/20031673.htm) (accessed June 2010)

8 BS 6440: 1999: *Powered lifting platforms for use by disabled persons. Code of practice* (London: British Standards Institution) (1999)

9 BS EN 81-40: 2008: *Safety rules for the construction and installation of lifts. Special lifts for the transport of persons and goods. Stairlifts and inclined lifting platforms intended for persons with impaired mobility* (London: British Standards Institution) (2008)

Table 11.4 Summary of lifting devices suitable for the transportation of people with disabilities

Lifting device	Travel	Rated speed (m/s)	Rated load (kg)	Platform size (mm) (width × depth)	Applicable standards	Relative cost
			Buildings other than dwellings			
Lift	Unlimited (typical = full travel)	0.4–6.0 and higher	450	1000 × 1250	BS EN 81-1: 1998 BS EN 81-2: 1998 BS EN 81-28: 2003 BS EN 81-71: 2003 BS EN 81-70: 2005 BS EN 81-72: 2003 BS EN 81-73: 2005	High
			630	1100 × 1400		
			1275	2000 × 1400		
			1600	2100 × 1600 and larger		
Lifting platform	Unlimited (typical = 6.0 m)	0.15 (max.)	205 (min.) 500 (max.)	800 × 1250 900 × 1400 1100 × 1400	prEN 81-41: 2009 BS 6440: 1999	Medium
Wheelchair stairlift	Unlimited (typical = flight of stairs)	0.15 (max.)	150 (min.) 350 (max.)	800 × 1250	BS EN 81-40: 2009	Low
			Dwellings			
Lift	As above	As above	As above	As above	As above	As above
Domestic 'through the floor' lifting platform	Two storeys (typical = 3.0 m)	0.15 (max.)	200 (min.) 500 (max.)	Various, to suit user requirements and building constraints	BS 5900: 1999	Medium
Wheelchair stairlift	Unlimited (typical = flight of stairs)	0.15 (max.)	150 (min.) 350 (max.)	700 × 900 750 × 1000 800 × 1250	BS EN 81-40: 2009	Medium
Seated stairlift	Unlimited (typical = flight of stairs)	0.15 (max.)	115 (min.)	N/A	BS EN 81-40: 2009	Lowest
Standing stairlift	Unlimited (typical = flight of stairs	0.15 (max.)	115 (min.)	325 × 350	BS EN 81-40: 2009	Lowest

Note: any variation from a harmonised standard, e.g. rated load, requires notified body approval

10 prEN 81-41: 2009: *Safety rules for the construction and installation of lifts. Special lifts for the transport of persons and goods. Vertical lifting platforms intended for use by persons with impaired mobility* (provisional standard under development) (Brussels: European Committee for Standardization) (2009)

11 BS EN 12183: 2009: *Manual wheelchairs. Requirements and test methods* (London: British Standards Institution) (2009)

12 BS EN 12184: 2009: *Electrically powered wheelchairs, scooters and their chargers. Requirements and test methods* (London: British Standards Institution) (2009)

13 The Lifts Regulations 1997 Statutory Instruments 1997 No. 831 (London: The Stationery Office) (1997) (available at http://www.opsi.gov.uk/si/si1997/19970831.htm) (accessed June 2010)

14 European Parliament and Council Directive 95/16/EC of 29 June 1995 on the approximation of the laws of the Member States relating to lifts ('The Lifts Directive') *Official J. of the European Communities* **L213** 1–31 (7.09.1995) (available at http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/lifts/index_en.htm) (accessed May 2010)

15 The Supply of Machinery (Safety) Regulations 2008 Statutory Instruments 2008 No. 1597 (London: The Stationery Office) (2008) (available at http://www.opsi.gov.uk/si/si2008/uksi_20081597_en_1) (accessed June 2010)

16 BS 8486-1: 2007: *Examination and test of new lifts before putting into service. Specification for means of determining compliance with BS EN 81. Electric lifts* (London: British Standards Institution) (2007)

17 BS 8486-2: 2007: *Examination and test of new lifts before putting into service. Specification for means of determining compliance with BS EN 81. Hydraulic lifts* (London: British Standards Institution) (2007)

18 Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast) ('The Machinery Directive') *Official J. of the European Union* **L157** 24–63 (9.6.2006) (available at http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/machinery/index_en.htm) (accessed May 2010)

19 BS EN 81-1: 1998 + A3: 2009: *Safety rules for the construction and installation of lifts. Electric lifts* (London: British Standards Institution) (1998/2009)

20 BS EN 81-2: 1998 + A3: 2009: *Safety rules for the construction and installation of lifts. Hydraulic lifts* (London: British Standards Institution) (1998/2009)

21 BS EN 81-28: 2003: *Safety rules for the construction and installation of lifts. Remote alarm on passenger and goods passenger lifts* (London: British Standards Institution) (2003)

22 BS EN 81-71: 2005: *Safety rules for the construction and installation of lifts. Particular applications to passenger lifts and goods passenger lifts. Vandal resistant lifts* (London: British Standards Institution) (2005)

23 BS EN 81-72: 2003: *Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts. Firefighters lifts* (London: British Standards Institution) (2003)

24 BS EN 81-73: 2005: *Safety rules for the construction and installation of lifts. Particular applications for passenger and goods passenger lifts. Behaviour of lifts in the event of fire* (London: British Standards Institution) (2005)

25 BS EN 81-80: 2003: *Safety rules for the construction and installation of lifts. Existing lifts. Rules for the improvement of safety of existing passenger and goods passenger lifts* (London: British Standards Institution) (2003)

26 BS 5900: 1999: *Specification for powered domestic lifts with partially enclosed cars and no lift-well enclosures* (London: British Standards Institution) (1999)

27 BS 5656-2: 2004: *Escalator and moving walks. Safety rules for the construction and installation of escalators and moving walks. Code of practice for the selection, installation and location of new escalators and moving walks* (London: British Standards Institution) (2004)

28 BS 9999: 2008: *Code of practice for fire safety in the design, management and use of buildings* (London: British Standards Institution) (2008)

Appendix 11.A1: Summary of the principal requirements of BS EN 81-70

This appendix provides a short summary of the principal requirements of BS EN 81-70[1] when applied to BS EN 81-1/2[19,20] lifts. Some of the concepts may be useful when considering other transportation facilities for disabled people.

BS EN 81-70 provides recommendations for passenger lifts, constructed to the BS EN 81 series of standards, relating to the design and positioning of fittings, controls and indicating equipment as well as the use of materials to maximise contrasts between controls and doors and the surrounds. The primary aim is to ensure that the design does not obstruct or impede the use of the lift by disabled people and to enable the unassisted use of lifts by all people including those with disabilities.

The landing area should be free of obstacles and sufficiently large to allow the free movement of persons, wheelchairs and accompanying persons, when entering or leaving the lift car with landing call buttons positioned 900 mm to 1100 mm above the floor level.

The lift should be able to provide a stopping accuracy of ±10 mm and a levelling accuracy of ±20 mm.

Automatic doors should be at least 800 mm clear width and protected with full height non-contact, infrared (or similar) safety edges (see section 7.8.6).

It is important, particularly on groups of lifts, that the door operation allows suitable dwell times for passenger who may have restricted mobility, to reach and enter the lift and an adjustable dwell time between 2 and 20 seconds should be provided accordingly. Typically this is set to 5 seconds. (It should be noted that extended dwell times will have a significant effect on the traffic handling capacity of a lift system (see section 3.7.1). This can result in increased costs to install extra equipment or the need to provide special signalling to enable anyone to call a lift with extended door dwell times.)

Control features such as advanced door opening should be avoided in hospitals and nursing homes or other environments where wheelchairs or trolleys etc. could be inconvenienced by the momentary presentation of a ledge as the doors open approaching floor level.

The lift car platform area should be large enough to meet the requirements of all persons. Special considerations may need to be made to accommodate some types of electrically driven wheelchairs.

Light colours are recommended inside the car to reduce the claustrophobic effects of small lifts and to optimise light levels within the car. Colour should be used to provide clear demarcation between the floor of the car and the landing entrance for users with visual impairment.

Functional, easily cleaned surface finishes are recommended, together with a half-height mirror which creates an impression of increased car size. *Note*: full height mirrors can be confusing for visually impaired passengers and therefore there should be a clear band of at least 300 mm between the bottom of a mirror and the floor.

A handrail along one side of the lift is essential together with large, easily operated push buttons. All control buttons in the lift car should be placed at between 900 and 1200 mm (1100 mm preferred) above the lift car floor level, and not less than 400 mm from the front or rear wall. The provision of a tip-up seat improves comfort for the elderly and infirm.

All push buttons should be provided with tactile, and possibly also Braille markings, either on or adjacent to the buttons. Since many visually impaired people are unable to read Braille it is recommended that Braille markings should only be used in addition to tactile markings.

In addition to the visual enhancements, voice synthesised announcements, of sufficient sound level to overcome background noise, should be included to announce door actions (opening and closing) as well as the floor level and direction of travel as the lift arrives at a landing. Emergency signals received from a fire alarm or building management system can also be announced by the voice synthesiser.

The inclusion of inductive loops is required in conjunction with the voice synthesiser and emergency communication unit to assist passengers who use hearing aids.

Provision of a 24-hour communication link is required in accordance with the Lifts Regulations 1997[13]. This is normally satisfied by utilising an auto-dial telephone unit although a new standard, BS EN 81-28[21] now provides additional recommendations on the design and minimum performance requirements of suitable systems. In premises that are attended 24 hours a day, consideration should be given to programming the auto-dial telephone system to call an attended telephone on the premises. This will minimise the possibility of false alarms being registered with the lift maintenance company, and also improve the response time to make a direct contact with any trapped passengers, enabling reassurance to be provided until release can be effected.

In environments where the lifts may be used by elderly or infirm passengers such as nursing homes, the use of an additional alarm push button mounted at low level should be considered. This will enable access to the alarm facility for passengers that may have fallen or collapsed in the lift car.

When designing lifts to provide access for persons with disabilities, reference should be made to Building Regulations Approved Document M[3].

12 Electrical systems and environmental conditions

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Section contents

12 Electrical systems and environmental conditions

12.1 Introduction

In designing a new lift system for a given building, the designer must consider not only the interface of the lift system with the building and its users, but also the more particular requirements of the lift system itself in terms of its environment, its dependence upon other services and future maintenance needs. It is important that the designer also considers the environment of those involved in installing, maintaining and inspecting the lift system and builds into the design appropriate features to minimise hazards to such persons.

This chapter provides guidance on the key environmental factors that must be considered during the design process. It should be remembered, however, that the recommendations contained in various regulations and standards covering lift systems, e.g. British Standards, the Lifts Regulations 1997[1] and the Building Regulations[2], often differ. Therefore, careful reference must be made to all the applicable regulations and standards.

The upgrading and modernisation of lifts installed before 1 July 1999 do not fall under the Lifts Regulations and are still subject to BS 5655-11[3] (electric) and BS 5655-12[4] (hydraulic) standards and the upgrading of safety is covered by BS EN 81-80[5]. However, the guidance given in this chapter can be taken as a basis for design.

12.2 Lift power supplies

The provision of power supplies and electrical systems for lifts must be considered in relation not only to the power supplies for the whole building but also to other electrical systems that may interact with the lift installation.

A series of questions needs to be considered to determine how and why good quality power supplies are required to meet the lift demands, followed by further questions to clarify how these requirements will be met in terms of power distribution hardware and its installation. The lift power supplies form part of a more extensive power distribution system and the power requirements of the lifts must be considered in relation to the other users of the system. In addition, the potential operating modes of the power distribution system and the building usage patterns should be investigated to determine how the services in the building are expected to perform when:

— the building is normally occupied

— the building is partially occupied

— the mains power fails

— systems fail or system faults are experienced.

Typical schedules for the electrical system requirements can be drawn up for the lift installation with cross-references to associated services (see Appendix 12.A1, Table 12.A1.1 for the machine room, Table 12.A1.2 for the lift car and Table 12.A1.3 for the lift well). This information should be given to all parties involved in specifying, designing and maintaining the finishes and services for the building. At each interface it should be made clear who is responsible for designing and supplying the relevant equipment and systems. It must also be agreed what facilities are considered essential.

The type of lift drive and associated control equipment will influence the design of the power supply system in terms of the cable distribution requirements, back-up supplies and with respect to the problems of harmonic currents drawn by the lift equipment, see sections 12.7 and 12.8. The design must result in adequately rated supplies to meet all operational demands, including meeting maximum power demands for simultaneous starting and stopping of lift cars.

Firefighting and evacuation lifts are provided with alternative supplies. Such supplies must, wherever possible, be physically protected by being installed along a different route to that of the normal mains supply. Where it is not physically possible to provide an alternative route, mineral insulated copper sheath (MICS) cables with a low smoke and fume (LSF) sheath should be used. Recommendations for compliance are provided in BS 7671: 2008[6] and BS 9999: 2008[7]. Firefighting lifts must also comply with harmonised standard BS EN 81-72[8], which is referenced by BS 9999: 2008.

Specifically, the lift contractor should declare on a schedule values of full load current, starting current and its duration, maximum permissible volt drop, and any other relevant details such as the range of ambient temperatures, e.g 0 °C to 40 °C, to enable the electrical contractor to determine the size of the mains isolating switch. Where an installation has more than one lift supplied from a common feeder, a diversity factor may be applied to the cable size (see section 12.9.1).

Installation methods for lifts may require temporary supplies at both a standard 110 volt (55-0-55 centre tapped to earth) safety supply in accordance with BS 7375[9] and a 400 (–6%, +10%) volt, three-phase supply to be available. The power capacity of the three-phase supply should be such as to allow the lifts to be commissioned and tested. Inadequate power capacity will cause delays and may require re-tests when the correct supply is available. If the lift electricity supply source is changed (e.g. from a temporary construction site supply to the permanent supply for the building) after the lift test then the supply should be tested at the lift isolator and a new supply safety certificate should be issued by the supply installer.

It should be noted that lift equipment is designed to run on the electricity supplies as defined by the lift installer. Installation of voltage regulators that are not approved by the lift equipment manufacturer and similar devices between the mains supply and the lift equipment may cause damage to and failure of lift equipment. In such circumstances, expressed and implied warranties on the lift equipment may be invalidated if the lift equipment installer has not agreed to such modification to the electricity supply.

12.3 Lift power factor correction

It is desirable to keep the power factor of the lift load (whilst the lift is running) greater than 0.9. The need for specific power factor correction equipment is dependant on the type of lift drive. The vast majority of lifts using variable frequency drives do not require additional power factor correction. Lifts using AC motors that are connected directly to the mains power supply can have power factor correction added.

Lifts using variable voltage AC (VVAC) drives and DC static converter drives (SCD) have such a wide range of power factor over the speed and load range that it is practically impossible to provide power factor correction that will bring the power factor up to greater than 0.9 under all load and running conditions.

Power factor correction can be implemented using fixed capacitors or automatic variable power factor units. Installation of this equipment in the machine room or machine space will reduce the kVAr load on the supply cable to the lift, thus possibly allowing a smaller cable to be used. When using automatic power factor correction equipment it is essential to ensure that there is sufficient inductive impedance between the lift and this equipment to prevent voltage notching due to capacitor charging tripping-out the drive protection on lift drives.

Fitting the power factor correction equipment remote from the lift installation may cause overloading of the capacitors due to the inadvertent correction of other loads and possible resonance effects.

It is preferable to apply correction local to the lift installation, if it is necessary.

12.4 Protection of supplies

Lifts must be protected against malfunctions in the power supply feeding the lift installation as shown in Table 12.1.

Table 12.1 Protection of supplies

Fault	Cause
Absence of voltage	Loss of voltage may be due to a system fault where power has been isolated by the operation of a protective device or due to loss of mains supply. On restoring power, the lift should be returned to service automatically. The lift controller must ensure that normal controls and safety devices function correctly when power is restored.
Voltage drop	A drop in voltage may be caused by a weak supply (i.e. high impedance source) and/or a particular mode of operation of plant and equipment in the building. Such conditions may exist when many independent loads are switched at the same time. Table 12.2 provides a checklist to help determine the cause. If the power distribution system for the building is incorrectly designed, the problem may occur every time there is a multiple switching of loads. When correctly designed, the power supply to the lift installation should not suffer a drop in voltage outside the limits agreed with the lift contractor for all modes of operation of all of the services in the building.
Loss of a phase	Loss of continuity of a conductor or loss of a phase can be the result of a broken conductor, or the operation of a single fuse. The lift control equipment should detect this condition and shut down. Normal operation can be resumed when the three-phase supply is restored and any lift control and/or motor protection has been reset.
Phase reversal	This can occur when alterations are made to the main electrical distribution system in a building. Means should be provided to detect an accidental phase reversal where traction motors derive their supply directly from the mains, i.e. not through an inverter.

Table 12.2 Typical schedule of voltage drop checks

Item	Check required	Comments
1	Reliability of external supply	If the supply is subject to voltage fluctuations consider the installation of a voltage stabiliser to feed the lift
2	Operation of other loads on the power distribution system*	Carry out load flow study
3	Operation of other independent loads*	Consider interlocked or sequential starting controls
4	Volt drop on lift feeder cables*	Size cables to ensure that under the worst operating conditions the voltage drop is always within limits agreed with the lift designer

* May require dynamic load flow study of the power distribution system

12.5 Standby power

In many buildings, particularly large ones, standby power supplies are installed to allow some or all of the normal activities of the building to continue and to ensure that the building can be evacuated safely[10]. The cost of providing a standby supply is usually high in relation to its expected operating life. The tendency, therefore, is to keep the standby capacity to a minimum to meet only essential loads.

Essential loads may include firefighting plant, partial or full lighting, consumer power supplies, computer power supplies, lifts, HVAC plant etc. The requirements for standby power will depend, therefore, on which of the services are to remain partially or fully operational during a mains failure.

The load to be imposed on the standby power plant will also vary, depending on when it is called upon to operate, i.e. night or day, winter or summer. It will also vary with any changes of building use. The standby supply must be able to meet all the demands of the dynamic loads (electrical) of the complete distribution system. The general design considerations given in the previous sections should be noted. In addition the following must be provided:

— controlled sequential starting systems for other loads, if necessary

— limited or special-purpose mode of operation of the lifts (if a full service is not required)

— controls for sequential starting of the lifts to limit power demand surges

— effect of lift braking on power demands

— sufficient capacity to absorb regenerative braking or prevent overspeed of the lifts when fully loaded

— where there are several lifts or groups of lifts, the lift supplier should specify the type and number of control cables to be run between lifts for standby supply control purposes.

Any operational restrictions imposed on the lift installation when operating under standby power must be clearly identified and agreed between the lift supplier and the purchaser. The lift supplier should indicate the power capacity of the supply necessary to achieve an agreed level of performance. The characteristic of the lift load also affects the type of alternator and its control. Electronic drives can produce harmonic currents levels that are not compatible with alternators designed to supply lighting loads. The amount of regenerated energy that the lift installation may require the supply to absorb must be clearly identified. It is often necessary to provide additional load on the supply just to absorb this energy because the engine driving the alternator cannot absorb the regenerated energy.

12.6 Isolating switches, lighting and socket outlets

Harmonised standards require that each lift shall have a main switch capable of breaking the supply to the lift on all live conductors at the highest normal load current. Mains isolating switches should be provided at the intake point and in the machine room. They should be lockable in the 'off' position, and readily identified and accessible from the machine room entrance(s). It is common to identify the main switch in multi-lift machine rooms and major lift equipment components by large, clearly visible numbers or letters. On groups of interconnected lifts, it should be possible to isolate an individual lift without affecting the supervisory control of the remainder.

The isolating switch should accept either high rupture capacity (HRC) fuses or an equivalent circuit breaker. The lift manufacturer must provide suitable protection for the lift controller. All such protection devices must be carefully coordinated with the electrical contractor to ensure proper fault clearance discrimination (see BS 5655-6, chapter 8). No form of no-volt trip mechanism should be included anywhere in a lift power supply.

The lifts main switch is dedicated to the lift and it should not isolate:

— the lift car lighting or ventilation

— the lift car roof socket outlet

— the machine or pulley room lighting

— the lift well lighting

— the alarm device (often a dialler powered from a separate supply to that of the lift)

— pit, pulley room or machine room socket outlets.

The lighting supply to the car, machinery space/pulley space, machine room/pulley room and well should be from a circuit separate from the lift power supply (e.g. a nearby distribution board) or taken from a point on the supply side of the mains isolating switch and controlled by a fused switch in the machine room. For multiple lifts with a common machine room, a separate fused switch should be provided to the lighting supply for each car. It is convenient to have two-way or three-way switching on the well lighting with operation points in the machine room and well.

The 13-amp switched socket outlet supply to the machinery space/pulley space, machine room/pulley room and well should be from a circuit separate from the lift power supply (e.g. a nearby distribution board) or taken from a point on the supply side of the mains isolating switch and controlled by a fused switch in the machine room. At least one socket outlet should be provided in each of the following locations:

— machine room

— pulley room

— pit

— car top.

Large machine rooms may warrant several switched 13-amp socket outlets to enable effective maintenance.

These may be 230 V socket outlets, preferably fitted with RCD protection local to the socket, and provide safety extra low voltage (SELV).

It is recommended that a consumer unit be fitted, dedicated to the lift installation's small power and lighting circuits. All isolators and switches must be clearly and indelibly marked and identifiable when viewed from the entrance to the machine space (if directly visible from that point).

12.7 Harmonic distortion

Since lifts present non-linear loads, all lift controllers and their associated motor drives draw non-sinusoidal currents. These include harmonic currents that will generate harmonic voltages on the power distribution system. The magnitude of the harmonic voltages will be dependent on the impedances of the distribution system and of the power source. These harmonic voltages can cause damage to other equipment if they exceed the limits specified by the electricity supply authority or the power system designer.

Lift installations that incorporate solid-state controllers (see sections 8.3.3 and 8.3.4) will draw significant harmonic currents, which must not exceed those permitted by the electricity supply authority. These limits relate to the maximum kVA rating of the device drawing the harmonic current. The Electricity Association's Engineering Recommendation G5/4(11) sets down limits for the magnitude of the individual current harmonics and the voltage distortion. Lifts are also required to comply with harmonised standard BS EN 12015(12).

Where multiple controllers are provided to control multiple lifts, and they are fed from the same supply, an assessment should be made of how the individual harmonic currents for each individual load will add up. However, in determining the total it should be noted that the arithmetic sum of the individual harmonic load currents is modified by a 'coincidence factor'.

In many large installations, harmonic filtering equipment will be needed for the lift controllers to ensure that the harmonic currents drawn do not exceed the supply authority's specified limits. However, filters should not be introduced without considering their adverse effects. For example, under certain load conditions they may cause damage to, or malfunctioning of other equipment connected to the power distribution system, particularly power factor correction capacitors.

Information on the magnitude of the harmonic currents drawn by the lift controllers must be conveyed to the manufacturers of any standby power plant. Failure to do so could cause damage to, and/or malfunctioning of the standby power system.

12.8 Electromagnetic interference

The lift installation will be subject to varying degrees of interference caused by voltage disturbances on the mains power supply (i.e. switching surges), induced voltages in control cabling and radio-frequency interference. The lift installation must not malfunction in an unsafe manner as a result of such interference, no matter how caused.

The system designer has a duty to minimise the possibility of interference being caused to the lift installation while the lift manufacturer is responsible for ensuring that the equipment is properly designed and protected to prevent malfunctioning should any interference occur.

The complete lift installation must comply with the UK Electromagnetic Compatibility Regulations 2005(13), which implement the EMC Directive(14) and product specific requirements relating to the emission of, and immunity from, electromagnetic interference are given in harmonised standards BS EN 12015(12) and BS EN 12016(15), respectively. Both the system designer and the lift manufacturer must comply with these requirements.

The components used to make up the lift installation need to satisfy all of the requirements of the various standards concerning interference. In some instances, this may be enough to satisfy the demands for the installation to comply. However, where lifts may be installed close to sensitive electronic equipment such as that found in laboratories, hospitals, operating theatres, computer rooms, communications facilities etc., extra design measures may need to be taken, over and above compliance with the harmonised standards. BS EN 81-72(8), clause 6 (Table 3) sets out the tests required to be carried out in a completed firefighting lift installation.

Notwithstanding any such tests and individual component compliance, the lift manufacturer should confirm in writing any limitations on the use of radio equipment in the vicinity of the lift installation. In particular, whether hand-held radio transmitters may be used adjacent to the lift controllers during maintenance work when covers are removed or panel doors are open. Similar assurances are also required for the use of hand-held radio transmitters either inside or on top of the lift car. Consideration must also be given to the effect of fixed radio or microwave transmitters mounted on the roof near to the lift machine room.

12.9 Cabling and wiring

12.9.1 Cable sizing

The requirements of sizing cables for voltage drop, current carrying capacity and the ability to withstand bursting and heating effects of short circuit currents are covered in BS 7671(6). However, the regulations assume that the designer has knowledge of the system being designed and the requirements must be used with judgement.

When determining an acceptable voltage drop, it is essential to take account of conditions of the power distribution system for its worst operating conditions at:

(*a*) start up

(*b*) abnormal or emergency conditions.

The power distribution system may be particularly heavily loaded under these conditions and normal voltage limits may be exceeded. The maximum variation allowed for the equipment connected to the system must not exceed the calculation for the worst case situation.

Motor starting currents can be high. The maximum voltage drop during starting must not allow the voltage across the motor terminals to fall below that required for the pull-out torque needed to get the connected mechanical load up to speed. It is most important that the minimum and maximum allowable voltage limits are provided by the lift manufacturer for both the power supply to the controller and to the lift motor.

Warning: most computer programs for cable sizing do not take account of the increase in fault current that synchronous or induction motors contribute to faults. There is no allowance that can be included in these programs. The calculated results will therefore be lower than measured (e.g. a rooftop plant room with large fans and pumps fed from a switchboard in the rooftop plant room will experience higher short circuit currents than those calculated taking into account its supply feeders from the ground or basement transformers).

Diversity factors may be applied to cables that supply more than one lift. Examples are given in Table 12.3.

Table 12.3 Diversity factor for lifts

Number of lifts	Diversity factor
1–2	1.0
3	0.9
4	0.8

Where there are more than four lifts, the lift installer should be consulted.

Supply cables for lift installations and their ancillary services, lighting and socket outlets must be segregated from other building services (see BS 5655-6[16]). Supplies for firefighting and evacuation lifts must be segregated so that the rest of the building supply can be isolated in the event of fire in all or part of the building.

12.9.2 Cable routes and protection

Where lifts are essential for emergency evacuation or are used for firefighting (see chapter 6), the cable routes for both the control wiring and the power supplies should be assessed and additional design precautions may be necessary to ensure that essential cables are protected from fire hazards. Where multiple lifts are used for these essential duties, the cable routes should be physically separate for each lift or subgroup of lifts.

Consideration should also be given as to how the integrity of the fire protection is to be maintained throughout the life of the building. For firefighting lifts, cables must be selected and protected in accordance with BS 9999[7] and BS EN 81-72[8].

The basic requirements for electrical installations are identified in the Electricity at Work Regulations 1989[17], BS EN 81-1[18] and BS EN 81-2[19], and BS 7671[6]. It should be noted that the lift installation on the lift side of the mains isolator, which is covered by BS EN 81-1/2, is excluded from the scope of BS 7671. However, in addition, the initial specification given to the lift manufacturer should state the type of mechanical protection to be provided for fixed wiring in the lift well, machine room and car.

The options available are:

— rigid wiring clipped to surfaces where other mechanical protection is not essential

— proprietary multicore cable systems with special cleating tap-off and terminating components

— PVC conduit and trunking

— steel conduit and trunking.

12.9.3 Wiring interfaces

The initial specification must identify clearly the interfaces between wiring directly associated with the lift installation and wiring for other services. These are likely to include:

— intercom systems

— telephone handsets and 'hands free' alarm communications in lift cars

— warden alarm systems (in sheltered accommodation)

— remote emergency bells/sounders

— connections required for equipotential earthing and bonding

— remote monitoring and signalling to building management systems

— heating and ventilation of the machine room and lift well (see sections 12.10 and 12.11)

— lift well lighting

— lift well socket outlets

— fire alarms and detection equipment

— security systems.

Precise information must be provided wherever such interfaces occur to ensure that the correct signals will be transferred. A schedule of interfaces (see Table 12.4) is recommended so that all the relevant parties can comment on the proposed system and confirm that the required signals are compatible.

12.9.4 Maintenance safety and records

A rubber safety mat should be placed in front of the lift controller and also behind where rear access is provided. A card or poster giving guidance on treatment following electric shock should be provided in the machine room or machinery space as appropriate.

The designer should consider risks that maintenance staff may encounter during the routine maintenance of the lift installation, particularly work in the lift well and on the car top. This is of particular importance when the lift control equipment or machine is located within the well or some other machine space. The designer should identify what provision is to be made for safety in the event of mains failure while working on the lift installation.

Table 12.4 Typical interface schedule

Data transferred	Transfer from	Transfer to	Comments
Power supply (voltage, phases, frequency)	Local isolator (rating)	Lift controller	Interface at isolator (load current)
Lift car lighting (voltage, phases, frequency)	Local isolator at controller	Lift controller (load current)	Fused before isolator; interface at isolator
Lift car power (voltage, phases, frequency)	Local isolator at controller	Lift controller (load current)	Fused before isolator; interface at isolator
Earthing and bonding (cross sectional area of cable)	Earth bar in machine room	All metalwork	Interface at earth bar bonded to earth
Standby power in operation (contacts close when generator is supplying load)	Standby generator controls (volt-free contacts)	Lift controller	Interface at lift controller
Emergency bell (sound output level of bell)	Lift controller via terminal in lift well at ground floor (24 V DC supply)	Remote bell in entrance hall (24 V DC, 5 A load)	Interface for wiring at terminal box in lift well

Note: the schedule should be extended to cover all interconnections between the lift installation and other services and/or plant in the building

The technical dossier provided with each lift installation should comply with BS EN 13015[20].

Maintenance and operating personnel should be given essential information about the system. It is recommended that lift motor rooms have the same basic information as electrical plant rooms. This should include the following:

— wall mounted schematics and single-line diagrams of the associated power distribution system feeding the lift showing power source(s), points of isolation and device ratings

— schedules for all distribution boards associated with the lift installation.

12.10 Machine room environment

12.10.1 Temperature considerations

At the planning stage for a building, the designer should be aware of the likely need for the heating, ventilation and cooling of the machine room. Adjustments may be necessary when the precise operating conditions for the building are later established. For example, solar heat gain through windows, or waste heat from other parts of the building rising up the lift well to the machine room, can considerably affect temperatures.

The motor and control equipment of a lift can generate significant quantities of heat such that special ventilation and cooling facilities are needed in the machine room. This is not only to maintain the ambient temperature within reasonable limits for consistent operation of the equipment, but also to make conditions tolerable for service personnel. In a large installation the amount of heat generated may be such that the building services designer should consider using the surplus heat, for example to preheat the domestic hot water supply.

Equipment supplied by different manufacturers will vary in terms of the amount of heat generated and the exact value should be obtained from the motor supplier or the lift installer. Some guidance is given in Table 12.5, which indicates that lifts with a large rated load are more efficient.

Table 12.5 Estimation of heat losses dissipated in the machine space

System type	Range of motor rating / kW	Range of heat losses (% of motor rating)
Geared VVVF	7.5 to 30	40 to 28
Gearless VVVF	7.5 to 40	38 to 26
Gearless permanent magnet synchronous motor	3 to 90	28 to 13
Hydraulic	4 to 20	70 to 30

To a first approximation[21] the rating (R) in kW of the electric motor for an electric traction lift (with 50% balance) can be estimated from:

$$R = Q\,v / 2\,\eta \tag{12.1}$$

where Q is the rated load (kg), v is the rated speed (m/s) and η is the gearbox (if any) efficiency (%) (= 100 for a gearless machine).

For example for a geared lift having a rated speed of 1.0 m/s, a rated load of 800 kg and a gear efficiency of 66% the motor rating would be 6.0 kW and the heat losses would be about 1.5 kW. A gearless lift with a rated speed of 5.0 m/s and a rated load of 1600 kg would have a permanent magnet synchronous motor rated at 40 kW and heat losses of approximately 8 kW.

BS EN 81-1[18] and BS EN 81-2[19] require the ambient temperature of machine rooms to be maintained between 5 °C and 40 °C. Except for single-unit installations, it will probably be necessary to provide some means of heating and/or cooling in the machine room to keep the temperature within these limits. In cases where the machine room temperatures are controlled within closer limits, the reliability of the lift machinery may improve. For new lifts, the Lifts Regulations[1] require the lift to be removed from service should the ambient temperature in the machine room fall outside the limits. Although the maximum temperature value varies between lift equipment manufacturers, 40 °C is a reasonable initial assumption for an upper limit. The actual value must be checked with the lift installer prior to finalising the machine room cooling and ventilation systems. It should be noted that non-compliance with the manufacturer's equipment operational temperature limits will probably invalidate any actual and implied warranties for the affected equipment.

Most geared electric traction drives employ an oil-bath worm reduction gear driven by an electric motor. However, the use of gearless drives is increasing, not just the traditional 'high speed, high-rise' situations but across all applications. All such electric motors produce heat that is dissipated directly into the machine room. The exception is 'machine room-less' lifts, where the motor is situated within the lift well.

The majority of hydraulic equipment presently available utilises an electric motor and screw driven pump, submerged in the oil reservoir tank (see section 7.3.4) The waste heat generated by hydraulic lifts is considerably more than that from a comparable electric traction lift, and the problem of heat disposal is often made greater because the machine room is sited within the building rather than on the roof. Unlike electric traction lifts, this heat is not dissipated directly into the machine room, but into the oil reservoir itself. This has the effect of reducing the oil viscosity. The opposite effect can be observed during periods of infrequent use. It is thus necessary to maintain the oil viscosity within acceptable limits for optimum performance of the equipment. To achieve these levels, direct oil heating or cooling may be required in many applications (see sections 12.10.3 and 12.10.4). This must be provided by the lift supplier.

Building designers should also take account of the possible need for standby heating and ventilating equipment. If the building has an integrated heating and ventilating system, they should make suitable arrangements to cope with lift operations when other building services are shut down, e.g. at weekends. Precautions against failure of air conditioning or cooling plant may also be necessary in busy buildings.

12.10.2 Ventilation

Under the section dealing with machine room construction, the harmonised standards require that stale air from other parts of the building should not be exhausted into the machine room. Suitable ventilation should be provided such that, as far as reasonably practicable, the equipment is protected from dust, harmful fumes and humidity. Although not prescribed by the standards, it is recommended that the free area of ventilation should be not less than 0.1 m^2 per lift. This can normally be provided by the necessary running clearances around the lift landing doors. For example, a 2-floor lift with 2 m high by 0.8 m wide entrance with 3 mm clearances has a free area of 0.118 m^2.

For lifts installed in low- to medium-rise buildings where the winding machine is installed within the lift well, i.e. the 'machine room-less' (MRL) configuration now offered by some manufacturers, the provision of ventilation to the lift well may be sufficient for all ventilation requirements. However, in some environments, e.g. an exterior location such as a car park, then the ambient temperature should be considered and air conditioning may be required.

Machine rooms for some lifts in high rise buildings may not have (adequate) access to natural ventilation from outside the building. For high-rise buildings with machine rooms on the roof, natural forced ventilation is highly unlikely to provide adequate cooling in hot climates where the outside ambient temperature is above 25 °C on a cloudless day. For these cases, it is essential to provide adequate forced air cooling or air conditioning. This must be sized to maintain the ambient temperature range for operating and storage of the equipment as defined by the lift installer. If forced ventilation or cooling is provided, it must be arranged so as not to leave undisturbed 'hot spots', such as the regions near a lift motor or a bank of resistors adjacent to a control panel. The air handling equipment should be integrated into the building requirement and not designed as a standalone system specific to the lift machine rooms. This will allow a more energy efficient design and minimise building design coordination issues. Maintenance of the air handling equipment located in the machine room must be carried out under the supervision of the lift maintenance company or by competent persons trained in working around lift equipment.

Exposed locations such as public multi-storey car parks and lift entrances to the outside of a building provide environmental conditions that can fall outside the storage and operational conditions for the lift equipment. In particular, hydraulic lifts are susceptible to extreme oil temperature variations that may cause breakdowns in low temperature conditions when the lift has not been used for some time. It is essential to provide adequate heating and cooling for the equipment both in the machine room and in other areas of the installation that may be affected in this manner. Incident solar radiation onto landing doors and entrances through south facing windows has been known to cause unsafe high surface temperatures and door distortion. Such locations may need the use of reflective window surfaces and other means to mitigate the effects of the incident radiation.

12.10.3 Heating

Heating to lift machine rooms should be available at all times and for this reason local electric heating is widely used, often in the form of thermostatically-controlled tubular heaters. Where cooling is required, packaged heat pumps may offer a cost-effective solution.

Harmonised standards require the control of condensation or/and frost protection in pulley rooms. If electrical equipment is also contained within the pulley room the temperature should be similar to that of a machine room.

Hydraulic lift machine rooms are often placed in architecturally convenient locations, such as basement areas or stair cores. In such locations, the ambient temperature may drop considerably, which has a thickening effect upon the oil. Light duty hydraulic lifts and those with machine rooms in convenient locations may require oil heaters to ensure that the oil viscosity is at the correct level after, for example, overnight shut-down. This may be readily achieved by an immersed heating element in the oil reservoir, controlled by a thermostat. Such devices must be provided by the lift supplier. The provision of a separate oil heater, however, does not affect the need to maintain the machine room ambient temperature between 5 °C and 40 °C or that specified by the lift installer.

12.10.4 Cooling

All machine rooms should be provided with adequate means of removing the heat generated by the lift equipment. The upper limit of 40 °C sometimes enables outside air to be used as the cooling medium, where ambient temperatures are not high. For some low usage single and double lift installations, natural ventilation by convection, using a high- and low-level louvred ventilator arrangement, may be adequate. For high usage lifts, where the heat generated is likely to be significant, and also for groups of lifts, mechanical ventilation will probably be required. This may range from a simple thermostatically controlled fan on the roof, which takes in outside air through external louvres, to sophisticated ducted systems. Care should be taken in all cases to prevent local 'hot spots'.

With electric traction lifts, the main sources of heat gain within the machine room are the motors and, in the case of variable frequency drives, banks of resistors and power semiconductor heatsinks. In some older installations, where the motors may be fan cooled, rather than allow the hot air generated in the motor to discharge directly into the machine room, it can be ducted to outside. With some types of motor, a secondary fan may be necessary but many motors are fitted with centrifugal blowers which develop sufficient pressure to deal with such discharge by themselves. Where all of the motor air is ducted to the outside, the reduction in room heat gain from the motor can be as much as 75%. This substantially reduces the cooling load and may remove the need to provide machine room air conditioning.

Where cooling air from the motor is ducted directly to the outside, replacement air will have to be drawn in. However, the replacement air will be warm during the summer and, in order to reduce running costs, the set-point of any supplementary cooling system should not be less than the temperature of the incoming air.

With large multiple lifts and intensive duty hydraulic lifts, vast quantities of ventilation air may be necessary to provide the cooling required. In many instances this is not practicable within the overall building constraints and air conditioning may prove to be a more acceptable means of cooling. Ideally, the cooling plant should be located in a separate room so that it can be maintained without entry to the machine room. Where this is not possible and building services personnel are required to work within lift machine rooms, precautions must be taken to ensure compliance with the requirements of the Health and Safety at Work etc. Act 1974[22].

Machine rooms that rely on cooling equipment to control the temperature should be provided with a remote alarm to draw immediate attention to system failures.

In rare instances, lift control panels may require their environment to be more closely controlled than is usually the case, and may require temperatures lower than those specified in harmonised standards. In some cases this may be limited to the control panel itself and panel coolers would be provided. These usually take the form of small proprietary direct expansion air conditioners mounted on top of each panel, blowing cooled air downwards through the cabinets, see Figure 12.1.

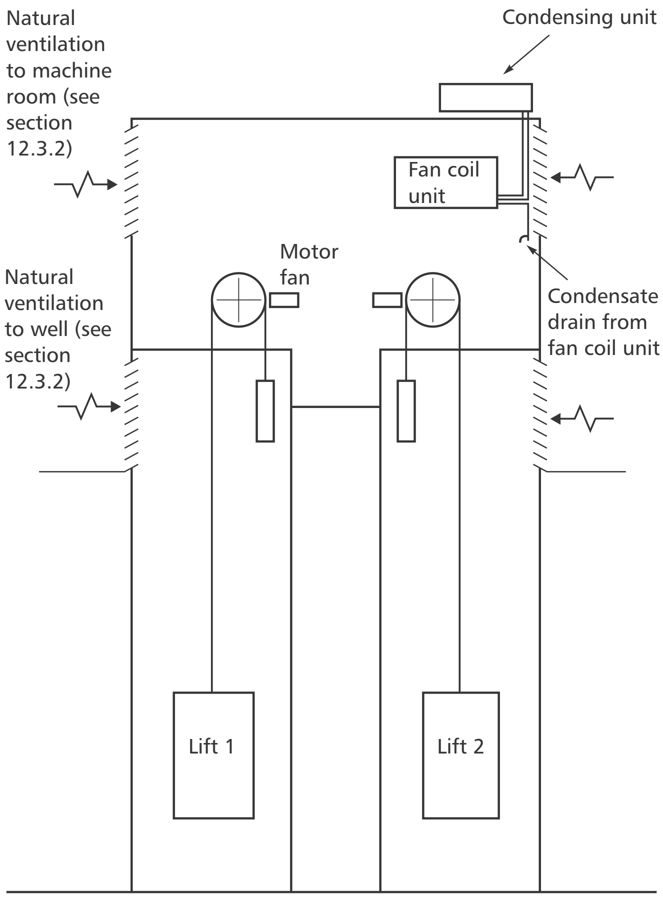

Figure 12.1 Schematic of typical combination heating, ventilation and air conditioning system applied to a rooftop machine room

Oil cooling should be considered where the duty of a hydraulic lift is likely to result in the dissipation of considerable amounts of heat into the hydraulic oil. This is best provided by the lift supplier as an integral part of the hydraulic pump and power unit. Oil cooling is usually achieved by passing the oil through a radiant fin cooler on its return to the reservoir. The radiator should be mounted outside the machine room otherwise it has no effect on the machine room and oil temperature unless there is a large volume of cooling air to remove the energy.

Nowadays many building operators consider that the lift machinery will have a longer and more reliable working life if the temperature is maintained well below the upper limit and therefore require air conditioning to be provided. An additional benefit is improved working conditions for maintenance personnel.

12.10.5 Lighting

Machine room and machinery space electric lighting should provide at least 200 lux at floor level in working areas, be permanently installed, and controlled from switches (two-way or intermediate, if appropriate) adjacent to all of the access doors. A pulley room can be fitted with similar lighting providing 100 lux at the pulleys unless the pulley room contains control panels, in which case it is considered a machine room in terms of lighting. Access to machine and pulley rooms is required to be permanently lit.

12.11 Lift well environment

Harmonised standards require that the lift well be suitably ventilated and not used to provide the ventilation of rooms other than those for the service of the lifts. Clause 5.2.3 of BS EN 81-1(18) and BS EN 81-2(19) has a note stating that provision be made at the top of the well for ventilation openings to the outside, either directly or via the machine or pulley room. The minimum ventilation area is 1% of the horizontal cross section of the well. This note is not part of the harmonised standard. Consequently, compliance with the note is not necessary. Generally there is sufficient ventilation of the well via clearance gaps in the door entrances. If ventilation air is provided via the machine or pulley room, through-ductwork should be used.

Lift buffers, other than spring buffers, usually found in the lift well pit, if new, require a declaration of conformity as a safety component identified in the Lifts Regulations(1). The testing of these CE-marked buffers requires ambient temperatures between 15 °C and 25 °C. Although many manufacturers will test and certify their buffers beyond this temperature band, if the ambient well temperature is likely to fall outside these temperatures the actual test parameters defined on the type-examination certificate for the buffer should be ascertained. The same principle applies to rupture and restrictor valves fitted to hydraulic lifts where the range of ambient temperatures applicable is stated on the type-examination certificate.

For lifts with speeds in excess of 2.5 m/s, wind noise and transient changes in lift well air pressure may occur due to lift car movement if pressure relief vents are not provided in the lift well walls. This can cause landing door rattle, wind whistle in lobbies and poor ride comfort. It is recommended that ventilation vents should be not less than 0.3 m^2 in free area for each lift well. A common lift well for two or three lifts having speeds in excess of 2.5 m/s requires a minimum vent area of 0.3 m^2. Where the common well accommodates four, five or six lifts, minimum vent areas of 0.4 m^2, 0.5 m^2 or 0.6 m^2 respectively should be used. The vents should be positioned at suitable intervals in the well walls. Vents in outside walls of the building should be louvred or otherwise protected to prevent rain, snow or vermin from entering the lift well. Local building regulations should also be consulted since these may require larger vent areas under certain circumstances.

For compliance with BS EN 81-1(18) and BS EN 81-2(19), lift well lighting should be installed so as to provide a minimum light intensity of 50 lux on the car top and in the pit. When control equipment and machinery is located in the well then the lighting level at the working location for those devices must be 200 lux. Where there is a machine room, these should be controlled from the lift machine room by a switch with a warning pilot light and by a switch within the lift well, either at the bottom entrance or at pit level. In any case the well lighting switch should be accessible from the entrance to the well.

12.12 Lift car environment

Under normal operation, the environmental conditions within lift cars present few problems. However, consideration must be given to the effects of breakdowns, especially if people are trapped inside a car. Sufficient ventilation within a lift car is deemed an Essential Health and Safety Requirement under the Lifts Regulations(1). Minimum ventilation apertures of at least 1% of the available car area should be provided in the upper and lower parts of the car, as described in harmonised standards.

For internal lift wells, a small fan extracting air from the car into the lift well may also be provided. It is prudent to ensure that the fan is able to operate on a back-up battery supply in case passengers are trapped as a result of mains supply failure.

Heat gains from light fittings should be considered, especially spotlights that can dissipate substantial amounts of heat. If spotlights are used, an emergency 'off' switch should be provided to reduce the lighting to an emergency level. Solid state LED units are now available that provide good illumination with low power consumption. Likewise the use of high frequency low energy fluorescent lighting should be considered to minimise energy consumption.

For external observation lifts, the effects of solar heat gains must also be considered. These may be sufficient to require the provision of comfort cooling during normal operation. During winter periods lift car heating may need to be provided. In the event of a breakdown, the loss of comfort heating/cooling could be dangerous to the occupants and the provision of a maintained electrical supplies or even duplicate plant should be considered. Where comfort cooling is provided to the lift car, consideration should be given to the disposal of the condensate. This could provide a hazard to health if allowed to collect in the base of the lift well. For installations in tropical climates, where lift car cooling is commonplace, small packaged electric boilers may be employed to evaporate the condensate. However, these may not be commercially available in the UK.

12.13 Human comfort considerations

It should be noted that most lift suppliers use Fourier analysis techniques to measure the noise and vibration characteristics of lifts. The resultant noise and vibration characteristic of a given type of lift equipment is also dependant on its environment. For low transmitted noise and vibration applications (e.g. theatres), the client and architect should liaise closely at the design stage with the proposed lift supplier.

12.13.1 Noise

Criteria for in-car noise levels must take into account lift speed, as high-speed lifts are subject to wind noise. In-car noise criteria must also cover noise resulting from door operations. In hydraulic lifts, the oil flow can generate wide-band high frequency noise that is coupled to the lift car via the cylinder. The addition of a silencer on the valve output can reduce this noise level in the car by up to 8 dBA.

Door noise, when measured at 1.5 m from the centre of the floor and 1.0 m from the door face with a precision grade sound level meter set to 'fast' response, should not exceed 65 dBA. Noise levels in the car at the rated speed in the cycle, when measured as above, should not exceed 55 dBA for lift speeds of 0.5–2.0 m/s and should not exceed 60 dBA for lift speeds of 2.0–7.0 m/s.

The acceptable level of noise in lobbies will vary according to the function of the building. Noise ratings (NR values) for various areas within buildings are given in CIBSE Guide A[23]. NR values are dependent on the frequency spectrum of the noise and there is no constant relationship between NR value and dBA. However, for practical purposes, the NR is approximately equal to the dBA value minus 6.0. The recommended NR for reception areas in offices and hotel lobbies is NR35–40.0. For public areas in banks, building societies etc., NR35–45 is recommended. For circulation spaces between wards in hospitals, NR35 is recommended.

Noise limits in the lift machine room should be specified in accordance with the Noise at Work Regulations 1989[24]. It is therefore essential that levels of machine noise are obtained from the lift supplier.

Lift noise, when measured at 1.5 m from the floor and 1.0 m from the door face using a precision grade sound level meter set to 'fast' response, should generally not exceed 55 dBA at any time during the lift cycle. For lifts opening directly into office spaces (i.e. where there is no lift lobby), this limit should be reduced to 50 dBA. However, there may be situations where levels up to 65 dBA may be acceptable and this should be checked with the client on each particular project.

It is also necessary to ensure that the sound reduction properties of the lift machine room construction, including doors, hatches, ventilation openings etc., are adequate to prevent the escape of noise at values that exceed the acoustic design criteria for the surrounding areas. Noise level information shall be made available as follows:

- maximum and average (L50) dBA level over a complete cycle of lift operation
- maximum levels in each of the eight octave bands centred at 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz.

The measurements must be made with a precision grade sound level meter fitted with an octave band filter set. The positions at which measurements are made should be noted on a drawing showing the principal noise-producing elements of the lift machinery. No measurements should be taken at distances less than one metre from any wall or floor surface. All measurements should be made using the 'fast' meter response.

12.13.2 Vibration

Human response to vibration is greatest at low frequencies. Therefore vibration limits in the range 1 to 80 Hz should be specified. Furthermore, human susceptibility to vibration differs between horizontal and vertical vibration and this should be taken into account when specifying acceptable limits of vibration.

Vibration measurements should be made at the centre of the car, at floor level, in three mutually perpendicular axes corresponding to vertical, front-to-back and side-to-side. Measurements should be made of the acceleration level in each direction over two complete cycles, one from the bottom of the building to the top, and one from the top of the building to the bottom. The measurement method is critical to the repeatability of results. It is, therefore, preferable to use an automatic recorder covering all frequency bands, as opposed to taking individual frequency band measurements over repeated lift runs. A cycle is defined as the period from just before the doors start to close at one level, to just after the doors open at the final level.

Measurements and analysis should be carried out in accordance with BS ISO 18738: 2003[25], which defines methods for the measurement of lift ride quality that have been adopted as standard by the lift industry. Acceleration levels should be measured as root mean square (RMS) values using a time constant of 0.125 s ('fast'), and the maximum values recorded in each 1/3 rd-octave band from 1–80 Hz inclusive over each complete cycle. The following limits will apply:

(*a*) Horizontal vibration frequency range 1–80 Hz inclusive: maximum (RMS) acceleration level should not exceed 0.08 m/s^2.

The above limit applies to any time during a complete cycle, in any 1/3 rd-octave band in the frequency range specified.

(*b*) Vertical vibration:

- at maximum speed: maximum (RMS) acceleration level in any 1/3 rd-octave band should not exceed 0.08 m/s^2 in the frequency range 1–80 Hz
- during acceleration/deceleration and start/stop periods: the maximum (RMS) acceleration level in any 1/3 rd-octave band should not exceed 0.1 m/s^2 in the frequency range 1–80 Hz.

The above limits apply to lifts with speeds up to 4 m/s. Lifts having speeds above this will be subject to increased vibration limits. For lift speeds in the range 4–7 m/s, a multiplier of 1.5 may be used for all acceleration level limits.

These measurements are taken using computer controlled measuring equipment that allows direct comparison of ride quality from installation to installation. The use of Fourier analysis techniques also allows the fine resolution in the frequency domain not given by 1/3 rd-octave filters as given in BS 6472[26]. This is essential for the identification of any troublesome sources of vibration in the lift. The use of special filter systems such as those described in BS 6841[27] are not recommended.

12.13.3 Acceleration and deceleration

'Ride quality' is also a function of the acceleration and deceleration and it may be considered necessary to specify criteria for these characteristics. To avoid excessive discomfort for persons with disabilities, pregnant women and older people it is suggested that lift acceleration and deceleration values should not exceed 1.2 m/s^2 and this figure should only be considered where a high degree of control is provided. Acceleration and deceleration values are obviously linked to optimum lift response times and, to some extent, it may be necessary to compromise between comfort and travel times. The highest values that should be considered are 1.4 m/s^2.

12.13.4 Jerk

Passenger and ride comfort will also be affected by the jerk, i.e. the rate of change of acceleration and/or deceleration. Acceptable jerk values for lift performance are dependent on the lift speed. Their values are linked to optimum lift response times and it may again be necessary to compromise between comfort and travel times. It is suggested that jerk values 50% numerically larger than the numerical for acceleration/deceleration values should be used with a maximum value of 2.0 m/s^3.

12.13.5 Communication with trapped passengers

The Lifts Regulations(1) requires that passengers trapped in a lift car have the means of two-way voice communication with a 24-hour attended rescue service (see chapter 14).

12.13.6 Lighting at landings

Harmonised standards require the luminance of electric or natural lighting to be at least 50 lux at floor level at each landing served. This level is required even with the lift car lights switched off. This requirement needs to be satisfied when a new lift is being installed and when it is used by the builder (builders use).

12.14 Environment for maintenance

12.14.1 General

In designing the transportation system, it is not only necessary to include those provisions required to ensure that the environment is suitable for the satisfactory operation of the lift. Consideration must also be given to those provisions necessary to ensure a safe and suitable environment for those persons involved in maintaining and inspecting the installation.

Many of these considerations are identified in the Health and Safety at Work etc. Act(22), the Workplace (Health Safety and Welfare) Regulations 1992(28), the Provision and Use of Work Equipment Regulations 1998(29), BS EN 13015(20) and BS 7255(30). For new lifts installed to harmonised standards, the building fabric and building services requirements for the lift installation, including the machine rooms, wells and pulley rooms, is defined.

12.14.2 Lift well

Harmonised standards require that the lift well is used exclusively for lift equipment. Cables, ducts, pipes or devices other than for the lift installation are not permitted. Heating equipment for the lift well (not steam or high pressure water systems) is permitted as long as the controls remain outside of the well.

Harmonised standards require and define the provision of permanent electric well lighting to ensure an intensity of illumination of at least 50 lux, one metre above the car roof and pit floor. This should preferably be installed by the lift supplier but is often installed by the electrical contractor who, if working from the lift car roof, should be under the supervision of the lift installer. The lift well lighting should incorporate emergency lighting to provide illumination in the event of power failure. Responsibility for subsequent maintenance of the well lighting is unclear because, generally, only the person maintaining the lift is likely to notice the failure of lamps. It should be noted that decorative lighting that is not part of the lift installation should not be designed to be located in the lift well. It is not certain that a Notified Body for the Lifts Directive(31) will provide a design examination certificate for such an installation.

A supply of replacement lamps should be kept on site to reduce the delay in replacing failed lamps. In modern buildings, fluorescent lamps are the most common and maintenance will be simplified if lamps of the same type are used for both the lift well and machine room.

For wells that are partially enclosed, such as observation lifts, well lighting may be omitted provided that the prescribed luminance can be achieved by surrounding ambient lighting at all positions of the lift car, and at all times when access to the lift well may be necessary.

Attention should be given to the internal wall surfaces of the well. The walls of the well may be constructed of brick, concrete or block-work, and dry-lined internal facings may also be employed. Each of these can give rise to dust. This should be limited by painting the walls with a suitable proprietary surface treatment. Painting the internal surface of the well will not only inhibit the spread of dust but will also provide a clean and safe working environment. For maximum visibility white paint should be used.

In the case of all types of lifts with entrances accessing directly into car parks, particular attention must be paid to providing adequate ventilation of the car, well and pit. This is to avoid the possible build-up of toxic gases in the lift car and well.

12.14.3 Machine room

Harmonised standards prescribe the construction, dimensions, lifting equipments, access and the provision of building services in machine and pulley rooms. The standards also limit the use of machine and pulley rooms to:

- lift equipment
- machines for service lifts or escalators
- cooling and heating equipment for machine and pulley rooms (except steam and high pressure water heating systems)
- defined fire extinguishers and detectors.

Fire extinguishers should be suitable for electrical fires and be stable over a period of time, and should be mounted so as to be suitably protected against accidental impact. The room should be accessible only to authorised persons and should not contain ducts, cables, pipes or other devices not associated with the lift installation, e.g. television signal amplifiers etc.

Emergency lighting should be provided in machine and pulley rooms not only to permit escape but also to enable the undertaking of emergency procedures such as hand-winding for passenger release during a power failure.

Should certain control circuits in a lift controller remain live after the particular lift is isolated, as is common where groups of lifts are interconnected, means of total isolation should be provided in the machine room. This is usually achieved by isolating all of the other lifts in the group.

Additional means of lift movement prevention, in the form of a stay-put 'stop' button, must be provided in the following locations:

- adjacent to the lift motor and pulleys in pulley rooms
- the top of the lift car (part of the car top controls), within one metre of car door entrances
- one metre above the sill at the lowest lift entrance
- in a location accessible from the pit floor.

12.14.4 Machine room-less installations

Maintenance of control equipment and machinery in a machine room-less installation is undertaken in the machinery spaces and on a landing for emergency access and movement control panels. All such locations should be illuminated to a level of at least 200 lux for safe working. Sufficient working area should be allowed for maintenance and the safe passage of building occupants. Emergency operation of the lifting machine generally occurs at the top landing and lighting in the lift lobby should be sufficient to undertake maintenance and emergency procedures. All intervention cabinets should be clearly marked and any emergency instructions displayed inside the cabinet. Consideration should be given to the location and safe storage of the landing door emergency unlocking key and its ready access to authorised persons.

12.14.5 Physical requirements

Harmonised standards define key dimensions of the machine room, machine room door and trap requirements as well as the requirement for the lifting beams. Where machine rooms are built on different levels, permanent ladders and removable guard rails should be fitted if there is a change of level greater than 500 mm. It is recommended that the floors and walls of the machine room are treated with dust inhibiting paint.

12.14.6 Maintenance of third party equipment

Equipment associated with the lift installation such as fire and smoke detectors, fire extinguishers, air conditioning plant, communications systems etc. require maintenance by persons not normally authorised to work in lift environments. Arrangements must be made to accompany these persons. However, wherever possible, arrangements should be made to allow these activities to be carried out safely by, for example, locating plant outside lift areas, or in the case of fire and smoke detectors, providing a means of withdrawing them from the well for testing.

12.15 Lightning protection

The bonding of lift guide rails and other lift components to the lightning protection system (LPS) should be carried out with great care.

Protection of buildings and their contents is covered in BS EN 62305: Parts 1 to 4[32–35]. Part 4 gives schemes for the protection of electrical and electronic systems within structures and Part 3 deals with physical damage to structures. Lifts are mentioned in Part 3 only. Clause 19.3.10 of the previous standard, BS 6651: 1999[36] (which was withdrawn on 31 August 2009), stated:

> 'In lift installations, the continuous metal structure, including the guide rails, should be bonded to the lightning protection system at the top and bottom of the installation.'

If the guide rails are bonded at both ends (top and bottom) it is possible that they can become an inadvertent lightning conductor, something for which they are not designed. In such a circumstance there is a significant risk of high voltages being induced into the lift car and the control system of the lift with possible injury to persons in the well.

In BS EN 62305-3 Annex E: 'Guidelines for the design, construction, maintenance and inspection of lightning protection systems', clause E.6.2.2 states:

> 'Metal installations, i.e. water, gas, heating and air pipes, lift shafts, crane supports etc. shall be bonded together and to the LPS at ground level.'

The term 'lift shafts' is ambiguous but, assuming that it means all the components in the lift well, then the only location where the lightning protection system and the lift earthing system should be allowed to come into close connection should be at the building main earth terminal in the electrical incomer room. This is a point of low impedance. The connection to the lift well (shaft) can be simply achieved at the main incoming earth bus bar as this is the point where the LPS connection and the lift earthing system are both made, assuming the metalwork in the lift well is properly connected to the lift earthing system.

Care should also be taken to avoid running lightning protection conductors in close proximity to and parallel to guide rails. This reduces the risk of induced currents in the guide rails.

Similarly, BS EN 62305-4[35] requires that power and data circuits are protected against surges, the addition of such protection to the lift installation needs to be done with care and in liaison with the lift installer. This is particularly true where the lift may be connected to building management and other systems in the building.

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Appendix 12.A1: Schedules for electrical systems requirements

Table 12.A1.1 Typical schedule for electrical system requirements — machine room

Requirements	Interface and notes
Power supply for lifts:	
— single main for firefighting lift	Supply monitored by building management system (BMS).
— single main for each lift or a single supply to feed each group of lifts	Supply monitored by BMS.
— single main for lift well and machine room power and lighting	Supply monitored by BMS.
Power for lift machine room:	
— small power socket outlets	See BS 5655[16].
Lighting:	
— lift well lights	
— lift car lights	Prominent means of isolation.
— lift car (top) maintenance socket outlet	Prominent means of isolation.
— emergency lighting	Emergency lighting to enable safe hand-winding operations during a power failure.
Environmental control:	
— heating	May be linked to central controls.
— ventilation	May be linked to central controls.
— cooling	Check if required for internal motor rooms or those subject to high solar gains.
Earthing and bonding:	
— all metal work to be bonded and connected to machine room earth bar	Separate machine room earth bar cabled to main building earth.
Fire detection and alarm:	
— smoke, rate of rise detectors, manual break-glass stations and sounders	Integrated with main building fire alarm system.
Communications:	
— car intercom	Linked to internal building intercom system.
— external communications (telephone)	Emergency dial-out feature through public network. Where this may be abused the dial-out may be barred to a single number or routed through the main reception or security desk serving the building.
— automatic dial-out	Where remote monitoring of the lift installation for performance and/or alarms is required, an automatic dial-out facility will be necessary using the public network
Fire service	Separate communication between lift motor room, lift car, firefighting lobbies and control rooms.
Monitoring and controls:	
— control for reduced lift service (i.e. reduced speed and acceleration when power is limited)	Signal from standby power supply to prevent simultaneous starting and overload, reduce speed and acceleration or other means to limit the lift load current
Status indication and alarms	Interface to BMS and automatic call-out for maintenance

Table 12.A1.2 Typical schedule for electrical system requirements — lift car

Requirements	Interface and notes
Lighting†:	
— normal and emergency lighting	Emergency standby battery system (specify minimum lighting levels required).
— car top	Consider emergency lighting.
Controls†:	
— car destination controls	Operation through the lift controller. Is 'key holder' override required?
— door hold controls	
— alarm control	
— maintenance controls (on car top)	Maintenance switch and push.
Indication†:	
— position	Operation through lift controller.
— selected floor	Operation through lift controller.
— overload/car out of service	Operation through lift controller.
Communication:	
— emergency bell	Remote sounder — off-site.
— intercom	Machine room and building system.
— telephone	Connected to external telephone line — single number auto-dial.
— audio system	Building or lift PA system.
Firefighting communications	Linked to landing and control room.
Ventilation	Forced ventilation if required.
Power	Maintenance power outlet on car top.

† These items interface with requirements for special finishes and decor

Table 12.A1.3 Typical schedule for electrical system requirements — lift well

Requirements	Interface and notes
Lighting:	
— permanent well lighting	Controlled from machine room and/or pit with warning pilot light
Power:	
— socket outlet in lift pit	See BS 5655[16]
Earthing and bonding:	
— guide rails and metal landing door surrounds bonded to earth	Connect to building earth system
Heating:	
— provided if necessary where there is a risk of condensation	Automatic controls or connection to central system
Monitors:	
— pit water flood detector if necessary	Remote alarm
Fire detection:	
— smoke detector	Linked to fire alarm system; detector located at top of the well

13 Energy consumption of lifts, escalators and moving walks

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Chapter contents

Contents continue

13 Energy consumption of lifts, escalators and moving walks

13.1 Legislative provisions

The European Community is increasingly dependent on external energy sources, but has little influence on the energy supply (oil etc.). A possible solution is to reduce energy consumption by improving energy efficiency. A directive on the energy certification of buildings (Directive 93/76/EEC[1]) was adopted before the Kyoto agreement.

In June 2002 the European Union published the Energy Performance of Buildings Directive[5].

In February 2003 the UK Government published an Energy White Paper[2] and then revised the energy efficiency provisions of the Building Regulations Part L[3]. These came into effect in April 2006 as Building Regulations 2000 Approved Document L2A: *Conservation of fuel and power*[4]. Paragraph 22d of Section 1: 'Design standards' states:

> 'd. exclude any service that is not a fixed building service (such as vertical transport systems)'

Therefore lifts and escalators are excluded from the energy efficiency provisions of the Building Regulations.

A UK consultation in 2009 to revise the Building Regulations[6] states in the amending proposals under 'Future Thinking Paper Part L' at paragraph 5.27:

> 'Vertical transport (lifts, escalators) is a significant energy consumer in some building types (accounting for up to 15% of energy costs[*]). This, coupled with a significant increase in high rise developments, means that they are an increasing contributor to energy use and we need to consider whether and how to ensure that reasonable energy efficiency is attained in practice.
>
> A key issue is if and how vertical transportation should be included … one [approach] would be to determine the energy budget for vertical transportation on an area basis, which would be likely to encourage low rise design … [or] alternatively the energy budget could be based on the number of storeys in the actual building and an assumed service provision … Consistency therefore suggests that the latter approach should be preferred … as this would mean that there is no compliance penalty in installing lifts, but there would be a benefit in installing a system that is more efficient than that assumed for the notional building.'

Resulting from this consultation, the 2010 edition of Approved Document L2A[8] has been published and comes into effect in April 2011. Vertical transport systems are not mentioned within this Approved Document.

* The 15% figure quoted is from CIBSE Guide F (2004): *Energy efficiency in buildings*[7] and is an extreme case with the average value probably being closer to 5%.

13.2 Energy consumption and energy efficiency

The total energy consumption over the entire life cycle of any equipment consists of the energy consumed in its manufacture, installation, operation, dismantling and disposal. Of these phases the operational phase is probably the most significant. Figure 13.1 illustrates for lifts the relationship of their energy consumption in comparison to other energy uses in an office building.

Where possible, designers should aim to minimise transportation requirements through good building layout during the design stage (see chapter 2). The number and type of transportation equipments installed in a building is determined by the traffic requirements of the building occupants. Energy cannot be sensibly saved by reducing the number of units installed. However, energy consumption can be minimised through good equipment design, appropriate selection to meet the traffic demands and efficient operational control of the transportation equipment (see chapter 3).

Although increased energy efficiency can sometimes involve higher initial capital costs, this may be recovered through energy savings over the lifetime of the equipments and thus each application warrants a full cost analysis. Importantly, capital and operational costs have been reduced as variable speed drives become cheaper. Obviously, the utility supply company's tariff structure can affect the final cost of the electricity consumption.

13.3 Energy consumption of lifts

Different estimates for the energy consumption of lifts as a percentage of the energy consumption of the whole building have been suggested, e.g. SAFE[9], but none of these studies is sufficiently comprehensive to provide reliable data. All these estimates are dependent on the other services running within the building and their efficiency.

There are different motivations for carrying out energy consumption estimation and energy measurement of lift systems, which arise from different needs. The four main motivations suggested by Al-Sharif[10] for examining the energy consumption of lift systems are outlined below (and each motivation is used to provide an answer to a different question).

(1) Understanding the energy consumption of one specific installation.

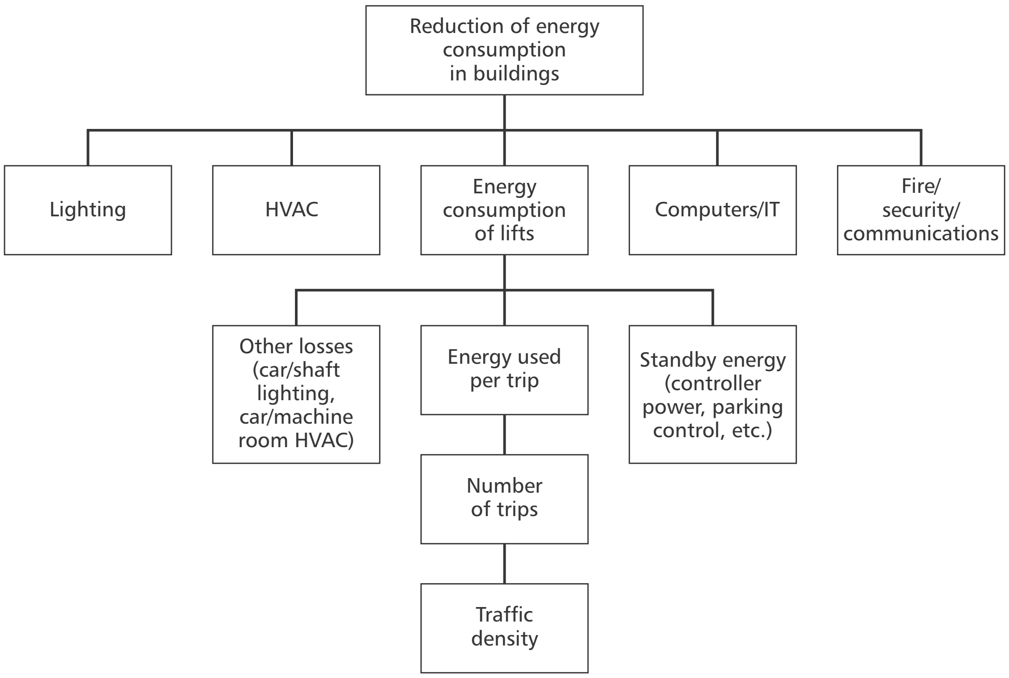

Figure 13.1 Relationship of lifts to other energy consumers in an office building

This answers the question: 'How much energy does the installation consume?'.

(2) Comparing the energy consumption of two different types of lift (e.g. different drives).

This answers the question: 'How much energy can be saved by replacing drive A with drive B?'

(3) Minimising the energy consumption of the lift on a journey by journey basis.

This attempts to answer the question: 'What is the optimum speed profile for the next journey that would minimise the energy consumption based on the load, direction and travel distance?'

(4) Predicting the energy consumption of a lift system based on its various parameters (e.g. type of drive, gearing, capacity, speed, travel distance, etc.).

This answers the question: 'What would the energy consumption of a new design of lift system be with a certain configuration and a specified set of components?'

These motivations have important implications in terms of the design of new lift configurations and predicting changes of energy consumption following modernisations. The last method aims to predict the energy consumed by a lift system, based on the various parameters of the lift system, its speed, loading etc.

13.4 Factors affecting lift energy consumption

Many factors affect the energy consumption of lift systems including the following:

(*a*) Mechanical system:

— drive sheave efficiency (traction etc.)

— idler sheave efficiency

— roping (reeving) ratio (1:1, 2:1 etc)

— guidance system (rails/slider/rollers)

— counterbalancing ratio

— compensation system.

(*b*) Drive system:

— motor efficiency including any cooling fans

— gear efficiency (if any)

— drive regeneration

— acceleration/deceleration profile

— creeping/levelling time

— brake consumption.

(*c*) Control system:

— controller (traffic and drive) consumption

— door system (drive, passenger detection etc.)

— traffic (dispatcher) efficiency.

(*d*) Electrical system:

— power factor

— heating and cooling

— well/machine room/car lighting.

In addition to the lift equipment aspects an important factor in energy consumption is the way the lift is used and operated.

(*e*) Operational aspects

— number of starts

— travel distance

— speed

— load

— duty.

Some factors are fundamental to providing the transportation service, such as travel distance, car capacity (rated capacity), speed (rated speed), the number of landings served (number of possible stops), and cannot be changed. There are several other factors, which should be considered at the design and specification stage, that affect energy consumption.

13.4.1 Mechanical system

The type of gearing (if applicable) employed can affect the consumption, for example worm gearboxes are less efficient that helical gearboxes. Worm type gears have efficiencies significantly lower in the reverse direction compared to the forward direction. Gearbox efficiencies can be as low as 30% for low torque systems approaching 70% for high torque systems. Modern gearbox efficiencies can be higher, typically 70–90%.

Lift systems employ a number of roping systems, such as 1:1, 2:1 etc., and single and double wrap. Generally the simple roping systems, e.g. 1:1, lead to more efficient lift systems.

Sometimes a flywheel is used on two-speed systems to smooth the sudden changes in torque. The use of a flywheel reduces the efficiency of the system. The inertia of other moving masses should always be minimised.

All lift systems need to overcome friction in the guide rails, guide shoes etc. and air resistance to the car moving in the well. The weight of the empty car has an important effect and should be kept to a minimum, whilst maintaining traction. In general, the weight of the empty car can be twice that of the rated load for the larger car sizes. Reducing the weight of the empty car has the advantage of also reducing the weight of the counterweight and hence the energy consumption.

13.4.2 Drive system

Drive systems are fully discussed in chapter 8.

The main types of electric traction drive systems available today are based on variable voltage, variable frequency (VVVF) technology. Older systems include: single/two speed AC, variable voltage (ACVV) with DC injection braking, Ward-Leonard, thyristor-Leonard and AC-thyristor. VVVF systems can be installed with or without regeneration back to the supply, the latter being very energy efficient

Hydraulic drives are considered to be less efficient than traction systems, as conventional hydraulic drives are unable to recover any of the energy consumed in driving the lift up during the return downward journey. However, systems are now appearing that overcome this problem. One uses a pressurised accumulator to recover some of the energy during the down trip. Another system uses a VVVF pump system to control oil flow more accurately.

13.4.3 Control system

The drive control system can allow the drive to operate efficiently by profiling the movement between stops in an optimal manner. The values selected for speed, acceleration and jerk (often dictated by the traffic design and ride comfort requirements) can affect the energy consumption. Some drive systems can optimise the energy used for the next journey dependent on the car load, direction of travel and distance to be travelled.

Some traffic control systems move lifts to parking floors when they become idle. This feature may be useful during peak periods, but is wasteful out of hours or in light duty environments.

13.4.4 Electrical system

The efficiency of various components is important. The motor and any generators incur iron and copper losses and suffer internal windage losses. There are losses due to the system running at power factors less than unity. Table 12.5 gives estimates of energy dissipation. Additional losses can also occur in the connecting wiring.

The drive and traffic controller uses energy (standby power) even when the lift is not moving. A system of powering-off a controller during low traffic conditions should be considered in a way similar to the MG (motor-generator) set shut down sequence used on older Ward-Leonard systems.

Energy is also used for car and machine room lighting, heating, cooling etc. If the car lighting can be reduced when the lift is idle significant energy savings are possible. Well lighting can often be left on accidentally and consideration should be given to automatically turning it off after (say) five hours.

The Hong Kong Government has proposed limiting the size of the hoist motor as a means of limiting energy consumption[11,12]. This proposal, however, can have a considerable effect on the handling capacity, passenger waiting and passenger waiting times and would not be acceptable in most situations.

For low-use lifts, the energy consumed on standby may be greater than that used when running.

13.4.5 Duty

The level of usage is defined by:

— the numbers of passengers demanding service

— the number of journeys made by the passengers and their destinations

— the variation of the load in the car

— the direction of travel

— idle time, and

— the weight of the car.

All of the above have a significant effect on energy consumption. Figure 13.2 shows the energy consumption graph[13] for different car loads. The shaded area shows the opportunity to recover energy back to the power supply for a 75% loaded down trip.

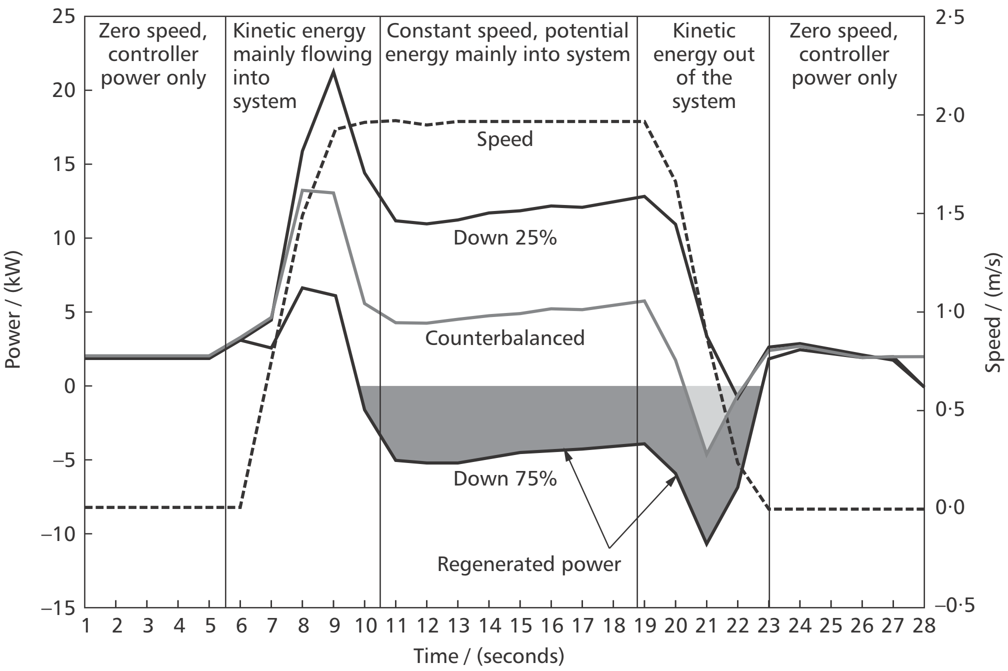

Figure 13.2 Speed and energy consumption of an elevator carrying different loads(13)

Lifts are generally designed to be counterbalanced at 40–50% of rated load. This is arranged by making the mass of the counterweight equal to the mass of the empty car plus 40–50% of the rated load in the car. Figure 13.2 assumes that the installation has a 42% counterbalancing. Thus the most efficient use, in this case, is when the car is 42% loaded.

The traffic control algorithm (see chapter 9) can have an influence on how the traffic demand is handled. For example, under heavy demand conditions, a hall call allocation system can be inherently more energy efficient as it groups passengers travelling to the same floors together. It is also possible for the traffic controller to provide an algorithm designed for energy saving operation.

Another method to reduce energy usage is to remove lifts from service outside the peak periods. This has the effect of increasing the car occupancy levels and hence brings the lift system closer to a balance condition. There can be an increase in passenger waiting times using this technique.

13.4.6 Regenerating energy back into the supply

In any hoisting application, potential energy is transferred back and forth from the power supply to the load and vice versa. When a lift system is running up empty (or down full), it is ‘overhauling’. The motor is effectively driven by the load, under the influence of gravity thus braking the lift system and preventing freefall. Lifts always need to dissipate excessive energy from the system, either as waste heat into banks of resistors, or by regeneration. Whether the energy can be regenerated and the mechanism for achieving it depends on the type of drive.

Regenerating lift drive systems return the stored energy back to the supply through the supply metering system. However, not every meter can record this reverse power and deduct units from the total. A special meter has to be fitted by agreement with the utility company. Where this is not possible arrangements should be made for the regenerated power to be used by other energy ‘sinks’ in the building, such as lighting, HVAC etc. (see Figure 13.1). It is important to remember that regeneration can cause the supply voltage to rise at the lift input terminals, unless it is connected to a low impedance supply.

13.5 Measuring the energy consumption of lifts

13.5.1 Measurement method

ISO standard DIS 25745-1: *Performance of lifts, escalators and Moving Walks*: *Part 1: Energy measurement and conformance*(14) issued for comment in 2008, proposes a standardised measurement system for lifts. It defines three operational conditions:

— *running*: when the lift moving in either the up or down directions

— *idle*: when a lift is stationary at a landing with its doors closed

— *standby*: when the lift is stationary at a landing with its doors closed, with parts of the electrical system de-energized or operating at reduced power.

The standby condition may be identical to the idle condition if parts of the electrical system are not de-energized or not operating at reduced power. DIS 25745-1 suggests that the change from idle to standby conditions should occur in less than five minutes from the lift’s last activity.

The standard specifies an accurate method to measure the energy consumed by the lift. The measurements are practical to apply in the field and repeatable when performed by a trained, competent person, and they utilise commonly available measuring equipment.

This standard specifies the measurement of the energy consumed by a running lift when making a 'reference cycle'. The reference cycle obtains an energy expenditure value for the movement of an empty car from the bottom terminal floor to the top terminal floor and back to the bottom terminal floor (or vice versa), including door operations. The total energy consumed is made up of four components:

(1) energy to travel from the bottom terminal floor to the top terminal floor

(2) energy consumed when the lift is stationary at the top terminal floor including that used to operate the doors

(3) energy to travel from the top terminal floor to the bottom terminal floor

(4) energy consumed when the lift is stationary at the bottom terminal floor including that used to operate the doors.

The energy consumed per reference cycle is presented in mW·h and given the symbol E_{rc}.

Full details of the measurement set-up, instrument type and accuracy etc. are given in ISO/DIS 24745-1[14].

13.5.2 Normalising the energy consumed

In order to compare different systems offered by suppliers, or to determine improvements when a modernisation is proposed, the energy consumed can be normalised to obtain a specific running energy. An idea for normalisation for the energy consumed by a lift was first proposed by Lam, So and Ng in 2006[15]. They divided the total energy used by the rated load of the lift and the distance travelled.

Relating this to the ISO reference cycle gives:

$$E_{sprun} = \frac{E_{rc}}{Q \times S_h} \tag{13.1}$$

where E_{sprun} is the specific running energy consumed for a single reference cycle (mW·h/kg·m), E_{rc} is the energy consumed for a single reference cycle to ISO/DIS 25745-1 (mW·h), Q is the rated load (kg) and S_h is twice the travel height between the bottom and top terminal floors (m).

This normalisation method relates the load carried over a travel distance to the energy consumed, i.e. the dynamic situation. It also gives an explicit value for the lift system with reference to the building in which it is installed. The same equipment installed in different buildings may produce different values.

Normalised values of energy consumption allow comparisons to be made between different tenders, new systems or when upgrading is being considered

Example 13.1

A lift with a rated load of 1000 kg and a travel height of 23.7 m consumes 58 500 mW·h of energy for an ISO reference trip cycle. This gives a specific energy value of 1.23 mW·h/kg·m.

13.5.3 Energy verification

ISO/DIS 24745-1[14]. also specifies a lift energy verification check to determine that the energy usage has not significantly changed over the life of the installation.

To allow for a quick, simple procedure, only the current is measured, as this is the most likely element of energy consumption that will change with equipment ageing. The procedure is to measure and record the main and auxiliary currents when the unit is running and when the unit is in standby.

After the initial full energy measurements have been made, periodic checks may be performed at any time during the operating life of equipment to determine whether the energy consumption of the equipment has changed.

Full details of the measurement set-up, instrument type and accuracy etc. are given in ISO/DIS 24745-1.

13.6 Estimating the energy consumption of lifts

ISO/DIS 25745-1[14] provides a calculation method to estimate lift energy consumption using the following formula:

$$E_L = \frac{S\,P\,t_h}{4} + E_{standby} \tag{13.2}$$

where E_L is the energy used by a single lift in one year (kW·h), S is the number of starts made per year, P is the rating of the drive motor (kW), t_h is the time to travel between the main entrance floor and the highest served floor from the instant the doors have closed until the instant they start to open (i.e. one half of a reference trip cycle) (s) and $E_{standby}$ is the energy used by a single lift in one year (kW·h).

Equation 13.2 relies on a number of assumptions:

— the building has a uniform floor population

— the number of up stops are equal to the number of down stops

— no allowance is made for regeneration

— no allowance is made for the actions of the traffic controller (single units only are considered)

— no significant number of stops are made below the main entrance floor

— there is no additional energy for travel through an express zone accounted for in this formula.

For hydraulic or similar technologies the number of starts should be divided by 2.

The derivation of equation 13.2 takes into account that, in practice, a lift operating over long periods of time has on average a very low car occupancy (estimated as less than 10%) owing to many trips being made empty or with one passenger. The periods when a lift is filled to high occupancy levels are very short. This correlates well with the ISO reference cycle based on measurements with an empty car.

Equation 13.2 also takes into account that an average trip may not run the total possible travel. Typically travels averaged over a long period only run approximately half the possible total travel.

The divisor '4' represents half travel by dividing t_h by 2, and accounts for the ISO Reference Cycle (including two starts) by dividing S by 2 .

The variables are obtained as follows:

— Finding S: a value for S may be provided for a proposed installation by the developer/architect, or obtained from Table 13.1 or, for an existing installation, obtained from a 'trip' counter. For example, an office might have 750 starts per day for 260 days a year, giving a total of 195000 starts per year.

— Finding P: a value for P may be provided for a proposed installation by the lift supplier or, for an existing installation, obtained from the rating plate of the drive motor. Both methods are likely to be inaccurate as motors are supplied to different frame sizes and the designer may slightly undersize or oversize by using the nearest frame size to meet the drive requirements.

— Finding t_h: a value for t_h may be provided for a proposed installation by the lift supplier or, for an existing installation, obtained by measurement. An approximate value can be calculated by dividing the travel distance (m) from the main entrance floor to the highest served floor, by the rated speed (m/s). When carrying out a calculation it should be noted that the time the lift rests at the landing during door operations is not included. Power is consumed under this condition at the idle value.

Table 13.1 Lift duty (source: ISO/DIS 25745-1[14])

Lift duty	Rating (starts/hour)	Starts/day	Examples (days/week)
Low	60	<100	Residential care (7), goods (5), library (6), entertainment centres (7), stadia (intermittent)
Medium	120	300	Office car parks (5), general car parks (7), residential (7), university (5), hotels (7), low-rise hospitals (7), shopping centres (7)
High	180	750	Office (5), airports (7), high-rise hospitals (7)
Intensive	240	1000	Headquarters office (5)

— Finding $E_{standby}$: a value for $E_{standby}$ may be provided for a proposed installation by the lift supplier or, for an existing installation, it may be obtained by measurement.

($P \times t_h$) is equivalent to the energy value obtained for one ISO reference cycle (i.e. 2 stops). If this energy consumption value is known by measurement or provided by a supplier, a more accurate estimate can be obtained by substituting this value for the ($P \times t_h$) term in equation 13.2.

To convert an energy value in watt-seconds (W·s) to kilowatt-hours, divide by 3.6×10^6.

Example 13.2

A small office lift with a rated load of 1000 kg and a rated speed of 1.0 m/s has a motor displaying a rating plate of 7 kW. The measured power rating is 8.5 kW. The lift makes 106 starts per hour and operates for 399 hours per year. The time to travel the full travel is 21.6 s. The standby power is given as 78 W and the energy used for an ISO reference cycle is given as 58.5 W·h.

Using equation 13.2:

$$\text{Number of starts per year } (S) = 106 \times 399 = 42\,294$$

For the first part of the equation:

(*a*) Using the motor plate power rating:

Energy used when running

$$= (42\,294 \times 7 \times 21.6)/(4 \times 3600)$$

$$= 444 \text{ kW·h}$$

(*b*) Using measured power rating:

Energy used when running

$$= (42\,294 \times 8.5 \times 21.6)/(4 \times 3600)$$

$$= 539 \text{ kW·h}$$

(*c*) For the ISO reference cycle:

Energy used when running

$$= (42\,294 \times 58.5)/(4 \times 1000)$$

$$= 618.5 \text{ kW·h}$$

For the second part of the equation:

$$E_{standby} = 78 \times (8760 - 399) = 652 \text{ kW·h}$$

where 8760 = number of hours in a year.

The values obtained in this example indicate the possible inaccuracies in the estimation method. The use of the measured power value, or that measured for an ISO reference cycle is likely to be the most accurate. This lift might use in a year 1270 kW·h. At a tariff of 15p per unit (kW·h) this is an annual running cost of £190.

13.7 Factors affecting consumption of escalators and moving walks

The majority of escalators and moving walks operate continuously at a constant speed. However, some are programmed to operate at lower speeds, either when no demand is detected or by the use of time clocks. Escalators and moving walks can also be fitted with an 'auto-start' control that detects the presence of potential passengers and starts the escalator or moving walk.

Escalator and moving walks energy consumption is dependent on:

- rise (if any)
- speed
- step/pallet width
- mechanical design
- direction of travel
- number of passengers
- whether or not passengers walk.

13.8 Estimating the energy consumption of escalators and moving walks

13.8.1 Escalators

Little work has been carried out on the energy consumption of escalators. The London Underground has carried out some work (Al-Sharif, 1998[16]).

Escalator power consumption may be divided into fixed losses and variable losses. Figure 13.3[16] diagrammatically illustrates the relationship between the power consumption of an escalator, its rise and the number of passengers boarding per minute.

Variable losses can be positive or negative depending on the direction of travel. Passengers, who walk on the escalator (rather than stand) have an effect on the variable losses and can reduce them by up to 30%.

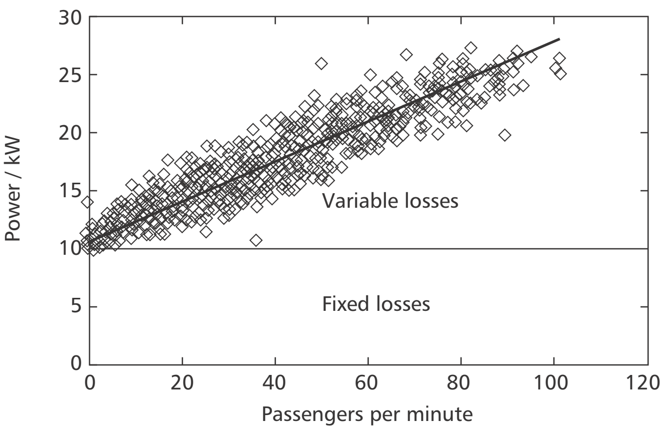

Figure 13.3 Fixed and variable losses for an up-escalator[16]

The fixed energy consumption (L_f) in kW·h per day can be calculated, using the following equation:

$$L_f = (0.55\,R + 1.95)\,H \qquad (13.3)$$

where R is the rise (m) and H is the number of hours of operation (h).

This equation ignores the mechanical design of the escalator. Mechanical design involves the type of bearings (plain or ball), guidance system (chain or wheel) and gearbox (involute or convolute). The majority of escalators use ball bearings, chain guidance and involute gearboxes, for which equation 13.3 applies.

The variable energy consumption (L_v) in kW·h per day can be calculated using the following equation:

$$L_v = \frac{P \times W \times 9.81 \times R}{3600 \times 1000} \times k \qquad (13.4)$$

where P is the number of passengers using the escalator per day, R is the rise of the escalator (m), W is the average 'weight' (strictly mass) of a passenger (kg) and k is the walking factor.

Note that the constant (3600 × 1000) is used to convert from joules to kW·h.

The walking factor (k) varies between 0.7 and 1.0 and is used to account for passengers who walk up or down the escalator. The lower value (i.e. 0.7) would apply to a high percentage of walking passengers at a fast pace. The upper value (i.e. 1.0) would apply if there are no walking passengers.

The total daily energy consumption (L_d) can be found by taking the fixed daily losses (L_f) and adding (for an up escalator) or subtracting (for a down escalator) the variable daily energy consumption (L_v).

$$L_d = L_f \pm L_v \qquad (13.5)$$

The total yearly cost can be found by multiplying the total daily losses by the applicable number of days in the year. This could be 365 days for escalators in public service (e.g. railway stations) or 260 working days per year for commercial premises (e.g. offices).

Example 13.3

Calculate the annual energy consumption for an escalator with a rise of 2.5 m running in the down direction, used by 5000 passengers per day. Assume that the 'weight' of an average passenger is 75 kg and the escalator runs for 10 hours per day, 365 days per year. Ignore the mechanical design of the escalator.

The fixed daily energy consumption is calculated from equation 13.3 as follows:

$$L_f = ((0.55 \times 2.5) + 1.95) \times 10 = 33.25 \text{ kW·h/day}$$

The variable energy consumption is calculated from equation 13.4:

$$L_v = \frac{5000 \times 75 \times 9.81 \times 2.5}{3600 \times 1000} \times 0.7 = 1.79 \text{ kW·h/day}$$

This is a 'down' escalator and the net daily consumption is the difference between the two values and the annual consumption (L_a) is:

$$L_a = 365 \times (33.25 - 1.79) = 11.5 \text{ MW·h/year}$$

It can be seen in general from these examples that the dominant factor for the energy consumption is the fixed energy consumption.

The variable energy consumption is averaged over a day and is very small. The fixed daily energy consumption is the significant term. However, during periods of heavy loading this relationship reverses, when the fixed losses may be only 15–20% of the total consumption.

13.8.2 Moving walks

No method currently exists to provide a mathematical analysis, thus energy estimations can only be made from measurements. The following section describes measurements that can be used to estimate energy consumption.

13.9 Measuring the energy consumption of escalators and moving walks

ISO/DIS 25645-1[14] specifies an accurate method to confirm manufacturers' declarations of energy usage and to verify energy usage during the life of the installation.

13.9.1 Energy measurements

The standard specifies an accurate method to measure the energy consumed by the escalator and moving walk equipment. When performed by a trained, competent person the measurements are practical to apply in the field, are repeatable, and utilise commonly available measuring equipment.

The procedure is to measure the energy consumed by an empty unit over a five minute period and, from this, calculate the power consumption. The running energy is recorded.

A second measurement is made with the unit in standby defined as either (*a*) in auto start status or (*b*) running at slow speed (or stopped for variable speed systems). The standby energy is recorded.

Full details of the measurement set-up, instrument type and accuracy etc. are given in ISO/DIS 24745-1[14].

13.9.2 Energy verification

The standard also specifies an escalator and moving walk energy verification check to determine that the energy usage has not significantly changed over the life of the installation.

To allow for a quick, simple procedure, only the current is measured as this is the most likely element of energy consumption that will change with equipment ageing. The procedure is to measure and record the main current when the unit is running and when the unit is in standby.

After the initial energy measurements have been made, periodic checks may be performed at any time during the operating life of equipment, to determine whether the energy consumption of the equipment has changed.

Full details of the measurement set-up, instrument type and accuracy etc. are given in ISO/DIS 24745-1[14].

13.10 Measures to conserve energy

Vertical transportation systems should be upgraded every 10–15 years to improve passenger service, increase reliability, performance and particularly to reduce energy consumption. The following measures should be taken into account when designing energy efficient vertical transportation systems. To take proper account of some of these measures requires specialist knowledge applied to the specific application.

13.10.1 Lifts[17]

Lift motors do not work continuously, nor do they work at constant loads and energy efficiency and energy saving measures that can be taken include:

— Group lifts together in order to minimise the number of journeys by collecting passengers to travel together.

— Locate lifts in the most appropriate positions and locate stairs before lifts. If passengers pass a well signposted staircase on the way to the lift, the demand for the lift may be less.

— Review the traffic patterns and consider the suitability of the lift traffic controls to the demand. Select the lift control strategy to minimise the number of journeys.

— Select lift speeds that are appropriate to the task, e.g. use slower speeds for goods lifts.

— Replace older drives with energy efficient motors. In particular, old Ward-Leonard systems can be very inefficient and lead to high energy consumption.

— Select an energy efficient drive for the lift and consider regeneration systems where the energy can be used on site or passed back to the utility company.

— Recover waste heat from lift motor rooms if the lifts are used intensely. Typically the heat generated into the machine space from an electric traction lift is 30% and from a hydraulic lift is 50%, see Table 12.5.

- In some multiple lift installations, it may be advantageous to omit the parking feature, where idle lifts are directed to specific floors.
- Consider the possibility of shutting-down some lifts whenever there is little demand. This avoids more lifts being in service than are required and also eliminates the controller standby consumption.
- Consider reducing car lighting and ventilation, when passengers are not being carried.

13.10.2 Escalators and moving walks

Unlike lifts, most escalators and moving walks operate continuously once they have been started up. Measures that can be taken include:

- Delay starting escalators and moving walks for as long as is practicable at the beginning of the working day.
- Stop some escalators and moving walks, when convenient, after peak periods.
- Stop some escalators and moving walks, when convenient, after normal working hours.
- Use auto start-up, or programme multiple escalators/moving walks to ensure they operate only when there is a demand.
- Use variable speed escalators and moving walks (see section 10.5.4).

13.11 Building energy classification systems

13.11.1 BREEAM

UK-BREEAM (Building Research Establishment's Environmental Assessment Method) is one of the world's leading and most widely used environmental assessment method for buildings, with over 115 000 buildings certified and nearly 700 000 registered. It sets the standard for best practice in sustainable design and has become the de facto measure used to describe a building's environmental performance. Other methods include LEED[18] in the USA and CASBEE[19] in Japan. They all include lifts, escalators and moving walks in the classification.

An aim of BREEAM is to stimulate the demand for sustainable buildings by setting criteria and standards surpassing those required by regulations and to challenge the market to provide innovative solutions that minimise the environmental impact of buildings.

There are at the present time BREEAM Scheme Manuals to cover seven building types*: courts, education, industrial, healthcare, offices[20], retail and prisons, although a bespoke assessment can also be carried out. All include a section on lifts, escalators and moving walks.

* Only BREEAM for offices referenced here; for information on BREEAM for other sectors, see http://www.breeam.co.uk

In the office scheme, credits are awarded in nine categories: management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, and pollution. These credits are then added together to produce a single overall score on a scale of 'pass', 'good', 'very good', 'excellent' and 'outstanding'. Lifts, escalators and moving walks are included within the 'energy' category.

The rating benchmarks for the 2008 office version of BREEAM are outlined in Table 13.2 for new buildings, major refurbishments and fit-out projects:

An example of a BREEAM score and rating calculation for a office is shown in Table 13.3.

Table 13.2 BREEAM 2008 rating benchmarks for offices

BREEAM rating	Score (%)
Unclassified	<30
Pass	≥ 30
Good	≥ 45
Very good	≥ 55
Excellent	≥ 70
Outstanding	≥ 85

Table 13.3 Example BREEAM score and rating calculation

BREEAM section	Credits achieved	Credits available	Credits achieved (%)	Section weighting	Section score (%)
Management	7	10	70	0.120	8.40
Health and wellbeing	11	14	79	0.150	11.79
Energy	10	21	48	0.190	9.05
Transport	5	10	50	0.080	4.00
Water	4	6	67	0.060	4.00
Materials	6	12	50	0.125	6.25
Waste	3	7	43	0.075	3.21
Land use and ecology	4	10	40	0.100	4.00
Pollution	5	12	42	0.100	4.17
Total score					54.87
Innovation credits					1
Final BREEAM score					55.87
BREEAM rating:					Very good

Lifts are in the 'Energy' section, which represents 19% of the overall possible rating.

The energy section has nine sub-sections as shown in Table 13.4 (page 13-10).

Lifts can attract two (2) credits, i.e. about 10% of the energy score or about 2% of the total score. Thus a building rated 'Good' with a score of 54 could gain two points from the provision of energy efficient lifts which would take the score to 56 and thus achieve a 'Very good' rating. Escalators and moving walks can only attract one (1) credit.

Table 13.4 Credits available in BREEAM energy section

Energy sub-section	Credits
Ene 1: Reduction of CO_2 emissions	15
Ene 2: Sub-metering of substantial energy uses	1
Ene 3: Sub metering of high energy load and tenancy areas	1
Ene 4: External lighting	1
Ene 5: Low or zero carbon technologies	1–3
Ene 6: Building fabric performance and avoidance of air infiltration	0
Ene 7: Cold storage	0
Ene 8: Lifts	2
Ene 9: Escalators and traveling walkways	1
Maximum total credits	22–24

13.11.2 Compliance requirements for lifts

One credit can be earned if:

(1) an analysis of transport demand and patterns for the building has been carried out by the design team to determine the optimum number and size of lifts and counterbalancing ratio on the basis of anticipated passenger demand

(2) the energy consumption for at least two types of lift or lift strategy ‘fit for purpose’ has been estimated and the system with the lowest energy consumption specified.

Two credits can be earned if:

(3) the first credit is achieved

(4) of the following energy-efficient features, the three that offer the greatest potential energy saving are specified:

(*a*) The lifts operate in a stand-by mode during off-peak and idle periods; e.g. the power side of the lift controller and other auxiliary equipment such as lift car lighting and ventilation fan switch off when the lift is not in motion.

(*b*) Where lift motors use a drive controller capable of variable-speed, variable-voltage, variable-frequency control of the drive motor.

(*c*) The lift has a regenerative unit so that energy generated by the lift (due to running up empty and down full) is returned back to the grid or used elsewhere on site.

(*d*) The lift car uses energy-efficient lighting and display lighting (>60 lumens/watt or fittings that consume less than 5 W, e.g. LEDs).

13.11.3 Compliance requirements for escalators and moving walks

One credit can be earned if:

(1) where each escalator and/or horizontal travelling walkway complies with either of the following:

(*a*) the escalator or walkway is fitted with a load sensing device that synchronises motor output to passenger demand through a variable speed drive, *or*

(*b*) the escalator or walkway is fitted with a passenger sensing device for automated operation, so the escalator operates in stand-by mode when there is no passenger demand.

13.12 Future legislation

The European Union published two directives on 16 July 2010:

— Directive 2010/30/EU of the European Parliament and of the Council on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (recast)[21].

This Directive replaces the 1992 Directive[22]. It defines the energy labels to be affixed to domestic appliances (preamble (2)) and specifically excludes ‘any means of transport for persons or goods’, i.e. home lifts (Article 1, 3 (b)). At Article 10, 4(d) it describes the now familiar A–G domestic rating labels.

— Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings (recast)[23].

This Directive replaces the 2002 Directive[5]. It is concerned with the overall energy performance of buildings, which includes ‘… inter alia, energy used for heating, cooling, ventilation, hot water and lighting’ (Article 2, (4)). In Annex I, (3) it states the calculation methodology should take account of (a) thermal characteristics, (b) heating installation, (c) air conditioning installation, (d) ventilation, (e) lighting, and at (i) internal loads. It would appear that lifts, escalators and moving walks might be categorised as ‘internal loads’.

Thus neither of these Directives considers transportation systems in buildings as worthy of specific consideration. However, the ISO/TC178/WG10 committee (‘Energy efficiency of lifts, escalators and moving walks’) may adopt a labelling system to ‘label’ lifts, escalators and moving walks, and is also currently working on an energy classification system.

13.13 Conclusions

Traction lifts have always been energy efficient as a result of their counter-balanced design. Today, those lifts with regenerative VVVF drives are even more so.

Hydraulic lifts have been less efficient, but recently they have been installed with energy accumulators to capture the ‘down’ movement energy and some suppliers now use VVVF flow control systems.

Escalators and moving walks in the UK have traditionally been left running (if they are stationary UK passers-by think they are out of service), even when there is no demand. However, auto-start control can considerably reduce energy consumption.

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14 Remote monitoring and alarms

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Section contents

14 Remote monitoring and alarms

14.1 Reasons for remote alarms and remote monitoring

This chapter offers some guidelines on remote alarms and remote monitoring, and suggests ways in which the resulting data can be used to improve the efficiency of vertical transportation systems, reduce their costs and allow them to be interfaced with other systems within the building and increase the safety of all users.

There is a wide variety of systems to meet three different and distinct market sectors: passenger safety (alarm) systems, estate management, and lift group management. These requirements can overlap for specific applications and may require a degree of integration between systems.

The first sector, which is dealt with in section 14.2, is to meet the requirements for the provision of 'remote alarm' systems to ensure passenger safety, for instance, persons trapped within a lift car. These systems should connect to a fully attended rescue service.

The term 'remote monitoring' has been used to cover a wide variety of systems ranging from simple alarm pushes, through manually initiated voice calls, to fully automated, computerised systems.

The second sector, which is dealt with in section 14.3.2, arises from the need to manage a large volume of dispersed lifts of varying manufacture owned by local authorities, private housing associations, airports etc. The primary requirement being that of fault indication coupled with the gathering of extensive management information and the transfer of this detailed data back to a central computer system, or third party bureau application.

The third sector, dealt with in section 14.4.3, is applicable to group systems, generally from the same manufacture, operating in a 'campus' situation. In addition to the remote monitoring described in the second sector above, these systems are more closely integrated with the lifts being monitored, being from the same manufacturer, and can offer technical optimisation, configuration and remote control of the lifts.

The second and third market sectors are optional, whereas the first is a mandatory requirement to ensure compliance to the Lifts Regulations 1997(1) for all lifts first put into service after July 1999.

Much of this chapter is concerned with the remote alarms and remote monitoring of lifts. However, some of the guidance can usefully be applied to escalators and moving walks.

Although lift and escalator/moving walk monitoring systems enable building owners to self-manage systems, not all building managers want or need this facility. Most major suppliers offer a monitoring service which simply reports the main facts.

14.2 Remote lift alarms

14.2.1 Remote alarms and BS EN 81: Part 28

The Lifts Directive 1995(2), enacted in the UK as the Lifts Regulations 1997(1), requires in clause 4.5 of Annex I (Essential Health and Safety Requirements), that 'Cars must be fitted with a two-way means of communication allowing permanent contact with a rescue service'.

Clause 14.2.3 of BS EN 81-1/2: 1998(3,4) provided a means to meet this requirement. These requirements were very short and not elaborated and thus gave rise to ambiguity. To clarify this, BS EN 81-28: 2003(5) was published to replace clause 14.2.3 *in toto*. This standard provides the requirements for the alarm system as indicated in the boxed area in Figure 14.1.

The standard requires that an alarm system is provided at all times that a lift is in service, in order to ensure the rescue of trapped persons. The entrapment of passengers is regarded as a foreseeable event.

The alarm system is to be permanently connected to a permanently available rescue service, who must respond within five minutes (under normal circumstances) by a voice communication with the entrapped persons.

The rescue service is to intervene on site within one hour (under normal circumstances) of the alarm being raised.

The standard also states that the trapped person is required to 'be released within the shortest possible time'.

An integrity check of the equipment by service interrogation or by remote initiation is required for 'the safety of the users … at least every three days'. The check is required to automatically simulate the input signal of an alarm (automatic test) and set up the subsequent connection. The requirement does mean that a person could be trapped for three days before the system is checked. Then the trapped passengers would need to be discovered and released. It is recommended that owners instigate an integrity check more frequently than this to ensure that the complete alarm system is operational.

The alarm and test alarms must contain information that allows the rescue service to identify the location without the aid of the entrapped passenger.

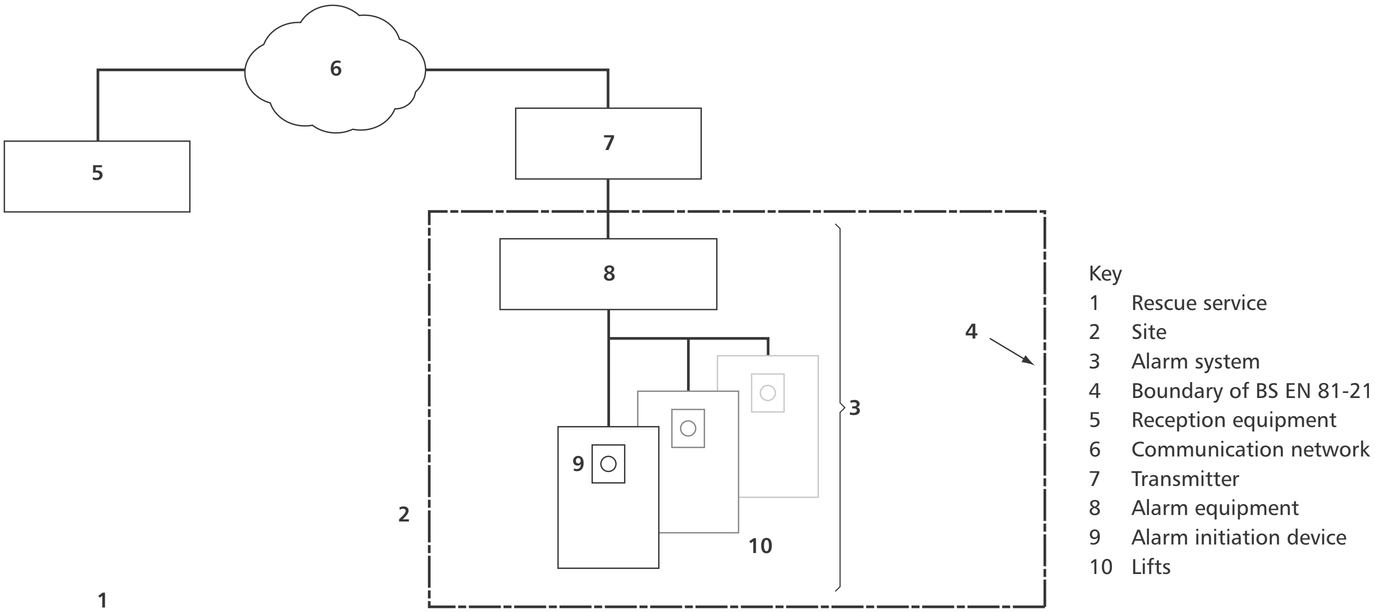


Figure 14.1 Diagram of a BS EN 81-28 lift remote alarm system (reproduced from BS EN 81-28, by permission of the British Standards Institution)

Figure 14.2 illustrates by means of a flow chart and accompanying text, the sequence of operations when an alarm is being processed. The numbers in parenthesis indicate clauses in BS EN 81-28[5].

There should be an exchange of information between the installer, the owner, the rescue service and the user.

After the completion of the lift installation, the following information should be given to the building owner:

— that they must ensure that the lift is connected to a rescue service (5.2)

— all the site information is passed to the rescue service (5.2)

— the need to keep the equipment in working order, and to remove the lift from service when the equipment is out of order (5.2)

— minimum maintenance requirements of the alarm system (5.2)

— how to change dialling parameters, e.g. telephone numbers (5.2).

Information that should be provided by the owner to the rescue service:

— the general information of the system with reference to BS EN 81-28 (5.3)

— the need to establish a continuous 2-way communication with trapped users (5.3)

— the address and location of the lift (5.3)

— building organisation and availability of on site rescue service (5.3)

— access details for the building and lift (5.3)

— special risks for entering building and lift (5.3)

— compatibility between equipment (5.3)

— time limit of emergency power supply unit (5.3).

Sign to be displayed in the lift to provide passenger information:

— 'This lift is equipped with an alarm system and linked with a rescue service' (7).

14.2.2 Communication protocol for Part 28 remote alarms

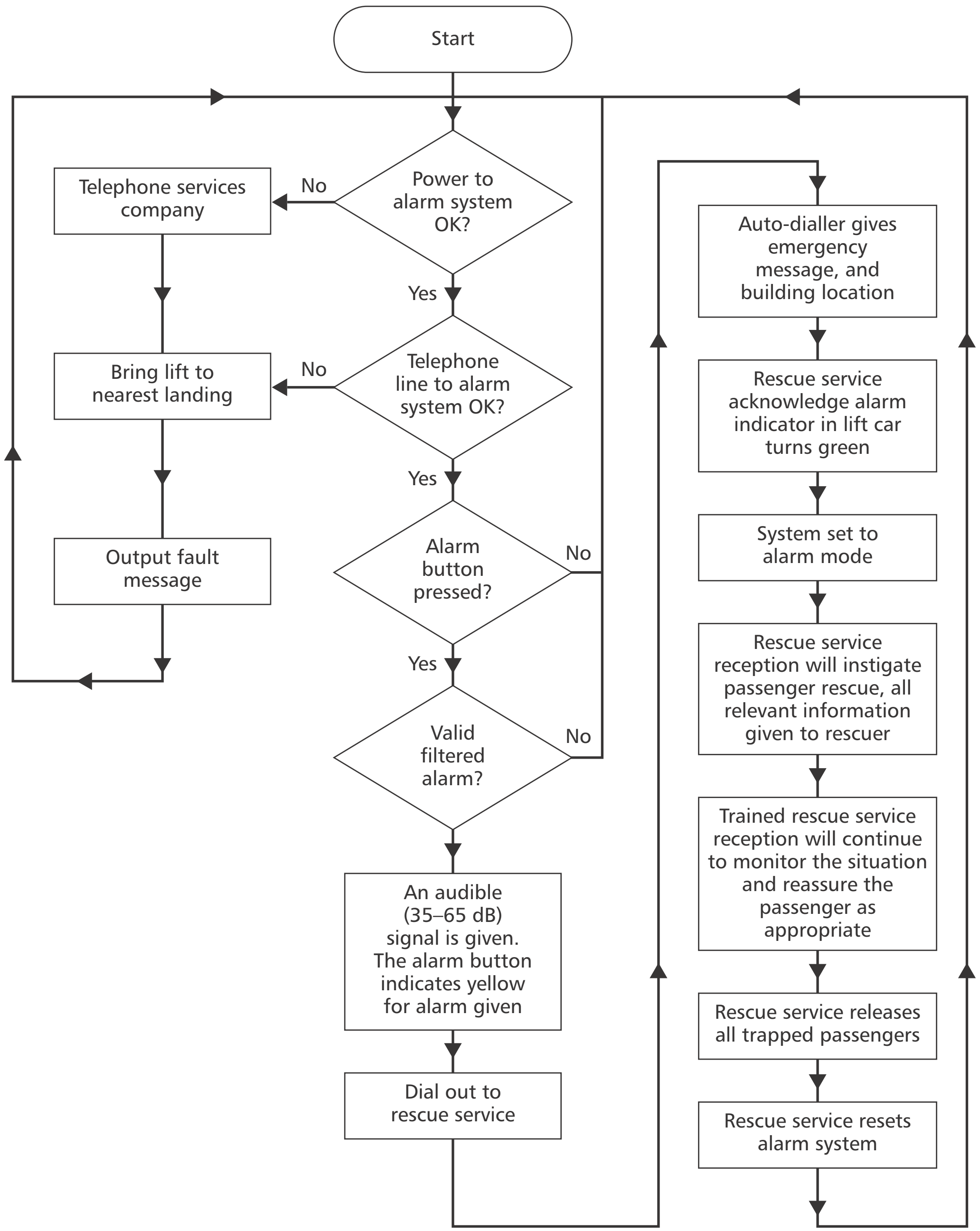
Figure 14.1 indicates the boundaries that apply to the application of BS EN 81-28: 2003[5]. The standard does not apply to item 5 (the reception equipment), item 6 (the communications network) or item 7 (the transmitter).

The lack of a standard communications protocol allowed manufacturers to develop proprietary systems, which did not interface with each other. This situation lead to the publication of DD 265: 2008[6] in response to requests from purchasers and users of lift alarm systems for the establishment of common signalling protocols to ensure that lift alarm systems from different manufacturers exchange essential information and controls in a compatible manner. This is particularly important when a lift alarm system is replaced or repaired, or the rescue service is changed. Essential information and controls include identification of individual lifts, the nature of any alarm and the controls necessary to operate any speech link between a local lift alarm system and an alarm receiving station.

BS DD 265 is based on a social alarm protocol, BS 7369: 1991: *Multi-frequency tone signalling protocol for social alarm systems*[7]. It uses the multi-frequency (MF) tone signals, which can be generated by standard telephone handsets. A communication exchange comprises a sequence of tones, which can be 20 tones long, to construct a message. Error checking is achieved by the receipt of two identical tone strings. Figure 14.3 illustrates the messages exchanged to deal with an alarm call.

Under BS 7369, the tones are given specific meanings as shown in Table 14.1.

The unassigned tone '4' from BS 7369 is used to indicate that the lift communications DD 265 protocol is operating. DD 265: 2008[6] provides full details of the operation



To be read in conjunction with flowchart, Figure 14.2

- Alarm button pressed by passenger (once) to initiate an alarm call.
- No further action is required by passenger.
- The alarm equipment checks that it is a valid alarm before dialling rescue service. *Note*: the rescue service reception equipment must be compatible with site alarm equipment.
- Filter alarm (4.1.5):
  — Is the lift in door zone, e.g. with the doors fully open?
  — Is the lift moving and will doors open at the next landing stop?
- Alarm Call filtering inhibited during maintenance, repair and/or manual test. (4.1.1, 5.2)
- Alarm Call filtering void when between acknowledgement and end of alarm. (4.1.1)
- Once the alarm equipment verifies a valid alarm call (4.1.5) the unit immediately places itself into alarm mode.
- The alarm equipment can then put out a message in the lift car to the passenger(s), e.g: 'Your call has been accepted please wait while we connect you'

  Yellow indicator to illuminate (4.1.4 and BS EN 81-70:2003, 5.4.4.3)
- The alarm equipment dials the rescue service reception equipment. If the first number is unobtainable then alternative number(s) would immediately be called (4.2.1). *Note: e*ach of these numbers must be connect to the reception equipment, not only the telephone handset.
- The rescue service will answer the call.
- The reception equipment identifies and records the site and location of the lift.
- Acknowledgement to the alarm equipment that the call has been received.
- Green indicator to illuminate.
- The rescue service will contact the rescuer and inform them of any relevant information (5.3).
- Whilst the rescue service is travelling to site, the rescue service reception speak regularly with the trapped passenger(s) to inform them of the status of the rescue operation.
- The rescue service arrives on site.
- The rescue service promptly releases the trapped passenger(s).
- After releasing all the passengers, the rescue service reception is informed using the voice unit in the lift car.
- The alarm system is reset. *Note*: the reset button/switch/key is located on the lift installation, inaccessible to unauthorised persons.
- The button/switch/key will generate an end of alarm message before hanging up (4.1.2).

Automatic checks to be made by alarm unit

- Where a rechargeable emergency electrical power supply is used, the reception equipment will be informed automatically that the alarm system has less than one hour of function remaining (4.1.3).
- The alarm equipment must check the system automatically with a simulated input signal at least every 3 days (4.2.1).

Manual checks

- Manual tests should be carried out periodically by the maintenance company or building owner.

Figure 14.2 Operation of a remote alarm: flowchart and description (figures in parenthesis refer to BS EN 81-28[5])

Table 14.1 MF digit assignments

Tone (key)	Function
0	Select sub-unit
1	Request information on outstanding calls
2	Manufacturer-specific functions
3	Control functions (speech)
4	Lift specific messages
5	[Not assigned]
6	[Not assigned]
7	Speak
8	Listen
9	Clear
Þ	Data request
#	End of data (stop)
[A]	Guard
A	Commencement of data (start)
B	Acknowledge
C	Initiate programming
D	Clear down

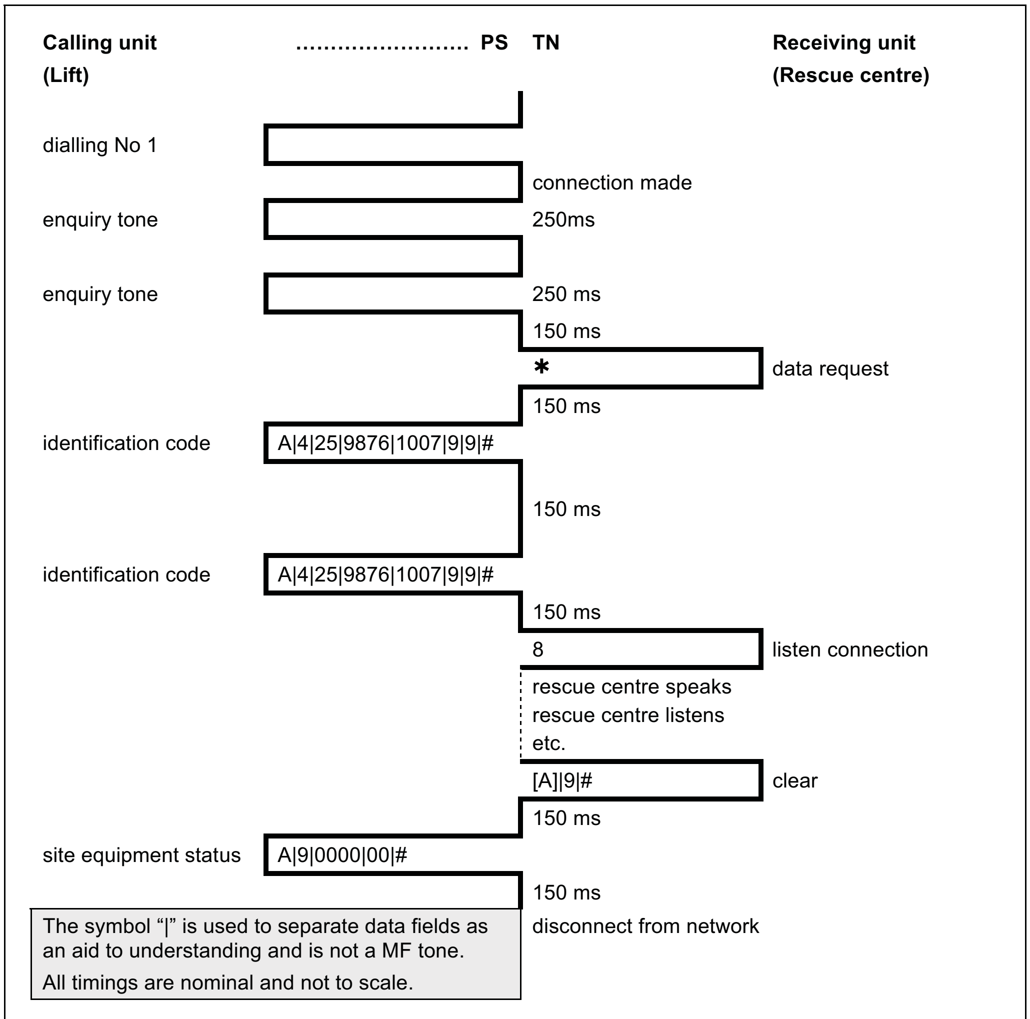
Note: the lettered tones (keys) [A], A, B, C and D cannot be generated from a normal telephone key pad

of the protocol and it is recommended that any remote alarm equipment installed be capable of operating this protocol in parallel with or in place of any proprietary protocol.

It is important to note that there are changes being proposed in the backbone PSTN (public switched telephone network) generally provided by BT, both to permanent lines and mobile (GSM) services to accommodate new internet developments such as 'voice over internet' protocol (VOIP). Users of DD 265 should keep themselves informed of these developments in order that equipment designed to the recommendations of DD 265 does not become inoperable at some future time. Manufacturers of equipment conforming to this protocol and proprietary protocols should also comply with the National Transmission Plan[8] to ensure that their equipment is compatible with 21CN ('21st. Century Network').

DD 265 does not cover any data processing aspects of the receiving station beyond those required by BS EN 81-28. This allows suppliers to provided value added services such as data processing, graphics displays, reports, etc.

It should be noted that a review of DD 265: 2008 is required to be carried out in 2010 and thus the details of the protocol may change.



In this example there is a message from the lift (4) to the automatic alarm receiving station, using manufacturer (25) equipment, at location (9876), sub-unit (1007), which reports an entrapment (9) at priority (9). After a conversation between the lift and the rescue centre the trapped persons are released and a clear [A]9 is sent. The site equipment (0000) reports no (00) events pending.

Figure 14.3 Diagrammatic representation of an example of an alarm message and speech communication using an automatic alarm receiving station (rescue service) (reproduced from DD 265[6] by kind permission of the British Standards Institution)

14.3 Remote lift monitoring systems

14.3.1 General features of lift monitoring systems

Remote lift monitoring can provide:

— *Fault monitoring*: informing the building owner or service company immediately the equipment has broken down; hence faster response, less downtime.

— *Condition based monitoring*: monitoring the number of starts and hours in service remotely allows data to be processed for efficient, selective, planned, maintenance.

— *Video monitoring*: use of a small camera to record and transmit compressed images.

— *Data logging*: graphical analysis of types of faults, fault comparisons on a unit by unit basis.

— *Monitoring site personnel safety*: after logging in during attendance, service personnel must periodically reset a 'watchdog' alarm.

— *Alarms and vandalism*: locations such as the machine room, car top, inside of a lift car etc. can be event-triggered and monitored for an unauthorised entry.

A remote monitoring system for a lift or escalator/moving walk comprises monitoring units, communication systems and management systems. The overall system may be designed to monitor one or more data sources: alarms, faults, events and information.

Figure 14.4 provides an outline of a computerised lift monitoring system. The general features of such a system should include:

— indication of lift-in-service status

— lift alarm integrity check

— performance indication

— early transmission of alarms and status to the lift maintenance contractor's monitoring and control centre

— automatic collection of lift performance data

— remote configuration of field units

— ability to conduct 'on-line' investigation and analysis of lift activity

— optional measurement of levelling performance

— statistical report generation.

In addition the system may include the management of:

— trapped passenger alarms

— two-way voice communication with trapped passengers.

Figure 14.5 (page 14-6) shows an example of an extensive monitoring system.

14.3.2 Estate management

These systems are provided to owners who have management responsibilities but little technical involvement over the lift stock. Generally the range and volume of lifts include lifts of varying manufacture, type and age. The remote monitoring system is required to integrate these lifts, provide a basic set of information to indicate faults, status and performance. The receiving central system should perform data acquisition, statistical calculations from site history files, alarm management, operator display and control. This enables the lift owner or operator to maintain the equipment to a high standard, offer immediate response to equipment failure, economically plan repair and refurbishment work and predict potential equipment failure.

An example of a report of availability is shown in Figure 14.6 (page 14-6).

14.3.3 Grouped systems

Lift remote monitoring can also be used for grouped control systems. However there is a requirement to differentiate between this and 'estate management (see 14.3.2), which represents true lift monitoring. Grouped systems are generally installed in a campus situation with the lift controllers and the lift monitoring system from the same manufacturer. These systems are generally managed by building occupiers. The 'monitoring' interface is

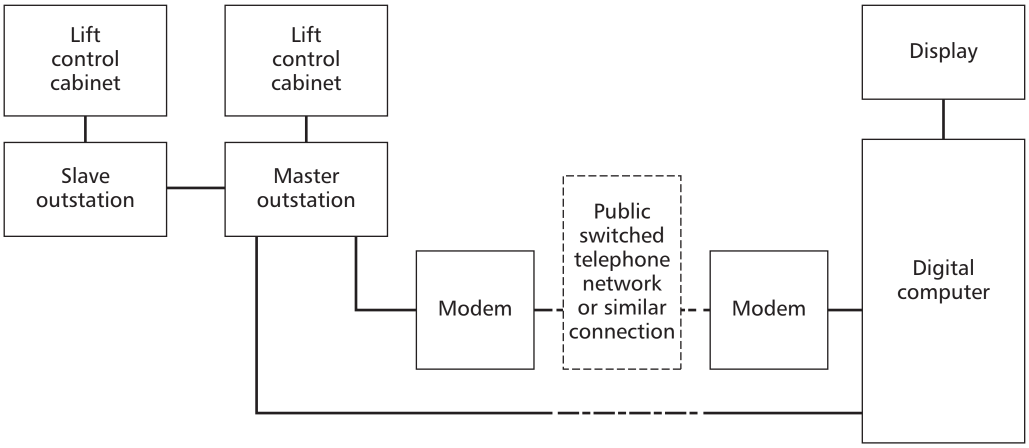


Figure 14.4 Outline of a computerised lift monitoring system

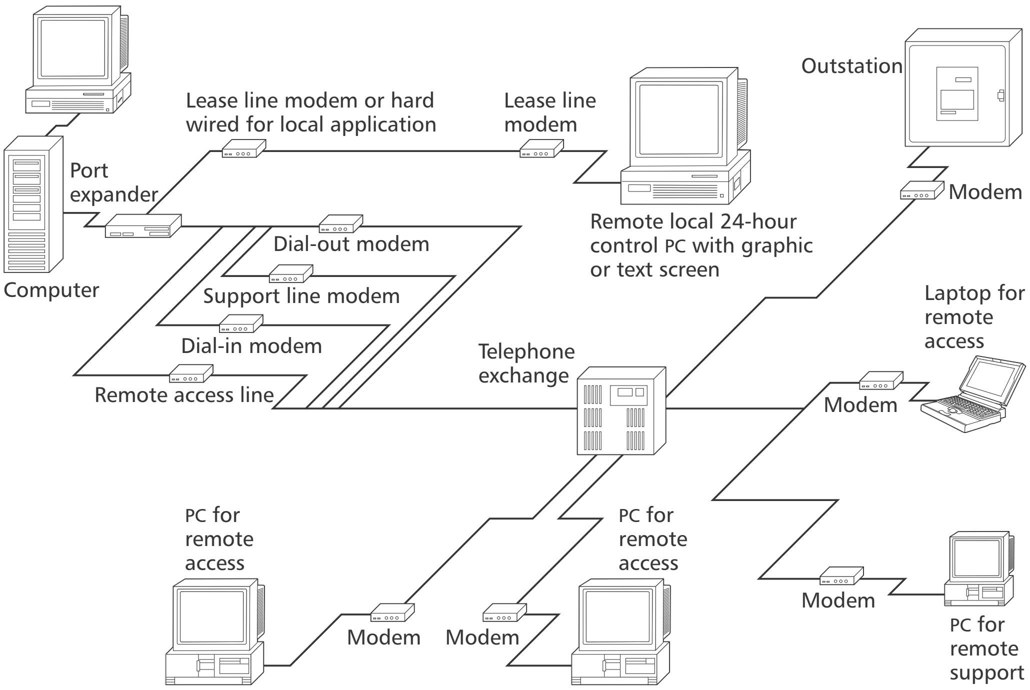
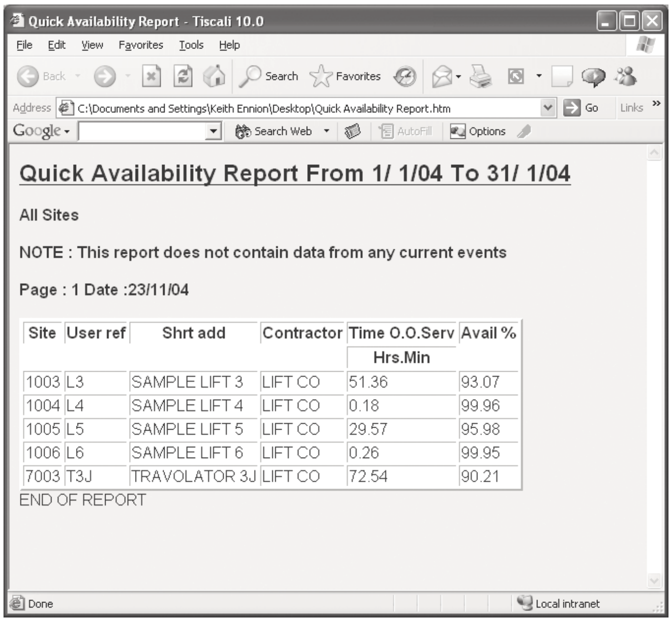


Figure 14.5 Example of an extensive monitoring system



Quick Availability Report From 1/ 1/04 To 31/ 1/04

All Sites

NOTE : This report does not contain data from any current events

Page : 1 Date :23/11/04

Site	User ref	Shrt add	Contractor	Time O.O.Serv Hrs.Min	Avail %
1003	L3	SAMPLE LIFT 3	LIFT CO	51.36	93.07
1004	L4	SAMPLE LIFT 4	LIFT CO	0.18	99.96
1005	L5	SAMPLE LIFT 5	LIFT CO	29.57	95.98
1006	L6	SAMPLE LIFT 6	LIFT CO	0.26	99.95
7003	T3J	TRAVOLATOR 3J	LIFT CO	72.54	90.21

END OF REPORT

Figure 14.6 Equipment availability analysis

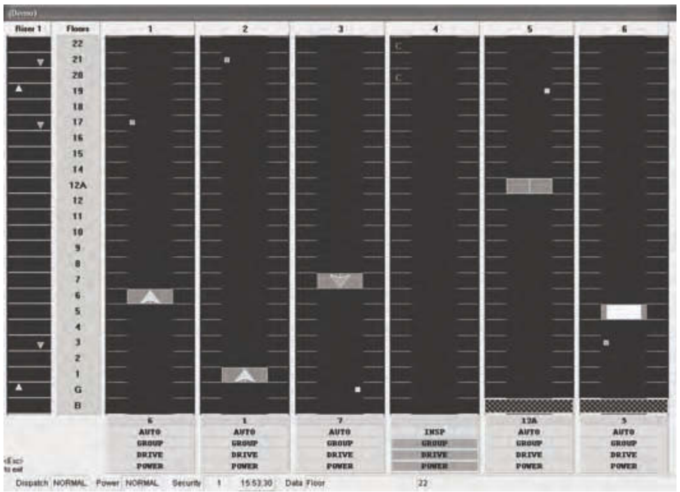


Figure 14.7 Example of a real-time display of lift activity

generally an 'always on' connection. The actual fault monitoring relates to loss of power supplies, alarms operated etc., but with no logical determination of other running fault conditions. In these circumstances it is possible for the controller-based fault logger to pass events directly to the outstation. However, this technique is only suitable for group systems as in an estate management system it would lead to varying and non-standard monitoring.

Group systems do provide some extra advantages:

- traffic reports: response times, percentiles, number of calls etc.
- security feature to enable/disable access to specified landings
- examples of real-time display of lift activity (see Figure 14.7).

14.4 Building management systems

14.4.1 Benefits of connection with a BMS

There are considerable benefits to be gained by connecting any building service into a building management system (BMS), and the following advantages should be noted:

- *Common user interface*: the lift system may be accessed using a standard interface, which is common to other services within the building, e.g. fire and security.
- *Cost savings*: a standard interconnection between the lift monitoring system and the BMS.
- *Space savings*: often there is insufficient space for more than one display terminal and keyboard.

High-resolution monitors and multiple-task software allows a single display terminal to be used.

— *Multiple access points*: the BMS communications network may be used to access the lift monitoring system from more than one supervisor computer within the building, e.g. security office, facilities manager's office etc. In such cases the lift system must connect into the BMS network and not directly to the BMS control station.

— *Use of common software packages*: software for BMSs is often integrated with other software such as word-processing, spreadsheets, graphics, databases and statistical packages. These may be used to aid the processing and improve the presentation of lift system data.

Co-ordination between the BMS and lift manufacturers often takes place after contracts have been awarded. Thus, the possibilities of linking into a BMS are frequently considered too late in the design process. Adoption of standard communications or open communications protocols is a contentious issue within the lift industry. Standard systems give the customer a choice of suppliers for the same components, ranging from push buttons to control systems. Some consultants see standard protocols as the means by which they can provide an integrated system without restricting their clients to a single supplier. Understandably, many lift manufacturers are wary of standard protocols; apart from commercial considerations, the integrity of systems may fall outside their control.

14.4.2 Interfacing with building management systems

Most BMS manufacturers promote themselves as supporters of the philosophy of open architecture and, increasingly, building management systems are being used to integrate the operation of systems other than heating, ventilation and air conditioning within buildings, and interfaces are being installed for fire, security and lighting control. Information from the various systems is then presented in a co-ordinated manner via the BMS supervisor.

The possibilities for the lift data to reach the end user (e.g. the building owner) is very limited. The lift and escalator industry could take advantage of the considerable success and widespread application of building management systems, which are now almost a standard item of equipment within the heating, ventilation, air conditioning and refrigeration industry.

Generally, a building management system consists of one or more microprocessor-based outstations (or network control units). Outstations are equipped with input and output points which control and monitor the operation of the heating, ventilation and air conditioning plant etc., see Figure 14.8.

Outstations are distributed throughout the building in close proximity to the items of plant under control. They can work independently and are usually supplied from an uninterruptable power supply (UPS) to ensure they can operate during a power failure.

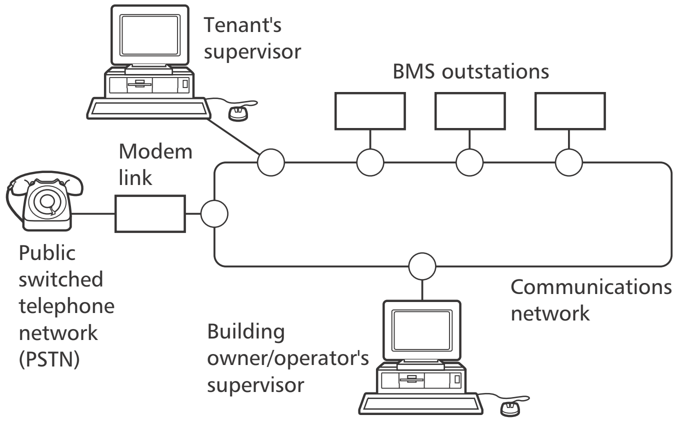


Figure 14.8 BMS architecture

The whole system can be managed from a digital computer loaded with the BMS operating system, known as a supervisor (or operator workstation). Through the supervisor, the user can gain access to any equipment within the whole BMS to accomplish the tasks of monitoring, control and statistics retrieval. There can be as many BMS supervisors as are required, e.g. one in the shift duty control room, one in the building management manager's office and one inside the maintenance workshop.

14.4.3 Communication systems and interconnection protocols

The outstations and management systems may be linked by a high speed local area network (LAN), allowing them to communicate continuously with each other. Commercial systems implementing standardised protocols defined by standards organisations include: BACnet, BITBUS, CANopen, CEBus, IEC Fieldbus, Interbus, LonWorks, P-NET, Profibus and WorldFIP.

The outstation and the central management unit must be connected together to form the complete system. Often this uses the public switched telephone network (PSTN) via a modem link. In other cases a network connection is used.

The protocol by which two computer systems intercommunicate consists of a comprehensive definition of all aspects of the connection including both the electrical and mechanical features of the connectors. Manufacturers often state that their protocol complies with the ISO 7-layer model[9]. The ISO 7-layer model provides only a framework for the implementation of network standards. In no way does compliance imply that such a system will communicate with any other system, although it may aid the design of communications interfaces between systems. Therefore, it is recommended that the remote monitoring equipment manufacturers agree the level of functionality with the owner, which is to be achieved by their interconnection. This must be based on a written protocol specification.

Such standards may eventually lead to the full integration of all building services with the internal transportation systems.

14.5 Escalators and moving walks

Many escalators and moving walks suffer from being out of service as a result of not being reset after a nuisance operation of the emergency stop button. Such a delay accumulates downtime. Remote monitoring brings many advantages to all operators of such equipment, e.g. railways, underground railways, retailing etc. Much of the guidance above is applicable.

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4 BS EN 81-2: 1998 + A3: 2009: *Safety rules for the construction and installation of lifts. Hydraulic lifts* (London: British Standards Institution) (1998/2009)

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6 DD 265: 2008: *Protocol for communications between a lift alarm system and an alarm receiving station (rescue centre). Specification* (London: British Standards Institution) (2008)

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15 Commissioning, preventative maintenance, testing and thorough examination of lifts, escalators and moving walks

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Section contents

15 Commissioning, preventative maintenance, testing and thorough examination of lifts, escalators and moving walks

15.1 Introduction

The proper commissioning, thorough examination, inspection and preventative maintenance of lifts, escalators and moving walks is critical to ensure that they are correctly installed and are then inspected and maintained in order to achieve longevity, reliability and safety. The capital cost of such equipment is high. Ensuring that it gives the maximum service life possible, considering its design and quality of manufacture, is essential. The purchaser of any installation should bear in mind that quality differs from manufacturer to manufacturer and the life expectancy of any installation is directly linked to this as well as to correct maintenance and inspection as well as usage. This chapter outlines the concepts behind the commissioning of new and modernised, or upgraded, equipment and details the subsequent preventative maintenance requirements during their operational life. It identifies the various regulatory requirements with regard to thorough examination/inspection and explains their role in the safe operation of lift, escalator and moving walk systems.

It should be understood that the roles of commissioning, thorough examination, inspection and maintenance are often undertaken by different persons. Many people are confused by meaning of these different aspects. Health and Safety Executive publication *Thorough examination and testing of lifts — Simple guidance for lift owners*[1] gives a layperson's interpretation of these aspects and valuable guidance to dutyholders. The meanings used here are as follows:

commissioning

final work on an installation prior to putting into service (of a new or upgraded installation)

thorough examination

systematic and detailed examination to detect any defects which are or might become dangerous

inspection

visual and functional checks to determine that the equipment is operating correctly

Note: the extent of the inspection is dependent on the potential risk that could arise from the equipment.

preventative maintenance

making of routine adjustments, cleaning, replacing worn or damaged parts, topping up fluids etc. to ensure the equipment is in an efficient and safe working condition

All these aspects include some element of testing, which includes checking the correct operation of various components, often to their maximum ratings.

A final important note to remember is that all the operations discussed in this chapter require persons to work on equipment. At all times they should work safely. Attention is therefore drawn to the requirements of the PUWER Regulations[2], MHSAW Regulations[3] and the guidance given in BS 7255: *Code of practice for safe working on lifts*[4] and in BS 7801: *Safe working on escalators and moving walks in use*[5].

15.2 Commissioning

15.2.1 General conditions

Commissioning is the process of testing an installation to ensure that it meets its specification and complies with recognised standards and legislation. Various types of building services require to be commissioned to simulate the conditions that they will meet when they enter service. Lifts, escalators and moving walks are no different and the early detection of possible defects can be critical to ensuring that the design life expectancy is achieved. Guidance to achieve a successful installation can be found in British Standard Codes of Practice BS 5655-6[6] and BS 5656-2[7].

Commissioning covers those activities undertaken to ensure compliance with the specified requirements. Within the framework of the Health and Safety at Work etc. Act 1974[8], the Lifts Regulations 1997[9] and the Supply of Machinery (Safety) Regulations 2008[10], a supplier has a responsibility to ensure that supplied goods are suitable for the stated intended purpose and in compliance with the relevant essential health and safety requirements (EHSRs) as endorsed by the CE-marking of a complete system or safety components.

This is in addition to the contractual responsibility to ensure that the goods are in accordance with the contract specification. Therefore lift and escalator manufacturers normally undertake their own systems of checks at various stages within the contract. The relevant design standard for the equipment (e.g. the BS EN 81[11,12] series of harmonised standards or BS EN 115-1[13]) may also recommend certain site tests to be undertaken on completion of the installation work.

The client may also supplement these systems with inspections by their personnel or by a third party. Such third parties may be insurance companies, inspection organisations or consultancies which specialise in lift and/or escalator/moving walk systems. The intention to carry out such inspections should be specified in the early stages of the contract negotiation so that adequate provisions can be incorporated.

A prerequisite to commissioning is the possession of the relevant contract documents including dimensioned drawings and specifications, together with details of all agreed changes effected since origination, together with access to the technical file required by the Lifts Regulations 1997[9] and Supply of Machinery (Safety) Regulations 2008[10]. In practice, even final installation drawings are commonly amended on site by agreement with those present at the time.

Specifications provide the contractual means by which specific requirements are recorded by the parties involved. In their most basic form, they may be based on a manufacturer's catalogue or a standard such as the BS EN 81[11,12] series or BS EN 115-1[13]. Specifications are also used to define particular requirements such as the desired performance or the handling characteristics. In addition client requirements with respect to aesthetics and/or finishes may be specified. In some cases it may be necessary to define the environmental standards required, see chapter 12.

The documentation prepared by the supplier should be checked to ensure compliance with the purchaser's requirements. Often this stage reveals oversights of detail known only to the client, or the inclusion of minor variations by the supplier in order to match a standard product item.

The preliminaries having been duly agreed, the manufacture of the lift, escalator or moving walk unit commences in the knowledge of the client's requirements. There are a number of intermediate checks that can be undertaken during manufacture, including manufacturing base visits and site inspections. However, the main check is generally the commissioning test undertaken upon completion of the installation. Broadly the sequence is:

— off-site checks, during manufacture

— on-site checks, during installation

— on-site commissioning

— on-site checks on completion.

15.2.2 Off-site checks during manufacture

For all supply organisations, the manufacture of a lift, escalator or moving walk involves a combination of buying-in manufactured components and producing components from raw materials. Reputable manufacturers will have systems of tests and controls, within the production cycle, to ensure compliance with specified requirements. These may relate to the purchase of materials, components or subassemblies, machining or fabricating processes, packaging, storage, transportation, installation etc. The systems are tailored to the organisation's general production requirements but may be supplemented by special conditions to meet the purchaser's requirements.

For standard lift units, the benefits of imposing additional or special tests during this stage of supply rarely justify the expenditure involved. Such tests are normally recommended only where the unit is beyond the manufacturer's normal range, e.g. some special configuration, or where significant development risks are involved.

Many manufacturers have quality management systems. Where these are in place, it is common to find 'manufacturing quality plans', which cover materials, drawings, processes, equipment etc. and the manufacturing interfaces during production. Such systems, if developed within a quality conscious manufacturing environment, afford increased assurance to the purchaser.

15.2.3 On-site checks during installation

After factory testing, pre-assembled lift components and escalator/moving walk units will be transported, perhaps over long distances, transferred across a building site or through a building and hauled into position, all of which may result in the need for adjustment or realignment. Pre-assembled components will then be connected to other components, structures and a power supply to produce the final installation.

Lifts are generally supplied to the site as consignments of components for assembly/reassembly in the lift well. Prior to the commencement of the installation, the manufacturer should carry out checks on the lift well within which the equipment is to be installed to verify its general alignment, finish, dimensions, location of fixings etc. Additionally, manufacturers normally undertake intermediate tests and checks at various stages during installation.

Alignment tolerances for lifts are becoming increasingly critical due to the increased emphasis on quality of ride, the tendency towards higher running speeds, and the development of steel framed buildings and 'fast-track' building techniques. This is particularly true for car and counterweight guide rails and the relative positions of the machine. Manufacturers have developed schedules for checking these items since errors left undetected until completion are expensive and time consuming to correct. Similarly, alignment and fixing of landing door equipment, door locks, fixings for lift well switches and other internal equipment will be checked at appropriate stages during installation when the respective items are easily accessible. It is normal practice to document these checks, together with the relevant documentation (i.e. drawings, specification, procedures etc.).

The majority of escalators and moving walks are supplied to site preassembled. Accordingly, checks on standard units during the installation process are generally confined to structural alignment and positional accuracy of fixings. Usually it is only special units that require extensive site assembly, for example the unusually long units required in transportation facilities such as airports and underground railway systems. In this case the installer will carry out various checks and tests prior to final commissioning.

15.2.4 Commissioning of lifts

15.2.4.1 New electric traction lifts

For new traction lifts specified to the BS EN 81 series of harmonised standards, there is a requirement under Annex D (normative) for examinations and tests before putting into service and the CE-marking applied. In that document, a number of tests are defined that need to be undertaken to ensure that the lift is functioning properly and has been installed to a satisfactory standard that complies with the specification and meets the requirements of current standards and legislation. These tests include:

- landing door locking devices
- electrical safety devices/systems
- suspension elements
- braking system
- measurement of speed and current (or power)
- insulation resistance and earth continuity
- limit switches
- traction and balance
- overspeed governor
- car safety gear
- counterweight safety gear (if fitted)
- buffers
- alarm devices
- functional tests
- ascending car overspeed protection device.

The tests can be reported using the pro-forma BS 8486-1[14] document. There may be additional tests applied by the installer. The client may also require supplementary tests, which should be agreed at the time the contract is awarded as these may involve extra time and expense to carry out. These tests are often termed 'witness tests', when carried out and witnessed by the client or their representative.

15.2.4.2 New hydraulic lifts

For new hydraulic lifts specified to the BS EN 81 series of harmonised standards there is a requirement under Annex D (normative) for examinations and tests before putting into service and the CE-marking is applied. In that document, a number of tests are defined that need to be undertaken to ensure that the lift is functioning properly and has been installed to a satisfactory standard that complies with the specification and meets the requirements of current standards and legislation. These tests include the same requirements as the traction tests above, except the braking system, traction and balance, but additionally including the following:

- limitation of piston stroke
- measurement of full load pressure
- relief valve
- rupture valve
- restrictor device
- system pressure test
- creeping and anti-creep devices
- emergency lowering systems
- motor run time limiter
- fluid temperature detecting device.

The tests can be reported using the pro-forma document BS 8486-2[15]. There may be additional tests applied by the installer. The client may also require supplementary tests, which should be agreed at the time the contract is awarded as these may involve extra time and expense to carry out. These tests are often termed 'witness tests', when carried out and witnessed by the client or their representative.

15.2.4.3 Lifts subject to important modifications (modernised lifts)

During the lifetime of any lift there may be modifications to the equipment, or it may be modernised (see chapter 16).

For lifts installed before 1 July 1999 the earlier versions of BS EN 81[11,12], BS 5655[16,17] and even BS 2655[18] apply. Any modernisation should attempt to comply to the latest standards. However, in some instances this is not possible. BS 5655-11: 2005: *Lifts and service lifts. Code of practice for the undertaking of modifications to existing electric lifts*[16], BS 5655-12: 2005: *Lifts and service lifts. Code of practice for the undertaking of modifications to existing hydraulic lifts*[17] and BS EN 81-80: 2003: *Safety rules for the construction and installation of lifts. Existing lifts. Rules for the improvement of safety of existing passenger and goods passenger lifts*[19] provide guidance.

Lifts installed after 1 July 1999 should continue to be in full compliance with the EHSRs of the Lifts Regulations 1997[9] or the current version of the relevant harmonised BS EN 81[11,12] standard. Any commissioning and testing should therefore be to those parts of PAS 32-1[20] or PAS 32-2[21] or BS 8486-1[14] or BS 8486-2[15] that apply to the changed equipment.

No test documents have been published by BSI specifically for modernised lifts. BS 5655-10.1.1[22] and BS 5655-10.2.1[23] are available, but apply to the commissioning tests for new traction and new hydraulic lifts, respectively. These documents can be used as a basis for the testing of modernised lifts as can the PAS 32[20,21] and BS 8486[14,15] documents previously mentioned.

15.2.5 Commissioning of escalators and moving walks

There are two generic types of escalators and moving walks: those that are built on site, and those that leave the factory as a pre-constructed package. The pre-constructed type are generally commissioned prior to leaving the factory. This allows any defects found to be rectified before the unit reaches the site. Clearly, units that are built on site need to be commissioned on site. New escalators should be built to conform to BS EN 115-1[13] and are generally commissioned to the manufacturer's specification. Clause 7.3 of BS EN 115-1 requires a constructional inspection and acceptance inspection and test before placing in service, comprising:

— overall visual inspection

— functional test

— test of electrical safety devices with regard to their effective operation

— brake tests

— insulation resistance tests.

These tests can be documented using BS 5656-1: *Safety rules for the construction and installation of escalators and passenger conveyors. Specification and proformas for test and examination of new installations*(24).

15.2.6 On-site checks after completion

Following testing of the installed units, the applicable standards recommend inspection as an integral part of the test procedure. This inspection usually involves examining the completed installation for conformity with the specification and with regard to proper workmanship. Although usually carried out by the manufacturer, third party inspection is often specified at this crucial stage of the client acceptance process.

This inspection generally results in a report, commonly known as a 'snagging list', that identifies items requiring attention by either the manufacturer or other parties involved in final installation (e.g. electrical supply contractor, builder etc.). These items may be minor and rectifiable immediately or, if of a more serious nature, may involve protracted contractual negotiations and/or delay to the programme.

There are no specific documents for the testing of escalators that have been modernised. Particular attention is drawn to prEN 115-2: *Improvement of the safety of existing escalators*(25). Following a modernisation the tests can be documented using BS 5656-1(24) as previously mentioned for new installations.

15.3 Preventative maintenance

15.3.1 Why maintenance is necessary

Lifts, escalators and moving walks are expensive items of equipment. It would be foolish to think that a piece of equipment could operate for long without adequate maintenance being undertaken. In this context, preventative maintenance refers to adjustment, cleaning, lubrication, replacement of worn components etc. Maintenance should neither be regarded as an optional extra, nor should a 'breakdown only' approach be adopted. Statutory provisions in Regulation 5 of PUWER(2) mention the requirement that the equipment be properly maintained. Failure to maintain equipment would lead to its safety and reliability being compromised and would be in contravention of the statutory provisions.

BS EN 13015: *Rules for maintenance instructions*(26) sets out the basic requirements for maintenance and its provisions should be used to form the basis of a maintenance contract. Annex A (informative) of this standard provides checklists of typical maintenance operations. Table 15.1 provides a summary of these checklists.

An important requirement of the standard is the provision of a maintenance instruction handbook to be supplied by the installer to the owner of each installation.

15.3.2 Maintenance contracts

Maintenance contracts vary from contractor to contractor, but in general there are two types of contract within the lift and escalator industry:

— contracts that provide for checking and lubrication only, repairs being subject to agreed further costs; these are more aptly called 'oil and grease' or 'basic' contracts

— contracts that provide for fully comprehensive preventative maintenance cover including parts, labour and call-out fees.

With the oil and grease contract, an operative from the lift maintenance company will attend and check lubrication levels, adjust anything that requires attention and clean the unit. Any further labour attendances or component replacement(s) etc. will normally attract an additional cost.

The fully comprehensive preventative maintenance contract usually includes for all activity described in the oil and grease contract, but the labour and component costs in the event of a breakdown are met by the maintenance contractor. The small print of such contracts needs to be read carefully to avoid misunderstandings regarding exclusions. It is normal to exclude vandalism and misuse but, in addition, some companies will exclude major items such as hydraulic ram seals, gear box repairs, etc.

Fully comprehensive maintenance contracts allow for a regular budgeted cost and should secure a predetermined performance level throughout the life of the installation. The on-going maintenance costs of lift/escalator/moving walk systems must be considered an integral part of the operating costs of the building. In most cases, they are negotiable with the equipment manufacturer in the form of a long-term agreement. The longer the agreement period, the greater is the incentive for the contractor to develop effective programmes for maintenance work. Contracting the equipment manufacturer to provide the maintenance beyond the initial warranty period has inherent advantages in respect of product familiarity, particularly in terms of design, development and training.

The overall costs of both forms of contract over the life cycle of the equipment should be similar. Unfortunately, the low initial cost of the oil and grease contract is often a deciding factor in their selection. The total budget for lift/escalator maintenance is then sometimes determined solely on the cost of the oil and grease contract and non-essential preventative works are regarded as unnecessary expenditure. This inevitably leads to poor performance, accelerated deterioration of equipment and premature failure.

Table 15.1 Summary of maintenance checklists from BS EN 13015: 2001[26]

Area	Equipment	Check
(*a*) Electric lifts		
General	Housekeeping	All components are clean; free from dust and corrosion
	Electric wiring	Insulation
Pit	Pit area	For excess oil/grease at bottom of guides; area is clean, dry and free from debris
	Anti-rebound device and switch	For free movement and operation; for equal tension of ropes; switch (where fitted); lubrication
	Buffers	Oil level; lubrication; switch (where fitted); fixings; operation
	Electric safety devices	Operation
Machine room	Drive motor/generator	Bearings for wear; lubrication; commutator condition
	Gearbox	Gear for wear; lubrication
	Traction sheave	Condition and grooves for wear
	Brake	Braking system; parts for wear; stopping accuracy
	Controller	Cabinet is clean, dry and free from dust
	Overspeed governor and tension pulley	Moving parts for free movement and wear; operation; switch
	Main rope and diverter pulley(s)	Condition and grooves for wear; bearings for abnormal noise and/or vibrations; guarding; lubrication
	Suspension ropes/chains	For wear, elongation and tension; lubrication only where intended
	Rope/chain terminations	For deterioration and wear; fixings
	Safety gear(s)/ascending car overspeed	Moving parts for free movement and wear; lubrication; fixings; operation; switch protection means
	Motor run-time limiter	Operation
	Electric safety devices	Operation; electric safety chain; correct fuses are fitted
Well	Car/counterweight guides	For film of oil where required on all guide surfaces; fixings
	Car/counterweight guide shoes	Guide shoes/rollers for wear; fixings; lubrication where necessary
	Suspension ropes/chains	For wear, elongation and tension; lubrication only where intended
	Rope/chains terminations	For deterioration and wear; fixings
	Final limit switches	Operation
	Well lighting	Operation
	Electric safety devices	Operation; electric safety chain
External	Lift car	Emergency lighting, car buttons, key switches; fixings of panels and ceiling
	Landing entrances	Operation of landing locks; doors for free running; door guiding; door gaps; wire rope, chain or belt when used, for integrity; emergency unlocking device; lubrication
	Car door	'Door closed' contact or lock; doors for free running; door guiding; door gaps; wire rope or chain when used for integrity; passenger door protective device; lubrication
	Floor level	Stopping accuracy at landing
	Emergency alarm device	Operation
	Landing controls and indicators	Operation
(*b*) Hydraulic lifts		
General	Housekeeping	All components are clean; free from dust and corrosion
	Electric wiring	Insulation
Pit	Pit area	For excess oil/grease at bottom of guides; the pit area is clean, dry and free from debris
	Buffers	Oil level; lubrication; switch where fitted; fixing
	Electric safety devices	Operation
Machine room	Tank unit	Hydraulic fluid level; tank and valve unit for leakage
	Controller	Cabinet is clean, dry and free from dust
	Pressure relief valve	Operation
	Manual lowering valve	Operation
	Hand pump	Operation
	Motor run time limiter	Operation
	Electric safety devices	Operation; electric safety chain; correct fuses are fitted
	Hose/pipe work	For damage and leakage

Table continues

Table 15.1 Summary of maintenance checklists from BS EN 13015: 2001[26] — *continued*

Area	Equipment	Check
(*b*) **Hydraulic lifts** (*continued*)		
Well	Jack	For oil leakage
	Telescopic jack	For synchronisation
	Overspeed governor and tension pulley	Moving parts for free movement and wear; operation; switch
	Main rope pulley(s)	Condition and grooves for wear; bearings for abnormal noise and/or vibrations; guarding; lubrication
	Car/balancing weight/jack guides	For film of oil where required on all guide surfaces; fixings
	Car/balancing weight/jack shoes	Guide shoes/rollers for wear; fixings
	Safety gear/pawl/clamping devices	Moving parts for free movement and wear; fixings; operation; switch
	Suspension ropes/Chains	For wear, elongation and tension; lubrication only where intended
	Rope/chain terminations	For deterioration and wear; fixings
	Well lighting	Operation
	Final limit switch	Operation
	Electric safety devices	Operation; electric safety chain
	Anti-creep device	Operation
	Rupture valve/one way restrictor	Operation
	Hose/pipe work	For damage and leakage
External	Lift car	Emergency lighting, car buttons, key switches; fixing of panels and ceiling
	Landing entrances	Operation of landing locks; doors for free running; door guiding; door gaps; wire rope, chain or belt when used, for integrity; emergency unlocking device; lubrication
	Car door	Door closed contact or lock; doors for free running; door guiding; door gaps; wire rope or chain when used for integrity; passenger door protective device; lubrication
	Floor level	Stopping accuracy at landing
	Emergency alarm device	Operation
	Landing controls and indicators	Operation
(*c*) **Escalators and moving walks**		
Machine space	Controller	Cabinet is clean, dry and free from dust
	Gear box	Gear and associated parts; lubrication
	Drive motor	Bearings for wear; lubrication
	Brake	Braking system; parts for wear
	Auxiliary brake	Braking system; parts for wear
	Intermediate gear box	Gear and associated parts; lubrication
	Main drive chain	For tension and wear; lubrication
	Step/pallet chain	For tension and wear; lubrication
	Step/pallet	Step/pallet and step/pallet wheels for integrity
	Conveyor belt	For condition and tension
	Drive belt	For condition and tension
	Track system	For condition and wear; fixings
	Safety devices	Operation
External	Clearances	Step to step and step to skirting clearances
	Combs	Condition; meshing with steps, pallets or belt
	Comb plate	Clearances and operation
	Handrails	For free running and condition; tension; synchronisation between step/pallet band and the handrail
	Safety devices	Operation
	Deflector devices	Condition
	Lighting	Operation
	Display	Operation
	Signs/pictograms	Condition
	Balustrade	Condition of panels; fixings of interior claddings
	Controls	Operation
	Unobstructed access	Availability

The level of activity undertaken by the maintenance contractor varies according to the age and complexity of each installation, the equipment usage and the performance requirements. These factors determine not only the number of visits per year (which may range from two to twenty) but also the scope of work undertaken at each visit over, say, a five- or eight-year programme.

The installation of performance data loggers, to either new, or existing lift control systems, makes it feasible to specify maintenance requirements in terms of quantitative performance criteria. With such equipment, it is now comparatively simple to record and analyse performance data such as service and usage characteristics, number of failures over a specified period, mean time between failures, average/maximum service response time and system downtime/percentage system availability.

Attention is drawn to the fact that some manufacturers make equipment known as 'closed protocol'. This sometimes means that the equipment can only be maintained by the manufacturer, as specialist equipment may be required to interrogate or adjust the system.

15.4 Thorough examinations and tests

15.4.1 Competent persons

A thorough examination of an installation is a systematic and detailed examination. It is performed by a competent person. The purpose is to determine the condition of the installation and report on its suitability for its continued safe use.

Thorough examinations are generally required to be carried out so that the dutyholder complies with the legislation. The principal applicable legislation is the Health and Safety at Work etc. Act 1974[8], specifically:

— Section 3: the duty of employers and self employed to conduct their undertakings in such a way that people they do not employ are not put at risk.

— Section 4: the duty of owners of premises to maintain safe conditions for persons other than employees who may use or come into contact with equipment within premises.

— Section 6: the duty of suppliers, importers and/or manufacturers to ensure equipment is safe for its intended use (including incorporation of safe means of cleaning, maintenance, setting and inspection) and is supplied with adequate information regarding safe use.

All these provisions must be complied with insofar as is reasonably practicable.

A competent person according to BS 7255: *Safe working on lifts*[4] is a:

> 'person, suitably trained and qualified by knowledge and practical experience, and provided with the necessary instructions, to enable the required work to be safely carried out'

It is important that the competent person is independent and impartial so that an objective assessment can be made. For example, it is not appropriate to engage someone employed by the maintainer of the equipment to be examined, as they could be responsible for assessing their company's work. Few organisations have such competencies in-house and must use a third party. An inspection body accredited by the United Kingdom Accreditation Service (UKAS) to BS EN ISO/IEC 17020[27] would be a suitable organisation to carry out thorough examinations. Insurance companies, who do not themselves carry out thorough examinations, or the Safety Assessment Federation (a trade organisation) can also recommend inspection bodies.

15.4.2 Thorough examination of lifts

The Lifting Operations and Lifting Equipment Regulations 1998[28] (LOLER) introduced requirements for the safe provision and use of lifting equipment and applies to lifts and hoists used to lift people and loads. Regulation 9 of these regulations requires that in-service thorough examinations take place to ensure the continued safe use of the equipment. These examinations are required to take place every six months for passenger lifts and annually for goods lifts, unless a risk assessment shows the frequency should be reduced or increased in accordance with an examination scheme drawn up by a competent person. The examination should include as a minimum:

— landing door locking devices

— door equipment

— main drive system components

— worm and other gearing

— electrical safety devices/systems

— suspension elements

— braking system

— governors

— safety gear

— overload detection devices

— control equipment

— supporting structure, guides and fixings

— clearances and tolerances

— hydraulics.

Following an examination a report should be issued by the competent person (see Figure 15.1). The requirements of such a report are detailed in Schedule 1 of the regulations. Many people still know this report as an 'insurance inspection'. This is incorrect as it is a statutory thorough examination. A LOLER thorough examination must also be carried out after substantial or significant changes have occurred, e.g. modernisation, major repair, or after an exceptional circumstance such as an accident. LOLER applies to workplaces and not to domestic dwellings, although a similar examination regime is recommended as it is seen as best practice.

REPORT OF THOROUGH IN-SERVICE EXAMINATION OF LIFTING EQUIPMENT

Type: (P) — periodic; (PS) — periodic, following a scheme of examination;
(O) — examination after the occurrence of exceptional circumstances

CIBSE LIFTS GROUP

Owner/occupier of premises: Anytown Borough Council

Address: Town Hall
Bishop's Place
Anytown
GC4 6PQ

Type of lift and description: Electro-hydraulic passenger lift

Owner's identification number: TH/01

Manufacturer: Essex Lift Co. Ltd.

Manufacturer's serial number: CE0037/1459

Location of lift: Town Hall foyer

Report type, periodicity and when applicable:	(P), 6-monthly
S.W.L. for the configuration examined:	8 persons (630 kg)
Test certificate date and no:	Not required
(A) Defects that are, or could become a danger to persons, remedial actions required, and date by which defects are to be remedied:	(A) That the car-top 13 A socket outlet be earthed before 19/10/2002 (1 month)
(B) Other defects:	(B) The suspension rope tensions should be equalised
(C) Observations:	(C) The following recommendations are made: 1. That an approved type rubber mat, to BS 921, be provided at the control panel. 2. That emergency lighting be installed within the machine room. 3. That ventilation be provided within the machine room. 4. That a safety barrier be provided in accordance with BS 7255 Lift Guidelines (LG1) Tests/ Examinations. Internal lock examination (PSL): 19/09/02. Levels 1 to 3 internally examined. Observation: the shaft-top lifting beam (S.W.L. 1 tonne) was included within the scope of this examination.

Last examination:

Next examination due before: 19/03/2003

I confirm that the equipment was thoroughly examined on 19/09/2002 and that, subject to the remedial action noted in section (A) being completed, is safe to operate.

Name: Michael Jones

Signature: M Jones

Date of issue of report: 19/09/2002

Address: Webster & Booth,
47 Canal Street,
Manchester, M1 3HF

Figure 15.1 Example report of thorough examination of a lift

15.4.3 Periodic testing of lifts

Generally thorough examinations are visual checks and functional tests and do not involve any extensive testing. However periodic tests are required to be carried out under section 16.3.3 of the BS EN 81-1[11] and BS EN 81-2[12] standards. To meet these requirements in the UK, guidelines have been issued by the Safety Assessment Federation (SAFed) in consultation with the Health and Safety Executive (HSE). These guidelines were known as the LG1 *Lift Guidelines*[29].

LG1 (1998) was replaced in 2006 by *Guidelines on the supplementary tests of in-service lifts*[30]. The later guidelines recommend supplementary examinations that are undertaken when the competent person undertaking the periodic thorough examination calls for them. These supplementary tests are generally to be completed before the next thorough examination. Previously these tests were recommended at specified time intervals, which some owners and/or operators of lifts continue to adopt. The supplementary tests can include:

Both electric and hydraulic lifts:

- earth continuity
- electrical safety devices
- terminal speed reduction systems
- landing door interlocks
- shafts and plain bearings
- roller, ball and needle bearings
- overspeed governors:
- safety gear
- overspeeding of ascending car
- car overload detection devices

Traction lifts only:

- traction, brake and levelling:
- geared machines
- energy dissipation buffers

Hydraulic lifts only:

- hydraulic systems
- hydraulic rupture/ restrictor valves
- hydraulic cylinders
- electrical anti-creep systems
- mechanical anti-creep device
- low pressure detection devices

These tests are required to be no more severe than those carried out at commissioning. They should be undertaken by a competent person, who may be employed by the maintenance company or by a third party. It is again important that the competent person is independent and impartial so that an objective assessment can be made. It may not be appropriate for the maintainer of the equipment to use one of their staff and many maintenance companies chose to sub-contract these inspections to a body specialising in their provision. Certificates are issued following each test with details of a pass or fail. An example is shown in Figure 15.2. The current SAFed Lift Guidelines certificates are available on the SAFed website (http://www.safed.co.uk).

15.4.4 Thorough examination of escalators and moving walks

There is no specific legislation requiring the thorough examination of escalators and moving walks. However, The Health and Safety at Work etc. Act 1974[8] applies generally together with the Management of Health and Safety at Work Regulations 1999[3]. Section 19 of the Workplace (Health, Safety and Welfare) Regulations 1992[31] makes reference to escalators and that regular inspections should be made. Previous Health and Safety Executive Guidance Note PM45[32] (now withdrawn) recommended a basic six-monthly examination by a competent person and the SAFed escalator and moving walks (EWM) guidelines (due for publication in 2010) are expected to recommend that periodic through examinations be undertaken.

It is recommended that the thorough examination include:

- check on running clearances
- check on general operation
- visual examination of exterior of the complete unit
- examination of step/pallet chains and guides
- examination of the main drive system and gearing
- examination of structure/truss
- examination of tracks/guides
- operational check of all safety devices
- check of lighting and warning notices.

Such an examination should be documented and reported to the duty holder.

Clause 7.4.1(f) of BS EN 115-1[13] recommends that the documentation provided with a new escalator or moving walk includes a periodic inspection and test that should ascertain whether the escalator or moving walk is safe in operation and should bear on:

- electric safety devices with regard to their effective operation
- brake(s)
- driving elements for visible signs of wear and tear and for insufficient tension of belts and chains
- steps, pallets or the belt for defects, true run and guidance
- dimensions and tolerances specified in BS EN 115-1
- combs for proper condition and adjustment
- interior panel and the skirting
- handrails
- test of the electric continuity of the connection between the earth terminal(s) in the driving station and the different parts of the escalator or moving walk liable to be live accidentally.

CERTIFICATE OF EXAMINATION AND TEST

ELECTRIC LIFT

This form details ALL the examinations and tests recommended to be undertaken at intervals not exceeding ONE YEAR. It addresses the most common lift arrangements. Where non-standard arrangements have been adopted, the most appropriate tests should be carried out and documented.

CIBSE LIFTS GROUP

Owner/occupier of premises:

Address:

Type of lift and description:

Owner's identification number:

Manufacturer's serial number:

Location of lift:

1 ELECTRICAL SAFETY DEVICES

If separate terminal stopping switches are fitted, do they operate satisfactorily? | N/A | YES | NO |

Comments:

2 LANDING DOOR INTERLOCKS

Are all landing door interlocks in good condition and do they operate satisfactorily? | YES | NO |

Comments:

3 ENERGY DISSIPATION BUFFERS

Do the buffers return to their fully extended position after they have been compressed? | N/A | YES | NO |

Comments:

4 CAR OVERLOAD DETECTION DEVICE | N/A | YES | NO |

Does the overload detection device operate satisfactorily?

State method of test:

Load at which the device was tested: _________ kg

Comments:

5 BRAKE

Are all gripping components within the brake in a satisfactory condition? | YES | NO |

Comments:

DECLARATION OF EXAMINATION AND TEST

Date of examination and test:

Person responsible for undertaking examination and/or test:

Name:

Job title:

Signature:

Employer name:

Address:

Figure 15.2 Example (blank) certificate for the one year tests under LG1

Report of Thorough Examination of Escalator or Moving Walk

Policy/Contract No.		Examination type/		Date of this examination	
Policy/Contract Name:		Owner/Occupier		Address	

Type: (P) - Periodic; (O) - Examination after the Occurrence of Exceptional Circumstances.

Distinguishing No. and Description	
Manufacturer and date	
Location	
Details of defects found. If none state 'none'. Defects noted should be consistent with the rejection criteria listed in Annex C	
Access and guarding	
Running condition	
Electrical Safety devices	
Earthing continuity	
Braking system	
Treadway (steps and pallets)	
Comb plate/comb	
Balustrades, decking, skirt	
Handrails	
Skirt Deflector devices	
Surrounds, lighting and warning/advisory signs	
Drive system	
Controller	
Other (specify)	
Parts inaccessible?	
Defects found which affect continued safety and repairs required immediately or in a specified time. If none state "none".	
Other defects and repairs required. If none state 'none'.	
Other observations. If none state 'none'.	
Date of last thorough examination:	Date of next thorough examination:

I confirm that the equipment was thoroughly examined on: …………………………………………
and that subject to any remedial action(s) noted above being completed, is safe to operate.

Signature………………………………… Authenticated by …………………………………
Print name:

Address:……………………………………………………………………………………………………
……………………………………..………………………..………………………..…………………
……..………………………………………………………………………………………………………..

Date of Issue of Report: …………………………………………

Figure 15.3 Suggested format for a report of a thorough examination of an escalator or moving walk; the details shown provide an example of the content of a report of a periodic thorough examination of an escalator or moving walk

Table 15.1(c) above summarises Table A.3 of BS EN 13015: 2001[26] and provides a maintenance checklist that gives guidance on checks to be carried out under a maintenance contract.

At the present time work is being carried out by an industry working party to provide a guidance note on the thorough examination of escalators and moving walks, which will indicate the areas for examination and the periodicity.

Figure 15.3 above illustrates the type of report that might be issued following the thorough examination of an escalator or moving walk. The table is based on the proforma provided in PM45[32], which in turn was based on a 1970 document and it could be used as an *aide-mémoire* in the event of a thorough examination being undertaken.

15.5 Documentation

Owners of lift, escalator and moving walk equipment should maintain documentation detailing their commissioning, preventative maintenance, testing and thorough examination. Besides the requirements to keep the statutory thorough examination documents (LOLER — lifts only), it is recommended that copies of the following information should be retained:

— the commissioning certificate and declaration of conformity (signed and dated)

— the test documents

— past and current maintenance contract documentation

— maintenance attendances (machine room log cards)

— break down attendances

— supplementary reports (lifts only).

These documents will provide a valuable source of information in the event of the equipment becoming unreliable, upgraded, involved in an accident, etc.

References

1 *Thorough examination and testing of lift — Simple guidance for lift owners* HSE INDG 339 (rev. 1) (Bootle: Health and Safety Executive) (2001) (available at www.hse.gov.uk/pubns/indg339.pdf) (accessed June 2010)

2 The Provision and Use of Work Equipment Regulations 1998 Statutory Instruments 1998 No. 2306 (London: The Stationery Office) (1998) (available at http://www.opsi.gov.uk/si/si199823.htm) (accessed June 2010)

3 The Management of Health and Safety at Work Regulations 1999 Statutory Instruments 1999 No. 3242 (London: (The Stationery Office) (1999) (available at http://www.opsi.gov.uk/si/si199932.htm) (accessed June 2010)

4 BS 7255: 2001: *Code of practice for safe working on lifts* (London: British Standards Institution) (2001)

5 BS 7801: 2004: *Escalators and moving walks. Code of practice for safe working on escalators and moving walks* (London: British Standards Institution) (2004)

6 BS 5655-6: 2002: *Lifts and service lifts. Code of practice for the selection and installation of new lifts* (London: British Standards Institution) (2002)

7 BS 5656-2: 2004: *Escalator and moving walks. Safety rules for the construction and installation of escalators and moving walks. Code of practice for the selection, installation and location of new escalators and moving walks* (London: British Standards Institution) (2004)

8 Health and Safety at Work, etc. Act 1974 Elizabeth II. Chapter 37 (London: Her Majesty's Stationery Office) (1974) (available at http://www.opsi.gov.uk/acts/acts1974a) (accessed June 2010)

9 The Lifts Regulations 1997 Statutory Instrument 1997 No. 831 (London: The Stationery Office) (1997) (available at http://www.opsi.gov.uk/si/si199708.htm) (accessed June 2010)

10 The Supply of Machinery (Safety) Regulations 2008 Statutory Instruments No. 1597 2008 (London: The Stationery Office) (available at http://www.opsi.gov.uk/si/si200815) (accessed June 2010)

11 BS EN 81-1: 1998 + A3: 2009: *Safety rules for the construction and installation of lifts. Electric lifts* (London: British Standards Institution) (1998/2009)

12 BS EN 81-2: 1998 + A3: 2009: *Safety rules for the construction and installation of lifts. Hydraulic lifts* (London: British Standards Institution) (1998/2009)

13 BS EN 115-1: 2008 + A1: 2010: *Safety of escalators and moving walks. Construction and installation* (London: British Standards Institution) (2008/2010)

14 BS 8486-1: 2007: *Examination and test of new lifts before putting into service. Specification for means of determining compliance with BS EN 81. Electric lifts* (London: British Standards Institution) (2007)

15 BS 8486-2: 2007: *Examination and test of new lifts before putting into service. Specification for means of determining compliance with BS EN 81. Hydraulic lifts* (London: British Standards Institution) (2007)

16 BS 5655-11: 2005: *Lifts and service lifts. Code of practice for the undertaking of modifications to existing electric lifts* (London: British Standards Institution) (2005)

17 BS 5655-12: 2005: *Lifts and service lifts. Code of practice for the undertaking of modifications to existing hydraulic lifts* (London: British Standards Institution) (2005)

19 BS EN 81-80: 2003: *Safety rules for the construction and installation of lifts. Existing lifts. Rules for the improvement of safety of existing passenger and goods passenger lifts* (London: British Standards Institution) (2003)

20 PAS 32-1: 1999: *Specification for examination and test of new lifts before putting into service. Electric traction lifts* (London: British Standards Institution) (1999)

21 PAS 32-2: 1999: *Specification for examination and test of new lifts before putting into service. Hydraulic lifts* (London: British Standards Institution) (1999)

22 BS 5655-10.1.1: 1995: *Lifts and service lifts. Specification for the testing and examination of lifts and service lifts. Electric lifts. Commissioning tests for new lifts* (London: British Standards Institution) (1995)

23 BS 5655-10.2.1: 1995: *Lifts and service lifts. Specification for the testing and examination of lifts and service lifts. Hydraulic lifts. Commissioning tests for new lifts* (London: British Standards Institution) (1995)

24 BS 5656-1: 1997: *Safety rules for the construction and installation of escalators and passenger conveyors. Specification and proformas for test and examination of new installations* (London: British Standards Institution) (1997)

25 09/30192761 DC: BS EN 115-2: *Safety of escalators and moving walks. Part 2. Rules for the improvement of safety of existing escalators and moving walks* (draft for comment) (London: British Standards Institution) (2009)

26 BS EN 13015: 2001 + A1: 2008: *Maintenance for lifts and escalators. Rules for maintenance instructions* (London: British Standards Institution) (2001/2008)

27 BS EN ISO/IEC 17020: 2004: *General criteria for the operation of various types of bodies performing inspection* (London: British Standards Institution) (2004)

28 The Lifting Operations and Lifting Equipment Regulations 1998 Statutory Instruments No. 2307 1998 (London: (The Stationery Office) (1998) (available at http://www.opsi.gov.uk/si/si199823.htm) (accessed June 2010)

29 *Guidelines on the thorough examination and testing of lifts* Lift Guidelines LG1 (London: Safety Assessment Federation) (1998) (superseded)

30 *Guidelines on the supplementary tests of in-service lifts* SAFed LG1 (London: Safety Assessment Federation) (2006)

31 The Workplace (Health, Safety and Welfare) Regulations 1992 Statutory Instruments 1992 No. 3004 (London: Her Majesty's Stationery Office) (1992) (available at http://www.opsi.gov.uk/si/si199230.htm) (accessed June 2010)

32 *Thorough examination of escalators and passenger conveyors* HSE PM45 (Bootle: Health and Safety Executive) (1984) (out of print)

16 Upgrading of safety, performance and equipment for existing lifts

Lead author

Ian Jones (Otis Ltd.)

Chapter contents

16 Upgrading of safety, performance and equipment for existing lifts

16.1 Introduction

In the UK there are about 200 000 passenger and passenger/goods lifts in service, 50% of which were installed before 1979. These are all candidates for some level of upgrading (see Figure 16.1).

16.2 Life cycle considerations

Some reasons for upgrading a lift are that as time progresses it becomes less reliable, probably less aesthetically pleasing and technologically backward. A more important reason for upgrading is to ensure that the owners fulfil their duty to provide a safe environment, since some old lifts would have unacceptable levels of safety when compared against today's state of the art.

Upgrading may be undertaken to improve the performance in terms of its traffic handling, ride quality or energy consumption or to improve the equipment. Often this type of upgrading is termed 'modernisation'.

A lift is often refurbished to restore it to a 'good as new condition'. Then the worn-out equipment and components are simply replaced. A like-for-like replacement of any equipment or any component is not considered to be upgrading. Some replacements can occur during routine maintenance operations, e.g. the replacement of a burnt-out motor. The status quo of the installation is unchanged and the level of safety is maintained.

Owners of lifts are conscious of the life cycle of their equipment with regard to the capital expenditure and recurrent costs. Most are concerned with the economic life cycle defined as the estimated number of years until an item no longer represents the least expensive method of performing its function. However, some owners may consider the technological life of their equipment important, i.e. when it becomes obsolete. These owners may choose to upgrade their equipment in order that their building is attractive to its tenants or prospective tenants. Other owners consider the useful life of their equipment, i.e. when it no longer performs its function to some established performance standard. For example, passengers now expect the lift ride quality to be better than that provided a decade ago.

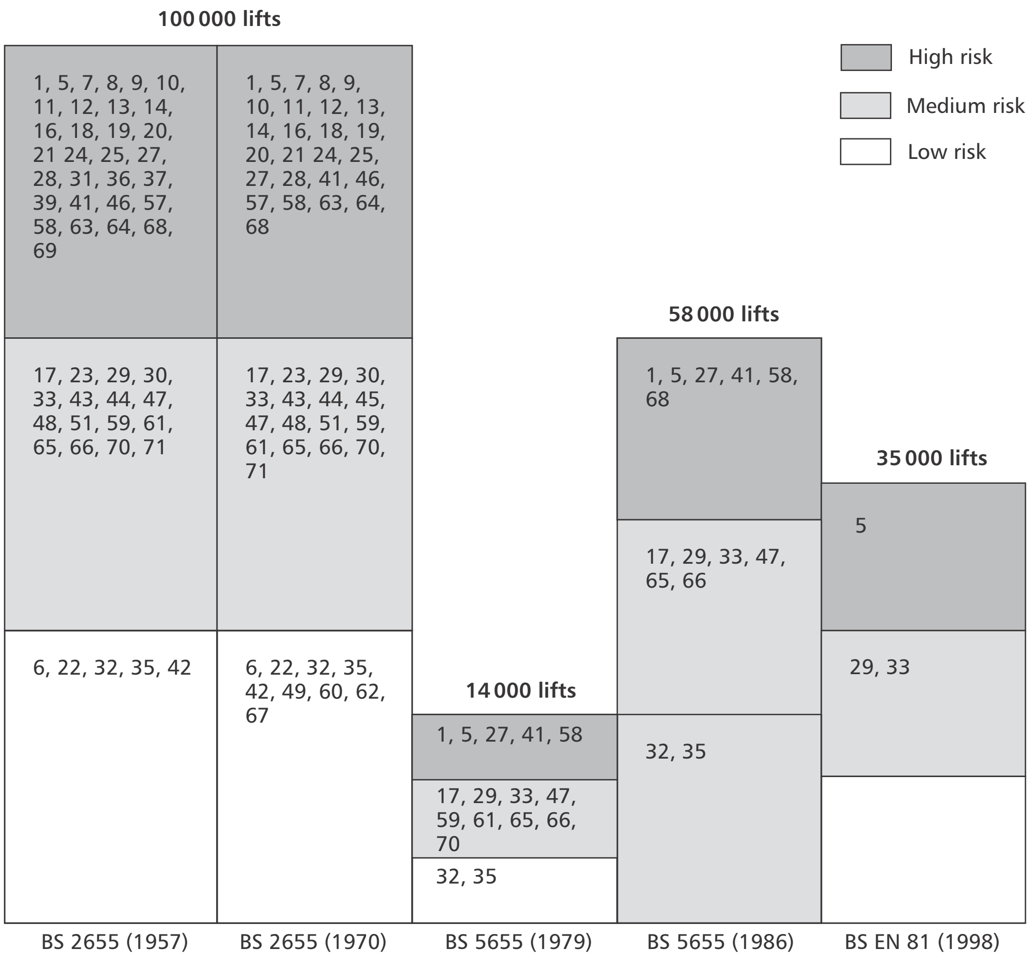

Figure 16.1 Approximate number of UK lift installations; the numbers refer to significant hazards identified in BS EN 81-80: 2003[1] and give guidance on those hazards likely to require consideration

16.3 Influencing factors to upgrading

The formulation of a lift upgrading scheme should be undertaken by a competent person in conjunction with the client in order to ensure the client's needs are fully satisfied, both from aesthetic and safety points of view. During the lifetime of a lift, taken as 20–25 years for an electric lift and 15 years for a hydraulic lift, it may have two changes of car interior and landing doors, one change of drive system and one change of traffic control panel. Each upgrading scheme will vary from one lift installation to another.

The type of installation often dictates whether an upgrading scheme is practicable and/or economic. A low-budget lift installed ten years ago may not be a viable proposition for upgrading as the equipment was not designed for a prolonged life. Conversely, a high quality lift installed 25 years ago may be further upgraded for a further decade of useful life. Upgrading can be undertaken as a step-by-step process in order to spread the cost.

A refurbishment is usually less expensive than a full upgrading, but may not extend the life of the lift by more than a few years. In the long term it could be more expensive.

Future plans for the building in which the lift is installed may influence the decision regarding the type of upgrading. A building purchased as an investment may only be prepared for re-sale. A building situated in an area selected for re-development would warrant little expenditure unless considered to be unsafe.

Compliance to the latest safety standards is an important factor. It would be unwise for a building owner to ignore changes in legislation and safety standards. In the event of an incident ignorance of such subjects would be no defence.

16.4 Relevant legislation, standards and codes of practice

The following will be referred to in the subsequent sections. An owner contemplating the upgrading of a lift should be familiar with, or engage someone who is, the following minimum legislation, standards and codes of practice.

The main legislation applying to lifts is the Lifts Regulations 1997(2), which enact the European Lifts Directive(3). It gives requirements for new lifts to be designed, manufactured and installed either to a harmonised European standard or to have design certification from a notified body, to ensure that the essential health and safety requirements (EHSRs) are met.

The two main harmonised standards for the construction and installation of lifts are BS EN 81-1: 1998 + A3: 2009(4) for electric lifts and BS EN 81-2: 1998 + A3: 2009(5) for hydraulic lifts. These two safety standards are applied to all lifts installed after 1 July 1999, unless otherwise approved by a notified body. Other standards in the BS EN 81 series may be applicable to meet some of the Lift Directive's EHSRs, e.g. alarm systems, accessibility etc., see section 16.6.

In addition there are, from time to time, queries raised against these standards, submitted to the European Committee for Standardization (CEN) from national Standards Committees. These queries relate to the interpretation of a clause within the standard. Once confirmed or rejected by CEN, the interpretations are published in DD CEN TS 81-11(6).

BS EN 81-80: 2003(1) provides guidance on the progressive improvement to the safety of existing lifts. This standard is not a harmonised standard, but represents the considered thinking of a number of European experts and it has been approved by all the standards institutions (including BSI) in Europe.

DD CEN/TS 81-82: 2008(7) follows on from BS EN 81-80, but gives guidance on the improvement in accessibility and use of controls by persons with disabilities. It is a technical specification rather than a full standard due to having a review on its successful application after three years from the date of publication. It should not be treated with less regard than a full EN standard.

Similarly, DD CEN/TS 81-83: 2009(8) is a technical specification for the improvement of existing lifts with regard to their vulnerability to vandalism.

Recommendations for the modernisation of lifts in existing buildings are given in BS 5655-11: 2005(9) for electric lifts and BS 5655-12: 2005(10) for hydraulic lifts. These standards do not state what to modify, but instead give rules for the upgrading of the lift once the choice of what to modify has been made, i.e. once the decision to make the lift operate at a faster speed has been made the standard will give guidance on the consequences of this action and what other equipment might need to be considered. See Table 16.2

BS 5655-6: 2002(11) is a code of practice for the installation of new lifts. It does suggest, however, that its recommendations may be used as guidance when making alterations to existing lift installations. Reference will be made to this standard.

Code of Practice BS 7255: 2001(12) indicates the environment for safe working on lifts. It is divided into two main sections. Section 4 deals with the responsibilities of the owner and Section 5 deals with the responsibilities of the worker towards safe working on lifts. Annex B offers suggested improvements for consideration by an owner to improve safe working.

16.5 Undertaking modifications to lifts installed before 1 July 1999

Lifts installed prior to 1 July 1999, when the Lifts Regulations 1997(2) came into force, should have been installed to the safety rules for the construction and installation current at the time it was put into service. The standards could have been to the BS 2655(13) series dating back to 1958, or the BS 5655[14] series dating back to 1979. Some lifts may have been upgraded from, for example, a BS 2655 standard to a BS 5655 standard over a period of time.

The technology and subsequent level of safety will therefore vary depending on the age of the lift. For example, some features commonly expected to be found on today's lifts in order to ensure the safety of the engineer, such as counterweight and pit division screens, may not have been required when the lift was first installed. Figure 16.2 (page 16-4) shows those hazards described in BS EN 81-80: 2003[1] and the probability of finding them on any given lift depending on the standard prevalent at that time.

When upgrading an existing lift it does not have to comply with the latest standard BS EN 81 1/2: 1998 + A3: 2009[4,5], but only to the standard applying at the time of the original installation. However the opportunity should be taken to upgrade it to current 'state-of-the-art' for technology and safety to maximise the improvements.

There is no compulsion on an owner, or operator, to bring a lift up to the latest level of safety; this is voluntary. However, in the event of an incident it is likely that their attention will be drawn to the best practice contained in the latest safety standards. This situation can be avoided by carrying out a safety audit from time to time and upgrading all lifts to the latest safety standard in order to ensure the highest currently perceived level of safety is obtained. It is not always reasonable and practicable to carry out all the recommendations resulting from an audit. In deciding what is practicable the seriousness of a risk to injury should be weighed against the difficulty and cost of removing or reducing that risk. In considering the cost no allowance should be made for the size, nature or profitability of the business concerned. Where the difficulty and costs are high and a careful assessment of the risk shows it to be comparatively small, action may not need to be taken. However, where the risk is high, action should be taken irrespective of cost. BS ISO 14798: 2009: *Lifts, escalators and moving walks. Risk assessment and reduction methodology*[15] is a suitable document to use for such assessments.

An owner contemplating the complete removal* of an existing lift may not be able to install a lift to fully meet the EHSRs of the Lift Regulations 1997[2]. For example, it may not be possible to provide refuge spaces at the extremes of travel to EHSR 2.2. However, if the existing lift is completely removed, or only the existing guide rails and their fixings remain, then the upgrading becomes the installation of a new lift in an existing building and the EHSRs of the Lifts Regulations apply.

16.6 Undertaking modifications to lifts installed after 1 July 1999

When a lift installed after 1 July 1999 is upgraded, it must continue to comply with the EHSRs of the Lifts Regulations 1997[2]. The upgrading should also take note of any revisions to BS EN 81-1/2: 1998 + A3: 2009[4,5] since installation, e.g. the amendment dated March 2000 (and any subsequent amendments), and any interpretations in DD CEN TS TR 81-11[6], published by BSI (see Appendix A3, section A3.6, for interpretations current at the time of publication of this Guide). In addition other amendments that may apply include:

— BS EN 81-1/2: 1998 plus A1 (Amendment 1) with regard to electronic safety systems

— BS EN 81-1/2: 1998 plus A2 (Amendment 2)† with regard to machine room-less lifts

— BS EN 81-1/2: 1998 plus A3 (Amendment 3) with regard to uncontrolled movement

— BS EN 81-1/2: 1998 plus BS EN 81-28: 2003[16] with regard to remote alarms

— BS EN 81-1/2: 1998 plus BS EN 81-70: 2003[17] with regard to provision of lifts for the use of persons with disabilities

— BS EN 81-1/2: 1998 plus BS EN 81-71: 2005[18] with regard to vandal resistant lifts

— BS EN 81-1/2: 1998 plus BS EN 81-72: 2003[19] with regard to firefighting lifts

— BS EN 81-1/2: 1998 plus BS EN 81-73: 2005[20] with regard to the behaviour of lifts in the event of a fire.

All the above standards (with their amendments) have been amalgamated into BS EN 81-1: 1998 + A3: 2009[4] and BS EN 81-2: 1998 + A3: 2009[5].

It is important to emphasise that an owner, or operator, of a lift be vigilant, or engages a competent person who is, to any changes to the standards and codes of practice.

16.7 Important considerations when undertaking modifications to existing lifts

Owners and operators of lifts have duties under various regulations to ensure the safety of persons transported in a lift, persons working on it and persons in its vicinity. To show due diligence it would be wise periodically to carry out, or have carried out by a technically competent and sufficiently trained person, a safety audit to determine the level of safety of the installation.

The improvement of the safety of lifts is a continual process. It results from expert considerations of any risk assessments carried out, experience of serious events occurring to lifts in service and the adoption of various directives, acts, regulations, standards, codes etc. that are issued from time to time. Lifts installed to the latest published British, European and International safety standards reflect the state-of-the-art for safety that can be achieved today according to the experts who have developed these standards and to the technology available. This is not to say that lifts cannot be made safer.

* Complete removal is considered to have occurred if only the guide rails and their fixings remain.

† Incorporated into Amendment 1 as published by the BSI

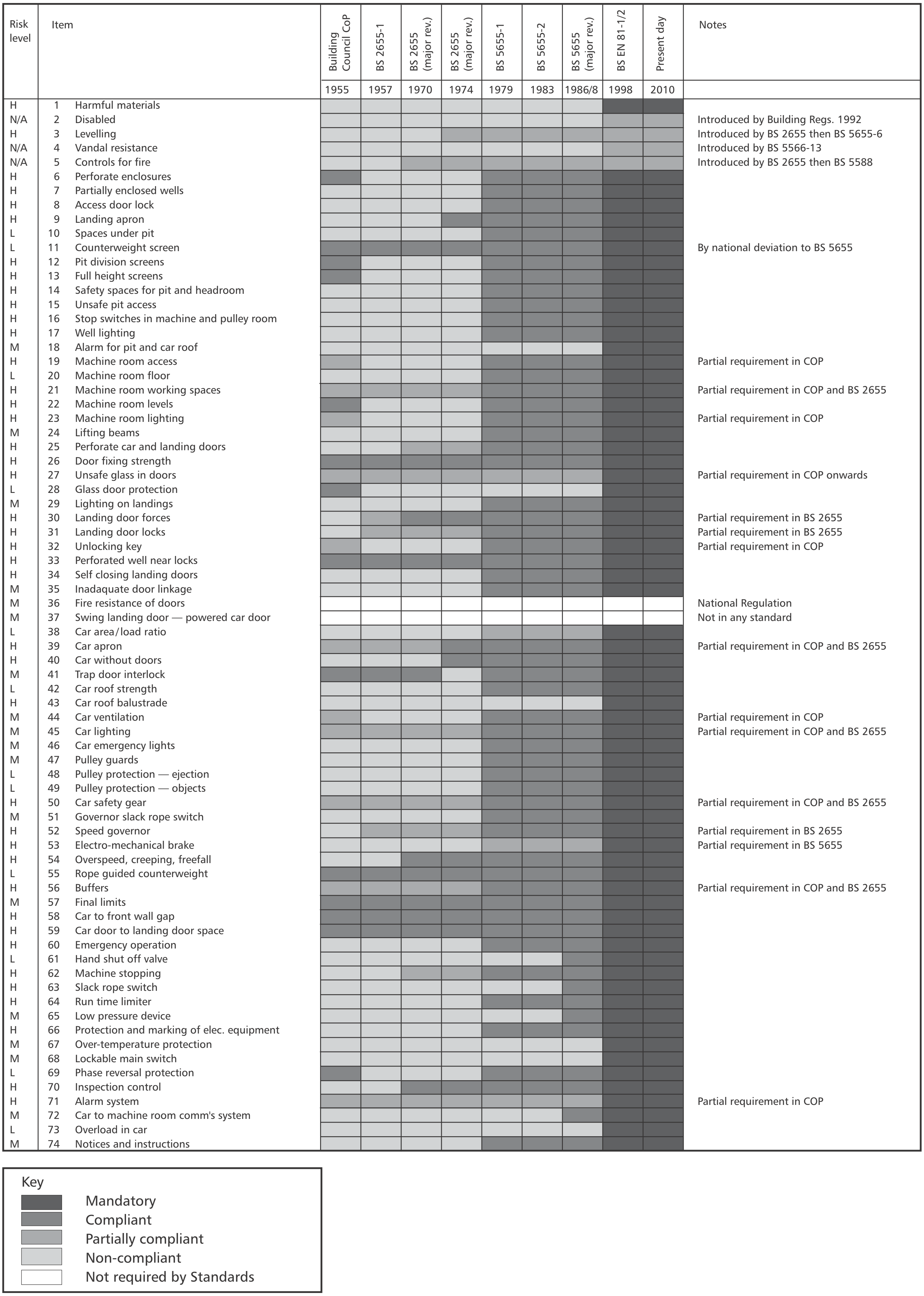

Figure 16.2 Comparison of lift safety standards and hazards identified in BS EN 81-80[1]

When installed, a lift will provide levels of safety deemed sufficient by the safety standard current at that time. As a lift ages it moves further and further from the currently applicable safety standards and thus its level of safety is likely to be lower than that provided by a newly installed lift. For example, consider a pair of lifts operating as a duplex, one installed in 1998 and the other in 2000. The younger lift will be provided with an emergency alarm permanently connected to a rescue service, which the slightly older lift may not have.

It is important for an owner (or operator) of a lift to be aware of the changes in safety requirements. This is illustrated by three examples from the current harmonized safety standard BS EN 81-1/2: 1998: + A3: 2009[4,5].

(1) To protect passengers, clause 14.2.3 requires an emergency alarm device to be permanently connected to a rescue service, to enable trapped passengers to be released.

(2) To protect workers, clause 5.9 requires that adequate lighting be provided in the well, to enable work activities to be conducted safely.

(3) To protect passers-by, clause 5.2.1.2 requires that partially enclosed wells be provided with a sufficiently high enclosure, to prevent human contact or interference.

The UK has adopted (BS) EN 81-80: 2003: *Safety rules for the construction and installation of lifts. Existing lifts. Rules for the improvement of safety of existing passenger and goods passenger lifts*[1]. This safety standard does not have the status of a harmonised standard under the European Directives and in the UK will not be enacted in law. BS EN 81-80 does, however, provide the rules for the upgrading of existing lifts with the aim of providing an equivalent level of safety to that of a newly installed lift. This not always possible, but measures should be put in place to reduce all hazards to the smallest residual risk.

There is no duty on an owner (or operator) to bring a lift up to the latest level of safety; it is voluntary. However, in the event of an incident it is likely that their attention will be drawn to the best practice contained in the latest safety standards. This situation can be avoided by carrying out a safety audit from time to time and upgrading all lifts to the recommendations of BS EN 81-80, in order to ensure the highest currently perceived level of safety is obtained.

16.8 Step-by-step approach to improving the safety of existing lifts

One way in which to improve the safety and service of the lifts over time is to apply a step-by-step approach. In this way hazards can be identified and those which represent the greatest threat can be eliminated first. Those hazards that are considered as minor might be attended to later. Thus the improvement in safety of existing lifts can be made over a period of time by tracking the changes required as the standards develop, allowing owners to budget for them. This is illustrated in Figure 16.3.

BS EN 81-80[1] is a European standard written to address the hazards that may be present on existing installations due to the differences in levels of safety between what was thought permissible at the time of installation and what would be considered as acceptable today.

Through risk assessment it has identified 74 significant hazards, listed in Table 16.1. In the examples given in section 16.7 above, (1) is No. 71, (2) is No. 17 and (3) is No. 7. Table 16.1 can be used as an *aide-memoire* to determine the number and basic requirements for each hazard present. The 'remedial action' column indicates the requirements for modification to be undertaken by reference to a current safety standard. These are mostly taken from BS EN 81-1: 1998: + A3: 2009[4] (electric lifts) and BS EN 81-2: 1998: + A3: 2009[5] (hydraulic lifts). Some remedial actions are specific to electric lifts and are shown (indicated by {1}) and others are specific to hydraulic lifts and are shown (indicated by {2}). Some hazards have a number of options that can be applied, i.e. (a), (b), (c), etc. Table 16.1 is necessarily succinct and should only be applied with appropriate reference to BS EN 81-1: + A3: 2009[4], BS EN 81-2: + A3: 2009[5], BS EN 81-28[16], BS EN 81-70[17] and BS EN 81-80[1].

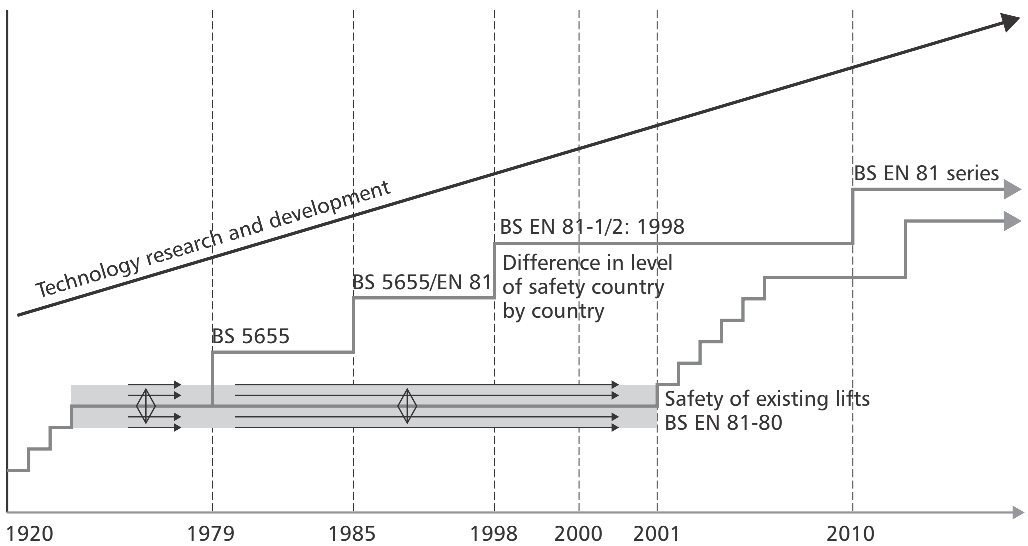

Figure 16.3 Step-by-step improvement of the safety of existing lifts

BS EN 81-80[1] was written as a European safety standard and as such has had to allow for the wide range of situations in all the CEN member states. To accommodate this range, the standard proposes a filtering method to identify the priority of each risk. This procedure is particularly useful in the UK as it permits each installation to be assessed individually. What is a high priority hazard in one installation may be low priority in another. Considering example 2, a lift with no well lighting would be at a higher priority than a lift installed to EN 81-1: 1985[21], which had some well lighting.

Applying the filtering process in the UK results in the 74 significant hazards being allocated high, medium or low priority as shown by the numbers in the boxes of Figure 16.1 or the left hand column in Figure 16.2. This priority allocation is for guidance only as each installation must be examined individually (by a competent person) in order to determine its particular risks. It will be noted that there are three significant hazards that require attention on post 1 July 1999 installations.

Table 16.2 also includes a remark 'Checks to BS EN 81-80' in the second column. This remark refers to the significant hazards listed in BS EN 81-80 and summarised in Table 16.1

Table 16.1 Summary of significant hazards from BS EN 81-80: 2003 that might be encountered while undertaking modifications to existing lifts; column 1 is hazard number, column 2 is a summary, column 3 refers to the relevant clause number in BS EN 81-80: 2003 and column 4 offers remedial action (references are to BS EN 81-1/2: 1998 unless indicated otherwise, see sections 16.8 and 16.9)

No.	Description	BS EN 81-80 clause	Remedial action to BS EN 81-1/2*
General			
1	Presence of harmful materials	5.1.4	0.3.1
Accessibility			
2	No or limited accessibility for disabled persons	5.2.1	Measures to BS EN 81-70
3	Drive system with bad stopping/levelling accuracy	5.2.2	BS EN 81-70, 5.3.3
Vandalism			
4	No or inadequate vandal resistance	5.3	Measures to prEN 81-71
Behaviour in the event of fire			
5	No or inadequate control functions in case of fire	5.4	Measures to BS EN 81-73
Lift well (Section 5 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
6	Well enclosures with perforate walls	5.5.1.1	(*a*) fit imperforate well enclosure, or (*b*) fit perforate enclosure to BS EN 294: 1992, 4.5.2
7	Partially enclosed well with too low enclosure	5.5.1.2	5.2.1.2
8	(*a*) Inadequate locking devices on access doors to well and pit	5.5.2	5.2.2.2.1
	(*b*) Car does not stop when access doors to well and pit are opened	5.5.2	5.2.2.2.2
9	Inadequate vertical surface below landing door sills	5.5.3	5.4.3
10	Counterweight/balancing weight without safety gear in case of accessible spaces below well	5.5.4	(*a*) provide solid pier, or (*b*) fit safety gear to counterweight/balance weight
11	No or inadequate partition of counterweight/balancing weight travel path	5.5.5	5.6.1
12	No or inadequate pit screen for several lifts in the same well	5.5.6.1	5.6.2.1
Lift well (continued)			
13	No or inadequate partition for several lifts in the same well	5.5.6.2	5.6.2.2
14	Insufficient safety spaces in headroom and pit	5.5.7	{1} 5.7.1–5.7.3 {2} 5.7.1–5.7.2
15	Unsafe pit access	5.5.8	{1} 5.7.3.2 {2} 5.7.2.2
16	No or inadequate stopping devices in the pit or in the pulley room	5.5.9	{1} 5.7.3.4, 6.4.5 {2} 5.7.2.5, 6.4.5
17	No or inadequate lighting of the well	5.5.10	5.9
18	No alarm system in pit and on car top	5.5.11	5.10 (14.2.3, BS EN 81-28)
Machine and pulley rooms (Section 6 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
19	No or unsafe means of access to machine and pulley room	5.6.1	6.2
20	Slippery floor in machine or pulley room	5.6.2	6.3.1.2, 6.4.1.2
21	Insufficient clearances in machine room	5.6.3	Guard to BS EN 294: 1992, Table 4
22	No or inadequate protection on different levels in machine pulley room	5.6.4	6.3.2.4–6.3.2.5
23	Inadequate lighting in machine or pulley room	5.6.5	6.3.6, 6.4.7
24	Inadequate lifting means for handling equipment	5.6.6	Test and display SWL of lifting means and check suitability of position
Landing doors and car doors (Section 7 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
25	Perforate landing doors and car doors	5.7.1	7.1, 8.6.1
26	Inadequate strength of landing door fixings	5.7.2	7.2.3.1, 7.4.2.1

* {1} indicates BS EN 81-1 series only, {2} indicates BS EN 81-2 series only

Table continues

Table 16.1 — *continued*

No.	Description	BS EN 81-80 clause	Remedial action to BS EN 81-1/2*
Landing doors and car doors (continued)			
27	Inadequate provision of glass in doors	5.7.3	(*a*) 7.2.3.2–7.2.3.4, 8.6.7.2–8.6.7.4, or (*b*) Annex J, or (*c*) 7.6.2, or (*d*) remove, add signal
28	No or inadequate protection against dragging of a child's hands on a horizontal sliding car or landing doors with glass	5.7.4	7.2.3.6, 8.6.7.5
29	No or inadequate lighting on landing	5.7.5	7.6.1
30a	No or inadequate protective devices on power operated car and landing doors (not intended for disabled use)	5.7.6	(*a*) 7.5.2.1.1, 8.7.2.1.1, or (*b*) BS EN 81-70, 5.2.3–5.2.4
30b	No or inadequate protective devices on power operated car and landing doors (intended for disabled use)	5.7.6	BS EN 81-70, 5.2.3–5.2.4
31	Unsafe or inadequate locking device of landing door	5.7.7	7.7.3.1
32	Unlocking of landing door without using a special tool	5.7.8.1	7.7.3.2
33	Access to door locks through perforate well enclosure	5.7.8.2	(*a*) fit imperforate well enclosure, or (*b*) fit protection around door locks
34	No automatic closing device on horizontal sliding doors	5.7.9	7.7.3.2
35	Inadequate link between panels of landing doors	5.7.10	7.7.6
36	Inadequate fire resistance of landing doors	5.7.11	Fit doors to specified fire regulations
37	Power operated car door moving with open hinged landing door	5.7.12	Ensure: the landing door is not unlocked until the car door is fully open AND the car door cannot close until the landing door is fully closed
Car, counterweight and balancing weight (Section 8 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
38	Large car area in relation to rated load	5.8.1	(*a*) reduce the available car floor area, or (*b*) restrict use of lift to instructed users only, or (*c*) verify the intended use
39	Inadequate length of car apron	5.8.2	8.4
40	No car doors	5.8.3	(*a*) fit power operated car doors to 8.6–8.10, or (*b*) fit manual car doors to 8.6–8.7.1, 8.9–8.10
41	Unsafe locking of car top emergency trap door	5.8.4	8.12.4.2
42	Insufficient strength of car top and emergency trap door	5.8.5	8.13.1
Car, counterweight and balancing weight (continued)			
43	No or inadequate balustrade on car to protect against falling	5.8.6	(*a*) reduce free distance to less than 0.3 m, or (*b*) fit balustrade to 8.13.3, or (*c*) fit full height partition to reduce free distance to less than 0.3 m
44	Insufficient ventilation in car	5.8.7	8.16
45	Inadequate lighting in car	5.8.8.1	8.17.1–8.17.3
46	No or inadequate emergency lighting in car	5.8.8.2	8.17.4 and illuminate alarm button
Suspension, compensation, overspeed (Section 9 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
47	No or inadequate protection against injury on sheaves, pulleys and sprockets	5.9.1	{1} 9.7 {2} 9.4
48	No or inadequate protection against rope/chains leaving the sheaves, pulleys or sprockets	5.9.1	{1} 9.7 {2} 9.4
49	No or inadequate protection against introduction of objects on sheaves, pulleys or sprockets	5.9.1	{1} 9.7 {2} 9.4
50a	No safety gear and/or overspeed governor {electric lifts}	5.9.2	{1} 9.8–9.9
50b	Incorrect functioning of safety gear {electric lifts}	5.9.2	{1} (*a*) adjust system, or and/or overspeed governor (*b*) 9.8–9.9
51	No or inadequate slack rope switch for governor rope	5.9.3	{1} 9.9.11.3 {2} 9.10.2.10.3
52	No protection means against ascending car overspeed on electric lifts with counterweight {electric lifts}	5.9.4	{1} 9.10
53	Inadequate design of lift machine to prevent uncontrolled movement with open doors {electric lifts}	5.9.4, 5.12.1	{1} (*a*) change to BS EN 81-1: 1998 machine, or (*b*) install protective means to BS EN 81-80, 5.9.4, Note 2, and/or (*c*) fit double acting brake to 12.4.2
54a	No or inadequate protection against free fall, overspeed and creeping {hydraulic lifts}	5.9.5	{2} 9.5 and Table 3
54b	Automatic return to lowest floor when anti-creep used {hydraulic lifts}	5.9.5	{2} 14.2.1.5
Guide rails, buffers, final limit switches (Section 10 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
55	Counterweight or balancing weight guided by 2 wire ropes {electric lifts}	5.10.1	{1} (*a*) 10.2.1, or (*b*) fit 4 wire ropes
56	No or inadequate buffers	5.10.2	10.3
57	No or inadequate final limit switches	5.10.3	10.5

* {1} indicates BS EN 81-1 series only, {2} indicates BS EN 81-2 series only

Table continues

Table 16.1 — *continued*

No.	Description	BS EN 81-80 clause	Remedial action to BS EN 81-1/2*
Distances car/landing doors (Section 11 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
58	Large horizontal gap between car and wall facing the car entrance	5.11.1	(*a*) reduce distance to 11.2.1, or (*b*) fit car door locking device to 8.9.3
59	Excessive horizontal distance between car door and landing door	5.11.2	11.2.3
Lift machine (Section 12 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
60a	No or inadequate emergency operation system {electric lifts}	5.12.2	{1} 12.5, 16.3.1
60b	No or inadequate emergency operation system {hydraulic lifts}	5.12.2	{2} 12.9, 16.3.1
61	No shut-off valve {hydraulic lifts}	5.12.3	{2} 12.5.1
62	No or inadequate means of stopping the machine and checking its position	5.12.4	{1} 12.7 {2} 12.4
63	No or inadequate slack rope/chain device	5.12.5	{1} 9.5.3, 12.9 {2} 12.13
64	No run-time limiter	5.12.6	{1} 12.10 {2} 12.12
65a	No or inadequate low pressure device {indirect hydraulic lifts}	5.12.7	{2} 12.9.1.5
65b	No or inadequate low pressure device, jack not rigidly fastened to the car {direct acting hydraulic lifts}	5.12.7	{2} 12.9.1.5
Electric installation/appliances (Section 13 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
66	Insufficient protection against electric shock and/or marking of electrical equipment; missing notices	5.13.1	(*a*) 13.1.2 and (*b*) 13.5.3.3 and (*c*) fit warning notice to group controllers
67	No or inadequate protection on lift machine motor	5.13.2	13.3.1–13.3.3
68	No lockable main switch	5.13.3	13.4.2
Protection against electric faults, etc. (Section 14 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
69	No protection against phase reversal	5.14.1	14.1.1.1.j
70a	No or inadequate inspection control station on car top	5.14.2	14.2.1.3
70b	No or inadequate stopping device on car top	5.14.2	14.2.2
71	No or inadequate emergency alarm device	5.14.3	14.2.3, measures to BS EN 81-28
72	No or inadequate communication system between machine room and car (travel height ≥ 30 m)	5.14.4	14.2.3.4
73	No or inadequate load control on car	5.14.5	14.2.5
Notices, markings, operating instructions (Section 15 of BS EN 81-1: 1998, BS EN 81-2: 1998)			
74	Missing notices, markings and operating instructions for safe use and maintenance	5.15	{1} 15.2.1, 15.3, 15.4, 15.5.1, 15.5.3, 15.7, 15.11, 15.15 {2} 15.2.1, 15.2.5, 15.3, 15.4, 15.5.1, 15.5.3, 15.7, 15.11, 15.15, 15.17, 15.18

* {1} indicates BS EN 81-1 series only, {2} indicates BS EN 81-2 series only

16.9 Improvement in accessibility

DD CEN TS 81-82[7] is a technical specification written to address the issues of improvement in access and use of lifts by disabled persons. This is of particular importance since the coming in to full force of the Disability Discrimination Act[22,23] and the removal of any time based exceptions for equipment in compliance with Building Regulations[24] at the time of installation.

Now all premises should be made accessible to disabled persons, where practical, including the removal of any physical barriers, which may include aspects of the lift installations.

To achieve this improvement the DD CEN TS 81-82[7] standard looks at the individual technical requirements of BS EN 81-70[17] and the effect of each item on different levels of disability. A value is then given to each as a way to avoid subjective decisions for the selection of the most effective solutions.

In addition to trying to make the process less subjective by adding quantative values, it can be of help to map out the decisions to be made with regard to possible lift modification, and deciding how effective various solutions are in removing physical access barriers. Figure 16.4 illustrates a typical example of a 'decision tree' for replacement of lift car and landing doors.

Decisions can be taken as a similar three-stage process to that used for risk assessment:

(1) Can the lift be modified to completely remove the barrier?

(2) If (1) above is not possible, what other alternatives may be available to make the lift accessible to most categories of disabled persons?

(3) If the lift cannot be modified to remove the physical barriers, are there alternative procedures, such as the provision of helpers, which may be put into place?

The first stage must consider the present equipment and what is required to make the lifts accessible to users with

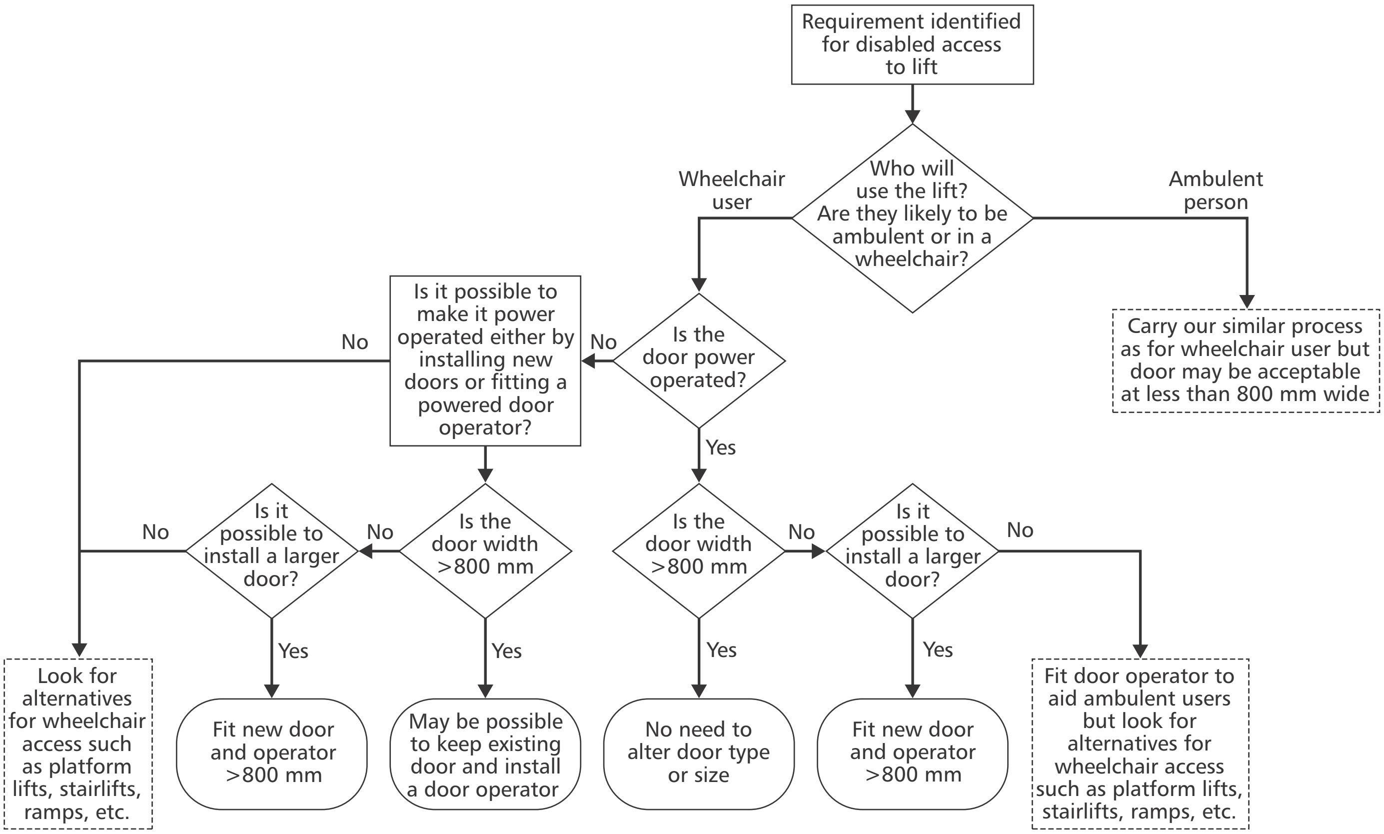

Figure 16.4 Typical example of a 'decision tree' for replacement of lift car and landing doors

disabilities, within the bounds of what is possible and practical.

For example, if the lift is only suitable for four persons then it is unlikely that an 8-person lift, suitable for use by unaided persons in wheelchairs, will ever be able to be accommodated in the existing lift well without extensive building alteration. Where in some public buildings this might be fully justified in other less diversely populated buildings it might not.

The second stage, having recognised that it may not be possible to make the lift entirely free from barriers to use by persons with disabilites, is to consider if the existing lift may be modified to make it suitable for use by persons with less severe disabilities. In this case the incorporation of power doors, accessible controls, audible and visual signals etc. will help in removing accessibility barriers for those persons whose disabilities do not restrict the user to a wheelchair.

Finally, where no practical solution presents itself for the vertical transport of persons with disabilities using lifts, or where their use is restricted by the physical constraints of the lift equipment, the only solution may be to consider alternative means of transportation. In this case stairlifts, ramps, the provision of helpers etc. may aid accessibility within the building by persons with disabilities.

These options should always be taken as the last resort. In adopting these solutions it is accepting that the needs of persons with disabilities may not have been fully met.

In similar fashion to BS EN 81-80[1], the DD CEN TS 81-82[7] standard also provides an audit checklist to enable a person to examine an existing installation against the requirements of BS EN 81-70[17] and determine the most applicable solution to aid persons with disabilities.

16.10 Improvement in protection from vandalism

Continuing in the BS EN 81-80[1] series of standards, technical specification DD CEN TS 81-83[8] gives recommendations for the improvement of existing lifts with regard to resistance to vandalism. Again it recommends that a survey be carried out by a competent person to identify requirements based on those found in BS EN 81-71[18].

This divides lifts into three categories of standard: those without special protection against vandalism (Category 0); those prone to vandalism in an observed area (Category 1); and those in an unobserved area (Category 2). The level of protection required increasing proportionally.

Care should be taken in the application of this standard. Whilst its recommendations are clearly warranted, the level of protection varies greatly between Categories 1 and 2.

Lifts in observed areas such as shopping centres and other public areas, whilst subject to minor acts of vandalism, may be easily modified to incorporate the aims of the document. However, those installed in social housing, car parks etc. where high levels of vandalism might be predicted would constitute a major refurbishment project, with high cost levels, in order to achieve the necessary improvements.

As with all BS EN 81-80 series standards, a checklist is provided giving details of each individual opportunity for improvement, categorised by level of risk, along with the suggested protective measure.

16.11 Improvement in performance

The performance of existing lifts can deteriorate in service as the equipment ages and wears. The requirements of the building in which the lift equipment is installed may also change, either in terms of the quantity of service (e.g. an extra traffic handling demand), or in terms of quality of service (e.g. improved passenger service times). These factors inspire the upgrading of the installation to meet these new requirements.

As an example, consider increasing the rated speed. This will almost certainly require changing the drive system as the principal alteration. Consequential alterations may be to consider changing the safety gear and overspeed governor, and to ensure the electrical power supply to the new equipment is sufficient to meet the changed electrical loading. A check might also need to be made that the traction provided at the new speed is adequate. Consideration might also be given to upgrading the machine room lighting for safety reasons.

16.12 Improvement by (minor) replacement of major components

Sometimes less significant work is carried out to improve the major components without any improvement in performance. This work often involves fewer changes.

For example, a traction drive motor may be changed for one with different electrical characteristics, but the same mechanical characteristics, or a relay-based drive controller may be upgraded to a solid state controller with the same performance characteristics, but a different interface to the installation.

16.13 Summary of modifications undertaken to existing lifts

The modernisation standards BS 5655-11(9) and BS 5655-12(10) list the following changes or replacements:

[1] Change of rated speed*

[2] Change of rated load*

[3] Change of travel*

[4] Change of mass*

[5] Change of complete controller including door operations

[6] Change of drive control system

[7] Change of traffic control system

[8] Change from manual to power-operated doors

[9] Change of entrances:

- [9.1] Alteration to existing landing entrances
- [9.2] Change in the number of landing entrances
- [9.3] Addition of car entrances

[10] Change of safety component:

- [10.1] Landing door locking devices
- [10.2] Safety gear
- [10.3] Overspeed governors
- [10.4] Buffers
- [10.5] Electronic safety devices
- [E10.6] (Electric) Ascending car overspeed protection
- [H10.6] (Hydraulic) Rupture valves and one-way restrictors
- [H10.7] (Hydraulic) Clamping and pawl devices

[11] Change of electric safety devices:

- [11.1] Electric safety devices; manually operated
- [11.2] Electric safety devices; non-manually operated

[E12] (Electric) Change of the drive components:

- [E12.1] Lift Machine
- [E12.2] Brake

[H12] (Hydraulic) Change of the jack and lift machine:

- [H12.1] Change of the jack
- [H12.2] Pump and pump motor
- [H12.3] Hydraulic control block
- [H12.4] Change of pressure relief valve

[13] Change of a car enclosure or interior finishes

[14] Change of a door operator

[15] Change from gates to doors

[16] Change of guide rails or type of guide rails

The reference numbers shown in square brackets refer to Table 16.2, where the definitions of the changes/alteration, the motivation and the main resulting actions are summarised. Cross references are given in Table 16.2 to the relevant clauses in BS 5655-11(9), BS 5655-12(10), BS EN 81-1: 1998 + A3: 2009(4), BS EN 81-2(5) and BS EN 81-80(1).

Users of Table 16.2 should note that it provides guidance only and they must carefully consider each cross reference, in order to identify if any other consequential alterations are required or if other factors need to be checked.

* See section 16.14

16.14 Tests and records

Where any changes listed in section 16.13 that are indicated by an asterisk (*) are made, a full test of the complete lift installation should be carried out.

Where any of the other changes or replacements listed in section 16.13 are made, there might be consequential changes and it is essential that appropriate tests be selected and conducted to ensure a safe installation. The tests indicated in the BS 5655-10[25] series, PAS 32-1/2[26,27] and BS 8486[28,29] series of standards are likely to be appropriate and these documents can also be used to make a suitable record. The document used will depend on when the lift installation was first put into service and what parts are retained/replaced.

Table 16.2 Undertaking modifications to existing lifts (users of this table should note that it provides guidance only and they must carefully consider each cross reference in order to identify any other relevant clauses and then to determine if any consequential alterations are required or if other factors need to be checked together with appropriate reference to BS 5655-11[9], BS 5655-12[10], BS EN 81-1[4], BS EN 81-2[5], BS EN 81-28[16], BS EN 81-70[17] and BS EN 81-80[1]

1 Change of rated speed	**Major modification — full tests and records required**
Definition For electric lifts a change in rated speed is any increase greater than 5% or decrease greater than 8% (see BS EN 81-1, Section 12.6). For hydraulic lifts a change in rated speed is any increase in rated speed greater than 8% (see BS EN 81-2, Section 12.8). **Motivation** An increase in rated speed can occur, for example, where it is desired to improve performance. A decrease in rated speed can occur, for example, as the result of change of use from passenger to goods service.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Dimensions at the well ceiling and pit (5) Safety gear (9.8) Buffers (10.3–10.4) Guide system (10.2) Limits of the unlocking zone (7.7.1) Power supply and switchgear (13) Inspection speed (14.2.1.3) Security of the counterweight/balancing weights (8.18) Safe working spaces and equipment clearances (6) **Electric only:** Suspension (9.1) and traction (9.3) Tripping means for safety gears (9.9) Overspeed governor, ascending car overspeed protection device (9.10) **Hydraulic only:** Suspension (9.1–9.3) Tripping means for safety gears and clamping devices (9.10) Rupture/restrictor valves (12.5) Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include: Electric: 3, 6–18, 19–24, 40, 47–53, 60, 62–64, 66–72, 74 Hydraulic: 3, 6–18, 19–24, 40, 47–49, 51, 54, 60–72, 74
2 Change of rated load	**Major modification — full tests and record required**
Definition A change in rated load is a change greater than 5%, or 75 kg (whichever is the greater). **Motivation** A change in rated load can occur as the result of a need to transport heavier loads or can result from changes to the available size of the platform area of the car.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Verification of the well structure (5) Drive supports, guide rail fixings, buffer supports (10) Safety gear (9.8) Overspeed governor (9.9) Guidance system (10.2) Buffers (10.3–10.4) Drive system (12) Available car area and the new rated load (8, Table 1) Load weighing detection system (14.2.5) Load plate (15) Safe working spaces and equipment clearances (6) Electric only: Suspension (9.1–9.3) and traction (9.3) Ascending car overspeed protection device (9.10) Hydraulic only Suspension (9.1, 9.3) Compatibility of the pressure relief valve (12.5.3) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 38-46, 50-53, 55-57, 60, 66, 70, 73, 74 Hydraulic: 38-46, 51, 54-57, 60-66, 70, 73, 74

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

3 Change of travel	**Increase in travel is a major modification — full tests and record required** **Decrease in travel is a modification — appropriate tests and records required**
Definition A change of travel is any increase or decrease of the travel distance between the highest and lowest finished floor levels. *Note*: a small change may cause refuge spaces and over-travel distances to be insufficient. **Motivation** A change in travel can occur where a lowest, or highest, finished floor level is raised, e.g. to accommodate a suspended floor, or lowered, e.g. to accommodate access for persons with disabilities. A change in travel can also occur where higher or lower floors are no longer served, e.g. service to a basement level is no longer required or higher floors are removed from a traffic zone. *Note*: the provision of additional entrances may be required.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Dimensions at the well ceiling and pit (5) System of guiding (10.2) Final limit switches (10.5) Changes to the wiring (13) should be checked Access (5.2.2, 5.5, 5.7.3.2) and rescue (5.10) Machine room/pulley room requirements (6) Structural and fire integrity (5.3) Pit depth (5.7.2.2) Stopping devices (5.7.2.5) Buffering characteristics (10.4) Top/bottom clearances (5.7) **Electric only:** Suspension system and traction (9.1–9.6) **Hydraulic only:** Suspension system (9.1–9.3) Hydraulic jack (12.2) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 6-18, 19–37, 40, 66 Hydraulic: 6-18, 19–37, 40, 66
4 Change of mass	**Major modification — full tests and record required**
Definition A change of suspended or driven mass of either empty car, or suspended mass, or mass of a jack is any increase, or decrease, greater than 5%. **Motivation** A change in mass can occur as the result of a larger or smaller car being installed, changes to the linings (car refurbishment), changes to the car doors/operators (manual to power doors, adding car doors, change of operator type), addition or changes of other equipment; and attachments carried on the car (car top balustrades, guarding, canopies, traps, etc.). *Note*: changes to the mass has similar effects to changing the rated load.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Verification of well structure (5) Guidance system (10.2) Suspension (9.1–9.3) Buffers (10.3–10.4) Safety gear (9.8) **Electric only:** Drive system (12) Traction (9.3) Governor (9.9) Ascending car overspeed protection (9.10) **Hydraulic only:** Tripping means (9.10) Balancing weight (8.18) Compatibility of the pressure relief valve (12.5.3) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 38–46, 50-53, 55-57, 60, 66, 70, 73, 74 Hydraulic: 38–46, 54–57, 60, 66, 70, 73, 74
5 Change of complete controller including door operations	
Definition A change of all or part of a controller. *Note*: a complete controller comprises the drive control system, the traffic controller and the door operator.	For details see drive control system (change 6); traffic controller (change 7); door operator (see change 14).

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

6 Change of drive control system	Appropriate tests and records required
Definition A change in the drive control system, which is the system controlling and monitoring the running of the lift machine (but not door operations), sometimes called motion control (see BS 5655-6: 2002, 9.2 and Chapter 8). *Note*: for electric lifts the drive system comprises the hoist motor, any gear (if installed), brake, sheave, bearing, bedplate, drive controller and signal interface. For hydraulic lifts the drive system comprises the pump unit, control valves, jack, piping, drive controller and signal interface. **Motivation** A change in the drive system might be required to improve the ride comfort to passengers, improve passenger handling, the accuracy of floor levelling, reduce the number of breakdowns, reduce energy consumption, or provide a greater level of safety to the operation of the lift. *Note*: a new electric motor (see BS 5655-6: 2002, 9.2) or pump motor (see BS 5655-6: 2002, 9.2.2) might be required to match the drive technology employed (see change 12).	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Earthing (13) Wiring (13) Safe working spaces and equipment clearances (6.3.2) Rated voltage, current, power (13) Electromagnetic compatibility (EMC) (BS EN 12015/12016) Inspection control (14.2.1.3) Ventilation (6.3.5) Auxiliary supplies (13.4.1) **Hydraulic only**: Anti-creep devices (9.12) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 53, 60, 62-64, 66-69, 74 Hydraulic: 54, 60-69, 74
7 Change of traffic control system	**Appropriate tests and records required**
Definition A change of the traffic control system, which supervises and distributes landing and car calls to specific lift car(s) in order to handle the calls in an efficient manner (see BS 5655-6: 2002, clause 7; Barney[30], chapter 9). **Motivation** A change of traffic control system might be required to reduce passenger waiting and journey times, increase the number of passengers served, provide special features to increase accessibility for disabled persons, reduce lift group failures by the replacement of relays with solid state technology, improve the behaviour of the lift in the event of fire, reduce any risks owing to the poor condition of wiring, etc.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Earthing (13) Wiring (13) Safe working spaces and equipment clearances (6.3.2) Rated voltage, current, power (13) Electromagnetic compatibility (EMC) (BS EN 12015/12016) Ventilation (6.3.5) Auxiliary supplies (13.4.1) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 23, 66, 68, 74
8 Change from manual to power-operated doors	**Appropriate tests and records required**
Definition This change involves the addition of powered devices to drive (operate) the car and/or the landing doors. **Motivation** A change from manual to power-operated doors might be required to improve the service to the passengers (traffic handling) or to reduce the burden on passengers to open and close the doors by hand, e.g. to assist persons with disabilities.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Verification of the well structure (5) Adequate clearances (11) Hazards on the car roof (5.7.1.1) Change the mass of the car (see change 4) Capability of the drive system (see change 6) Child hand protection (7.2.3.6) Protection against electric shock (13.5.3.2 and 13.5.3.5) Dynamic requirements (8.7.2.1.1) Fire integrity of the landing entrance (7.2.2) **Electric only:** Traction (9) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 4, 6-18, 25–44, 58, 59, 66, 68, 70
9 Change of entrances	
9.1 Alteration to existing landing entrances	**Appropriate tests and records required**
Definition This change involves alterations to the landing entrances which can occur when they are refurbished by the addition of new panel skins or when they are completely replaced by different components not of the same specification as the original, e.g. heavier. *Note*: the type of operation, manual or powered, is not changed (see change 8). **Motivation** To replace damaged or distressed door panels or complete doors.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (7) Fire integrity (7.2.2) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 6–18, 25–37, 58, 59, 66, 74

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

9.2 Change in the number of landing entrances	**Appropriate tests and records required**
Definition This change involves the provision of additional entrances or the reduction in the number of entrances. *Note*: see change 3 for change of travel. **Motivation** Additional landing entrances might be required where an existing lift does not serve all floors throughout its existing travel, e.g. skip/stop arrangements, or where a mezzanine floor is introduced. There might also be occasions when entrances are to removed, e.g. at the extremes of travel.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Structural integrity (5.3) Fire integrity (7.2.2) Clearances (11) Safe working spaces (5.7.1) Compatibility with door operator (7) *Note*: new locks to be a 'CE' type-tested design. **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 6–18, 25–37, 50–53, 58, 59, 66, 73, 74
9.3 Addition of car entrances	**Appropriate tests and records required**
Definition This change involves the provision of additional car entrances. **Motivation** An additional car entrance may be addedto service landings at the rear or side of the well.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Hazards on the car top (8.15) Car structural integrity (8.3) Refuge spaces (5.7.1, 5.7.2) Clear working areas (8.13.2) *Note*: if floor area changes, see change 2. If suspended mass changes, see change 4. **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 25, 27, 28, 30, 33, 37, 58, 59
10 Change of a safety component	
10.1 Landing door locking devices	**Appropriate tests and records required**
Definition This change involves the changing or replacement of a landing door locking device. **Motivation** Landing door locking devices can be changed or replaced by a more modern device, as the result of the unavailability of an identical equipment. New landing door locking devices might be fitted as the result of the change in the number of entrances (see change 9).	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (7.7) Fire integrity of landing door (7.2.2) Fire integrity of locking device *Note*: new locks to be a 'CE' type-tested design. **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 1, 4, 29 to 37, 40, 58, 59
10.2 Safety gear	**Appropriate tests and records required**
Definition Safety gear can be of an instantaneous or progressive type. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (9.8) Energy absorption (F 3.2.4.1) Compatibility with associated safety system (see change 10.3) Soundness of the mountings. **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 1, 10, 50a or 50b
10.3 Overspeed governors	**Appropriate tests and records required**
Definition This change involves the changing or replacement of an overspeed governor. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (9.9) Calibration Compatibility with associated safety system (see change 10.2) Clear working space (6.3.2) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 1, 50a or 50b

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

10.4 Buffers	**Appropriate tests and records required**
Definition Buffers can be of energy accumulation or energy dissipation types. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (10.3–10.4) Safe working spaces (5.7.3) and equipment clearances Pit strength (5.3.2) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 14–18, 56–57
10.5 Electronic safety devices	**Appropriate tests and records required**
Definition Electronic safety devices, replacing the functions of devices listed in BS EN 81-1/2:1998, Annex A. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (14, F.6, Annex H)
E10.6 (Electric) Ascending car overspeed protection	**Appropriate tests and records required**
Definition Ascending car overspeed protection comprises speed monitoring and speed reducing elements. **Motivation** A change can occur when a replacement is required or another change requires a different device. Ascending car overspeed protection may be added, as it was first required by the Lift Regulations 1997.	**Checks to clauses of BS EN 81-1 (detailed in BS 5655-11), include:** Conformity (9.10) Integration with other equipment Integration with building structure **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 10, 50a or 50b, 52
H10.6 (Hydraulic) Rupture valves and one-way restrictors	**Appropriate tests and records required**
Definition A rupture valve is a device that is capable of stopping a downward moving car and holding it stationary. A restrictor is a device that is capable of restricting the downward speed of a car in the case of a major leakage. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-2 (detailed in BS 5655-12), include:** Conformity (12.5.5, 12.5.6) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Hydraulic: 54, 65
H10.7 (Hydraulic) Clamping and pawl devices	**Appropriate tests and records required**
Definition A clamping device is a device that is capable of stopping a downward moving car and holding it stationary, and can be of a progressive or instantaneous type. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-2 (detailed in BS 5655-12), include:** Well structure (5) Conformity (9.9, 9.11) Compatibility with tripping system (9.10) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Hydraulic: 54, 56
11 Change of electric safety devices	
11.1 Electric safety devices — manually operated	**Appropriate tests and records required**
Definition Electric safety devices — manually operated are one of the seven manually operated stopping devices listed in Annex A of BS EN 81-1/2 (incorporating A2), e.g. pit switch stopping device. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (14.1.2, 14.2.2) Location (Annex A) Prevent involuntary release (14.2.2.2) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 16, 70a, 70b
11.2 Electric safety devices — non-manually operated	**Appropriate tests and records required**
Definition Electric safety devices — non-manually operated are one of the 37 non-manual devices listed in Annex A of BS EN 81-1 (incorporating A2) and 30 non-manual devices listed in Annex A of BS EN 81-2 (incorporating A2), e.g. buffer switch. **Motivation** A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (14.1.2) Location (Annex A) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 8, 31, 41, 51, 57, 6

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

E12 (Electric) Change of the drive components	
E12.1 Lift machine	**Appropriate tests and records required**
Definition The lift machine comprises the hoist motor, gear (if installed), sheave, pulley, bearing and bedplate are changed. **Motivation** This change can occur for many reasons, including where excessive wear has taken place, fatigue of the main components is suspected, change of speed, change of levelling accuracy, etc. A traction sheave might be changed as the result of wear or other damage.	**Checks to clauses of BS EN 81-1 (detailed in BS 5655-11), include:** Safe working spaces and equipment clearances (6.3.2) Integration with other equipment Rated voltage, current, power (13) Electromagnetic compatibility (EMC) (BS EN 12015/12016) Ventilation (6.3.5) Rated voltage, current, power (13) Guarding (9.7) Traction (9.3). **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 21–24, 47–49, 53, 60, 62–64, 66–68, 69, 74
E12.2 Brake	**Appropriate tests and records required**
Definition Device which can operate automatically and hold a car stationary. Motivation A change can occur when a replacement is required or another change requires a different device.	**Checks to clauses of BS EN 81-1 (detailed in BS 5655-11), include:** Conformity (12.4.2.1) Safe working spaces and equipment clearances (6.3.2) Integration with other equipment Rated voltage, current, power (13) Electromagnetic compatibility (EMC) (BS EN 12015/12016) Ventilation (6.3.5) Rated voltage, current, power (13) Guarding (9.7) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 1, 21, 47, 60, 66, 74
H12 (Hydraulic) Change of the jack and lift machine	
H12.1 Change of jack	**Appropriate tests and records required**
Definition A jack comprises a cylinder and ram (piston) and its connecting pipework. **Motivation** A change of jack might be required as the result of damage or wear or as the result of another modification, such as a change in travel or rated load.	**Checks to clauses of BS EN 81-2 (detailed in BS 5655-12), include:** Compatibility of hydraulic fluid Potential fire hazards Well structure (5) Pressure and buckling calculations (12.2.1–12.2.2) Compatibility with building structure Guarding (9.4) Safe working spaces and equipment clearances (6.3.2) Top/bottom clearances (5.7) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Hydraulic: 3, 6–18, 54, 61, 65
H12.2 Pump and pump motor	**Appropriate tests and records required**
Definition Unit comprising an electric motor and attached pump which circulates the hydraulic fluid. **Motivation** A change in the pump/pump motor can occur when the capacity and/or the control characteristics of the system has been changed, or a like-for-like replacement cannot be found.	**Checks to clauses of BS EN 81-2 (detailed in BS 5655-12), include:** Compatibility of hydraulic fluid Potential fire hazards Integration with other equipment Rated voltage, current, power (13) Electromagnetic compatibility (EMC) (BS EN 12015/12016) Ventilation (6.3.5) Rated voltage, current, power (13) Guarding (9.4) Safe working spaces and equipment clearances (6) Cooling (12.14) Wiring (13) **Checks to BS EN 8 1-80 (see Table 16.2 and BS EN 81-80 for details), include:** Hydraulic: 19–24, 61, 62, and 64–69

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

H12.3 Hydraulic control block	**Appropriate tests and records required**
Definition A hydraulic control block controls the hydraulic fluid in and out of the jack and provides control of rated, inspection and emergency lowering speeds. **Motivation** A change might be required as the result of damage or wear or as the result of another modification, such as a change in travel or rated load.	**Checks to clauses of BS EN 81-2 (detailed in BS 5655-12), include:** Compatibility of hydraulic fluid Potential fire hazards Integration with other equipment Rated voltage, current, power (13) Electromagnetic compatibility (EMC) (BS EN 12015/12016) Ventilation (6.3.5) Rated voltage, current, power (13) Inspection speed (14.2.1.3d) Emergency lowering (12.9.1.2) Non-return valve (12.9) Wiring (13) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Hydraulic: 3, 5, 19-24, 54, 60, 61, 65
H12.4 Change of pressure relief valve	**Appropriate tests and records required**
Definition A pressure relief valve is needed to limit the system pressure to 1.4 times the full load pressure (exceptionally to 1.7 times). **Motivation** A change might be required as the result of damage or wear or as the result of another modification, such as a change in travel or rated load.	**Checks to clauses of BS EN 81-2 (detailed in BS 5655-12), include:** Compatibility of hydraulic fluid Potential fire hazards **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Hydraulic: 54, 61, 65
13 Change of a car enclosure and/or interior finishes	**Appropriate tests and records required**
Definition The car enclosure is the passenger/goods carrying unit, including the car frame, car interior and fit out. **Motivation** From time to time the car interiors begin to look tired and dated and require a new fit out. Sometimes the car enclosure requires change to accommodate a change in landing doors or change of rated load. At this time consideration should be given to increasing the platform area to include the floor area of any extensions or recesses (BS EN 81-1: 1998, 8.2.1), e.g. stretcher extensions, or they should be removed. (*Note*: a car with a stretcher extension (see BS 5655-6: 2002, 9.1.4) is one where the extension is available for the transport of stretchers under controlled conditions.)	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Disability access (BS EN 81-70) Platform area, see change 2 (15) Load change, see change 4 **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 38–40, 44 to 46, 58, 59, 73 Hydraulic: 38–40, 44 to 46, 58, 59, 73
14 Change of door operator	**Appropriate tests and records required**
Definition Mechanism for opening and closing the landing and car doors. **Motivation** The door operator is changed to one with a different specification. A change in positional performance might be desired from open loop to closed loop control, or the dynamic performance might require improvement.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Structural compatibility with car/car frame Compatibility with locking devices Unlocking zone (7.7.1) Apron (8.4) Adequate clearances (5.7, 11) Hazards on the car roof (5.7.1.1) Change the mass of the car (see change 4) Protection against electric shock (13.5.3.2 and 13.5.3.5) Dynamic requirements (8.7.2.1.1) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 34, 35, 66, 74 Hydraulic: 34, 35, 66, 74

Table continues

Table 16.2 Undertaking modifications to existing lifts — *continued*

15 Change from gates to doors	**Appropriate tests and records required**
Definition Gates are used to protect the access to a lift car and are perforate. **Motivation** In order to improve safety the gates can be replaced by doors. The change might retain manual operation or the opportunity might be taken to fit power-operated doors.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include:** Conformity (7, 8) Well structure (5) Clearances (11) Change the mass of the car (see change 4) **Electric only:** Traction (9.3) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric/hydraulic: 25 to 37, 40, 58, 59, 66, 74
16 Change of guide rails or type of guide rails	**Appropriate tests and records required**
Definition Guidance system for the lift car and counterweight/balancing weight. **Motivation** A change of guide rails or type of guide rails can occur when an installation is upgraded or modified.	**Checks to clauses of BS EN 81-1/2 (detailed in BS 5655-11/12), include**: Guidance system (10, Annex G) Well structure (5) Clearances (5.7) Compatibility with fixings Compatibility with safety gear (9.8) Compatibility with governor (9.9) **Checks to BS EN 81-80 (see Table 16.2 and BS EN 81-80 for details), include:** Electric: 11-13, 50, 55 Hydraulic: 11-13, 50, 55

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17 European Directives, legislation, standards and codes of practice

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Chapter contents

17 European Directives, legislation, standards and codes of practice

17.1 Important note

This chapter is provided for information only. Of necessity it is brief, may not include all possible information and may or may not be applicable to all activities in the vertical transportation field. Responsible persons and duty holders must review the contents and decide applicability. The Institution cannot be held responsible for any loss or injury resulting from the use of this information. Other sources of information include:

— Department for Business, Innovation and Skills (BIS) (http://www.bis.gov.uk)

— British Standards Institution (BSI) (http://www.bsigroup.com)

— Communities and Local Government (CLG) (http://www.communities.gov.uk)

— European Commission (Enterprise and Industry) (http://ec.europa.eu/enterprise/sectors/mechanical/lifts/index_en.htm)

— Office of Public Sector Information (http://www.opsi.gov.uk/legislation/original)

— The Stationery Office (http://www.tsoshop.co.uk)

— Health and Safety Executive (HSE) (http://www.hse.gov.uk)

European and UK legislation is generally available free of charge through the internet and links to specific items of legislation are given in the list of references at the end of this chapter.

The sections below list entries alphabetically by title to avoid any presumption of relative importance.

17.2 European Directives

17.2.1 Electromagnetic Compatibility Directive

The Electromagnetic Compatibility Directive[1] deals with the two elements of electromagnetic compatibility (EMC), i.e. emission and immunity. Generic standards that support the Electromagnetic Compatibility Regulations 1992[2] are BS EN 61000-6-1[3] for residential, commercial and light industry and BS EN 61000-6-2[4] for industrial environments. Industry standards for lifts are BS EN 12015[5] and BS EN 12016[6].

The emission requirements of the Directive are specified so as to ensure a level of electromagnetic emission that will cause minimal disturbance to other equipment.

The immunity requirements of the Directive are specified so as to ensure a level of electromagnetic immunity that will allow minimal disturbance to vertical transportation equipment.

Generic immunity and emission standards that support the Electromagnetic Compatibility Regulations 1992 is the BS EN 61000[7] series. Industry standards for lifts, escalators and passenger conveyors are BS EN 12015[5] and BS EN 12016[6].

17.2.2 Framework Directive

European Directive 89/391/EEC[8] deals with 'the introduction of measures to encourage improvements in the health and safety of workers at work.' The Directive is largely implemented in the Management of Health and Safety at Work Regulations 1992[9] (MHSWR) (see section 17.1.13).

17.2.3 Lifts Directive

Directive 84/529/EEC was published in 1984 and related to electrically, hydraulically or oil-electrically operated lifts. It did not ensure freedom of movement for all types of lift and was declared to constitute barriers to trade within the Community.

A new Lifts Directive 95/16/EC[10] was published in 1995 permitting the national rules on lifts to be harmonized. Some small changes were made in 2009 in expectation of the revised Machinery Directive, see section 17.2.5, coming into force on 29 December 2009. Further revision is expected in the near term.

See section 17.4.8 for UK enactment.

17.2.4 Low Voltage Directive

European Directive 2006/95/EC[11] is concerned that electrical equipment, when properly installed and maintained, does not endanger persons, domestic animals and/or property and provides safe operation of the equipment by users free from risk of electric shock. Low voltage is defined as 50–1000 V AC or 75–1500 V DC.

Electrical parts for passenger and goods/passenger lifts are excluded in Annex II of the Directive, as lifts can be treated as a factory built assembly for the purposes of the Directive. Escalators and passenger conveyors are not excluded from the Directive.

17.2.5 Machinery Directive

First published as 89/392/EEC and amended by 91/368/EEC, 93/44/EEC, 93/68/EEC[12] and 2006/42/EC[13].

See section 17.4.12 for UK enactment.

17.3 Acts of Parliament

17.3.1 Disability Discrimination Act 1995 and 2005

The Disability Discrimination Act 1995[14] (DDA) gives people with disabilities new rights in access to goods, facilities and services, buying and renting land and employment. The right of non-discrimination came into force in December 1996 requiring goods, facilities and services to be accessible to disabled people; this can include the removal of physical barriers, but does not impose specific requirements.

Service providers have had to change their policies and provide auxiliary aids from October 1999. Businesses and service providers have had a duty, from 1 October 2004, to make 'reasonable adjustments' to the 'physical features' of both old and new buildings, in order to overcome barriers to access. These reasonable adjustments must consider a range of disabilities such as people with mobility, vision, hearing, speech and dexterity impairments as well as those with learning difficulties and mental health disabilities.

'Reasonable adjustments' take account of practicality, financial and other costs, disruption, resources available, availability of financial assistance.

Lifts, escalators and moving walks are examples of 'physical features'.

The Equality and Human Rights Commission has published a number of codes of practice relating to duties applicable under the Disability Discrimination Act 1995 available from the EHRC website (http://www.equalityhumanrights.com/advice-and-guidance/public-sector-duties/guidance-and-codes-of-practice/codes-of-practice/index.html).

The Disability Discrimination Act 1995[14] has been amended (but not repealed) by the Disability Discrimination Act 2005[15].

17.3.2 Health and Safety at Work etc. Act 1974

This Act[16] is an item of primary legislation, also used to enact other safety regulations. The Act places duties on employers, the self-employed and employees. Persons concerned with lifts have duties under the Health and Safety at Work etc. Act 1974 (HSWA), which include the following:

(*a*) Employers have a duty to ensure, so far as is reasonably practicable, the health and safety of their employees while at work. This includes:
- — the provision of plant and systems of work that are safe and without risk to health
- — the means to safely use and handle articles and substances
- — all necessary information, instruction, training and supervision
- — a safe means of access and egress
- — a safe working environment.

(*b*) Employers, the self-employed and employees have a duty to conduct their undertakings in such a way as to ensure, so far as is reasonably practicable, that all persons who might be affected by the work activity are not exposed to risks to their health and safety.

(*c*) Manufacturers, suppliers etc. of articles for use at work have a duty to ensure, so far as is reasonably practicable, that the articles are so designed and constructed that they will be safe and without risk to health when they are being set, used, cleaned or maintained.

(*d*) Erectors and installers of articles for use at work have a duty to ensure, so far as is reasonably practicable, that nothing about the way articles are erected or installed is unsafe or a risk to health.

(*e*) Persons concerned with premises have a duty to persons other than employees who use non-domestic premises made available to them as a place of work. It is the duty of the person who controls the premises to take such measures as it is reasonable for them to take to ensure, so far as is reasonably practicable, that the premises, the means of access to and egress from the premises, and any plant of substance in the premises, are safe and without risk to health.

17.4 Regulations

17.4.1 Construction (Design and Management) Regulations 2007

The Construction (Design and Management) Regulations 2007[17] (CDM) place duties on the client, CDM co-ordinator, designer, principal contractor and contractors to coordinate and manage the health and safety aspects of a construction project with the aim to control and reduce the risks involved.

The design, installation and maintenance of lifts and escalators is always subject to risk assessments being carried out and their installation and continued operation will be subject to the CDM Regulations.

These regulations are extensively covered in chapter 18.

17.4.2 Control of Asbestos Regulations 2006

The Control of Asbestos Regulations 2006[18] require employers to prevent the exposure of employees to asbestos or, if this is not reasonably practicable, to control such exposure to the lowest possible level. Before any work with asbestos is carried out, the Regulations require employers to make an assessment of the likely exposure of employees to asbestos dust, which can include a description of the precautions that are taken to control dust release and to protect workers and others who may be affected by that work.

These Regulations are superior to the Provision and Use of Work Equipment Regulations 1998[19] (PUWER) (see section 17.4.10), the Control of Substances Hazardous to Health Regulations 2002[20] (COSHH) (see section 17.4.3) and the Construction (Design and Management) Regulations 2007[17] (CDM) (see section 17.4.1), which rely upon them. More information can be found at the HSE website (http://www.hse.gov.uk/asbestos/regulations.htm).

17.4.3 Control of Substances Hazardous to Health Regulations 2002

The Control of Substances Hazardous to Health Regulations 2002[20] (COSHH) and subsequent amendments set out a framework of action for employers and self-employed persons to follow that aims to protect the health of all people who might be exposed to hazardous substances at work. Employers must protect employees and others who may be affected by:

— carrying out a risk assessment

— identifying and implementing control measures

— ensuring that the control measures are used

— ensuring that employees are properly informed, trained and supervised.

Hazardous substances include chemicals, dust, gases and fumes. Asbestos is excluded from the COSHH Regulations as it is covered by separate legislation (see section 17.4.2).

The COSHH Regulations originally resulted from European Directive 80/1107/EEC[21] and first came into force in 1988. The latest version came into force in November 2002. More information can be found at the Health and Safety Executive website (www.hse.gov.uk/coshh/index.htm).

17.4.4 Electricity at Work Regulations 1989

These Regulations came into force on 1 April 1990 and introduce a control framework incorporating fundamental principles of electrical safety applying to a wide range of plant systems and work activities. They apply to all places of work, and electrical systems at all voltages. They apply to employers and self-employed persons and set out requirements for all electrical systems, including construction, integrity, maintenance and isolation.

17.4.5 Electrical Equipment (Safety) Regulations 1994

The Electrical Equipment (Safety) Regulations 1994[22] implement the requirements of composite European Directive 93/68/EEC[12] and cover the supply of electrical equipment that, when properly installed, does not endanger persons, domestic animals or property and provides safe operation of the equipment by users free from electric shock. Low voltage is defined as 50–1000 V AC, or 75–1500 V DC.

Schedule 2 of these Regulations excludes parts for escalators and passenger conveyors, as these are considered to be a factory-built assembly.

17.4.6 Health and Safety (Safety Signs and Signals) Regulations 1996

Certain safety signs are required by law to communicate essential safety directions and information. Where applicable, such signs should comply with the Health and Safety (Safety Signs and Signals) Regulations 1996[23] (HSSSS), which puts into practice the European Safety Signs Directive (92/58/EEC)[24], to ensure the standardisation of safety signs so that they have the same meaning thus reducing the risk of misunderstanding. Safety signs are categorised as prohibition, mandatory, warning and information. The first three must follow the shape and colours stipulated. Certain information signs, such as those which indicate a safe place, emergency exit, first aid or firefighting equipment must comply with the regulations. More prescriptive signs should follow the shape, i.e. rectangular or square, but may use pictograms and different colours providing they are not confusing. The regulations only apply to employers in respect to their employees. However, they are considered good practice in all applications.

17.4.7 Lifting Operations and Lifting Equipment Regulations 1998

The Lifting Operations and Lifting Equipment Regulations 1998[25] (LOLER) give effect to European Directive 89/655/EEC[26] on the health and safety requirements for the use of work equipment by persons at work as amended by European Directive 95/63/EC[27] and came into force on 5 December 1998.

Lifting operations mean an operation concerned with the lifting or lowering of a load. Lifting equipment means work equipment for lifting or lowering loads and includes its attachments for anchoring, fixing or supporting it. An accessory for lifting means work equipment for attaching loads to machinery for lifting. Work equipment means any machinery, appliance, tool or installation for use at work. Load includes a person and the Regulations include passenger lifts.

LOLER applies to lifting equipment for lifting persons, but does not apply to escalators and passenger conveyors.

LOLER requires that a 'thorough examination'* be carried out every six months (or by a written scheme determined by risk assessment) by a competent person and a report issued. The report should notify any defect that in the opinion of the competent person could be, or become, a danger to persons. Where there a serious risk of personnel injury the competent person should inform the duty holder immediately and a report should be sent as soon as reasonably practical to the relevant enforcing authority (HSE or Local Authority).

Further information is available in HSE publications *Simple guide to the Lifting Operations and Lifting Equipment Regulations 1998*[28] and *Thorough examination of lifting equipment*[29].

The Provision and Use of Work Equipment Regulations 1998[19] (PUWER) also apply to lifting equipment, see section 17.4.10.

17.4.8 Lifts Regulations 1997

These Regulations[30] implement Directive 95/16/EC[10] (the Lifts Directive) in order to meet the essential health and safety requirements (EHSRs) defined in the Directive. The Regulations came into full force on 1 July 1999. The Regulations contain fifteen complex schedules setting out the arrangements. The most important of these is Schedule 1, which sets out the EHSRs relating to the design and construction of lifts and safety components. Among the definitions included are those for 'lift', 'harmonised standard', 'installer', 'safe', 'placing on the market', 'essential health and safety requirements' and 'responsible person'. 'Putting into service' is not specifically defined. The Lifts Directive was slightly amended by the publication of the Machinery Directive 2006/42/EC[13], when the boundary was elaborated between lifts on one hand and machines that transported persons on the other.

The ESHRs set down in the Regulations apply to the entire lift installation, including the building fabric and supporting building services. Compliant installations will carry a CE-mark in the lift car. The CE-marking denotes that either (*a*) the entire installation complies in full to harmonised standards or to a pre-approved 'model' standard, or (*b*) the installation meets the minimum essential health and safety requirements approved by a 'notified body'. These are known as the 'routes to conformity'. The most common routes to conformity are the installation of 'model' lifts and lift installations meeting harmonised standards. Schedule 1 is summarised below:

(1) General:

- 1.2(a) Car to be designed for adequate space and strength for rated load.
- 1.2(b) Provide (if possible) unimpeded access to disabled persons.
- 1.3(a) Provide adequate means of suspension.
- 1.3(b) Provide at least two ropes or chains.
- 1.4.1 Provide an overload device.
- 1.4.2 Provide overspeed limitation.
- 1.4.3 Provide speed monitoring and speed limiting on fast lifts.
- 1.4.4 Adequate traction is required.
- 1.5.1 Each lift has its own machine.
- 1.5.2 Machinery is inaccessible to public.
- 1.6.1 Controls for use of disabled may be provided.
- 1.6.2 Function of controls to be clearly indicated.
- 1.6.3 Group call circuit interconnections provided.
- 1.6.4(a) No confusion with lift supply.
- 1.6.4(b) Possible to switch off lift under load.
- 1.6.4(c) Movement dependent on an electrical safety circuit.
- 1.6.4(d) A fault in the electrical system not dangerous.

(2) Hazards to persons outside the car:

- 2.1(a) Adequate well size.
- 2.1(b) Entering well, stops lift.
- 2.2 Provision of refuge spaces.
- 2.3(a) Provide strong landing doors.
- 2.3(b) Provide landing door interlocks.

(3) Hazards to persons in the car:

- 3.1(a) Fully enclosed cars.
- 3.1(b) Doors cannot open between floors.
- 3.2(a) Prevention of free fall/uncontrolled upward movement.
- 3.2(b) The device is capable of stopping lift with rated load and speed.
- 3.3 Buffers to be provided.
- 3.4 If device in 3.2 set then lift cannot move.

(4) Other hazards:

- 4.1 Power doors not to crush passengers.
- 4.2 Doors to have fire resistance.
- 4.3 Counterweights to be guided.
- 4.4 Provision of equipment to release trapped passengers.
- 4.5 Two-way permanent communication with rescue service.
- 4.6 Lift machine over-temperature detection.
- 4.7 Car ventilation to be provided.
- 4.8 Car lighting (normal and emergency) to be provided.
- 4.9 Alternative power for communication and lighting.
- 4.10 Fire control.

* The Safety Federation (SaFed), in association with the Health and Safety Executive (HSE), has published guidance in its *Guidelines on the supplementary tests of in-service lifts* (http://safedco.uk)

(5) Marking:
- 5.1 Car rating plate.
- 5.2 Release of trapped passengers without outside help (if so designed).

(6) Instructions for use:
- 6.1 Provide instruction manual for safety components.
- 6.2(a) User instruction manual to be provided.
- 6.2(b) Log book to be provided.

For installations where conformity is to be obtained other than by installing to harmonised standards, the specific requirements for the lift installation's environment should be sought. This is defined in the model lift's technical documentation, or otherwise approved by a notified body. The harmonised standards that satisfy the EHSRs are the BS EN 81 series of safety standards.

For lift modernisations where the lift is not deemed to be new, the installation falls outside of the scope of the Lifts Regulations 1997 and older standards such as BS 5655 and earlier EN 81 series of standards, still apply.

The Regulations do not apply to lifts installed and put into service before 1 July 1999 and a number of specialist lifts listed in Schedule 14.

17.4.9 Management of Health and Safety at Work Regulations 1999

The Management of Health and Safety at Work Regulations 1999[9] (MHSWR) outline the responsibilities and actions regarding the management of health and safety. These implement most of European Directive 89/391/EEC[8] and European Directive 91/383/EEC[31] dealing with the health and safety of persons employed on a fixed term or temporary basis. Regulation 3 requires:

> 'Every employer and self employed person to make a suitable and sufficient assessment of safety risks to employees and others not directly employed, but who are affected by the employer's undertakings, in order to put in place appropriate control measures. Reviews of the assessments shall be made and significant findings recorded if more than five people are employed.'

In particular the duty holder is required to assess the risks to health and safety from their undertaking. This includes risks from the use, operation, repair and examination of escalators and moving walks on their premises. The risk assessment should be 'suitable and sufficient' and undertaken by a person who is competent.

The purpose of the assessment is to identify and quantify the risk. Employers are required to implement preventative and protective measures to eliminate risk, and to put in place effective control measures to address residual risks and hazards.

The employer is required to appoint competent persons to assist the employer in order to develop controls and procedures for health and safety management. The regulations include requirements for training, health and safety assistance, information, organisation, control, monitoring and review.

Further guidance on risk assessments may be found at the HSE website (http://www.hse.gov.uk) and in its leaflet *Five steps to risk assessment*[32].

17.4.10 Provision and Use of Work Equipment Regulations 1998

The Provision and Use of Work Equipment Regulations 1998 Regulations[19] (PUWER) revoke and re-enact the Provisions and Use of Work Equipment Regulations 1992[33], which gave effect to Directive 89/655/EEC[26] on the minimum health and safety requirements for the use of work equipment by workers at work, and came into force on 5 December 1998.

The Regulations require risks to the health and safety of persons from equipment they use at work, to be prevented or controlled by ensuring that it is:

- suitable for use
- maintained in a safe condition, and
- inspected in certain circumstances.

'Use of work equipment' means any activity involving work equipment and includes starting, stopping, programming, setting, transporting, repairing, modifying, maintaining, servicing and cleaning.

'Work equipment' covers all machinery, appliance, tool, equipment or installation used by an employee or a self-employed person at work and includes static and mobile machinery, installations, lifts, escalator and passenger conveyor equipment. It includes hoists and elevating work platforms.

The Regulations also cover thorough examination, guarding, controlling, provision of information, training in the use of work equipment.

LOLER (see section 17.4.7) additionally applies to lifting equipment.

17.4.11 Personal Protective Equipment Regulations 2002

The Personal Protective Equipment Regulations 2002[34] implement the requirements of Personal Protective Equipment Directive[35] (89/686/EEC) (as amended).

Personal protective equipment means: 'All equipment designed to be worn or held by a person at work to protect against one or more risks, and any addition or accessory designed to meet this objective.'

Personal protective equipment includes helmets, eye protection, ear protection, safety footwear, gloves, safety harness, protective clothing, high visibility clothing.

Employers are required to provide suitable personal protective equipment to each of their employees who might be exposed to risk.

Personal protective equipment is to be used as a last resort after all measures to prevent or control risks at source are exhausted.

The Regulations cover suitability, compatibility, maintenance, replacement, information, loss, defect etc.

17.4.12 Supply of Machinery (Safety) Regulations 2008

The Supply of Machinery (Safety) Regulations 2008[36] implements the requirements of the Machinery Directive[13] (2006/42/EC) and came into force on 29 December 2009. The Machinery Directive applies to a wide range of machines including chain saws, power presses, mechanical diggers etc. It also applies to lifting equipment of various types such as escalators, moving walks and other vertical transportation equipment not appropriate to be regulated by the Lifts Directive, e.g. lifting platforms, stairlifts and home lifts.

Directive 2006/42/EC represented a complete overhaul of the original Machinery Directive[37] (consolidated as 98/37/EC), which was repealed with effect from 29 December 2009. As such it re-draws the previous boundary between itself and the Lifts Directive[10] by directly amending that directive. Accordingly the UK regulations that transposed it in turn amended the Lifts Regulations. The Supply of Machinery (Safety) Regulations 2008 implements the requirements of the Machinery Directive 2006/42/EC and amends Directive 95/16/EC (the Lift Directive).

Annex 1 of the Machinery Directive lists the essential health and safety requirements that apply to all machines.

The harmonized standard that supports the Machinery Directive and the Supply of Machinery (Safety) Regulations for escalators and moving walks is BS EN 115[38].

17.4.13 Workplace (Health, Safety and Welfare) Regulations 1992

These Regulations[39] implement most of the requirements of the Workplace Directive[40] (89/654/EEC) and are concerned with the minimum standards for workplace health and safety and the reduction of risk. The Regulations have been applied in full since 1 January 1996. The provisions have long been part of UK law but their application was not. Areas covered include maintenance of workplace, maintenance of workplace equipment, ventilation, temperature, lighting, cleanliness, traffic routes, fall protection, doors and gates, sanitary and washing facilities etc.

Regulation 19 requires lifts, passenger conveyors and escalators to function safely, be equipped with any necessary safety devices and have one or more identifiable and accessible emergency stop controls.

17.4.14 Work at Height Regulations 2005

The Work at Height Regulations 2005[41] (WAHR) are specifically aimed at reducing the risks of falling from height. They set out requirements relating to precautions and actions to be taken or considered when there are exposed voids or persons are at risk from falling, e.g. over open atria. These are not specific to escalators or moving walks but considered generally in respect of all risks from falls at height.

17.4.15 Other regulations

In addition to the above, the following statutory provisions might be applicable to the construction, installation, service, maintenance and use of vertical transportation equipment:

— Building Regulations 2000[42] (e.g. Part M) and subsequent amendments
— Confined Spaces Regulations 1997[43]
— Construction (Head Protection) Regulations 1989[44]
— Fire Precautions (Workplace) Regulations 1997[45]
— Health and Safety (First Aid) Regulations 1981[46]
— Health and Safety (Display Screen Equipment) Regulations 1992[47]
— Manual Handling Operations Regulations 1992[48]
— Noise at Work Regulations 1989[49]
— Reporting of Injuries, Diseases and Dangerous occurrences Regulations 1995[50] (RIDDOR)

17.5 Standards and codes of practice

This section is provided to indicate some of the standards and codes of practice pertinent to vertical transportation equipment.

17.5.1 British Standards Institution

The British Standards Institution (BSI) is an independent organisation that works with industry, trade associations and government to produce British, European and International standards. BSI is also involved in product testing and certification and quality assurance management systems. BSI's aim is 'to help British business become more efficient and competitive'.

The Mechanical Handling Equipment (MHE/4) technical committee for lifts, escalators and moving walks is responsible for the production of standards and provides experts for the various CEN and ISO committees developing harmonised standards.

In the production of national standards, BSI aims to ensure that they are consistent in content and format. For some time now this has included international work which is eventually either produced as a national standard or, more usually now, as a BS EN or BS ISO. BSI is now heavily involved in the work of the International Organisation for Standardisation (ISO), the International Electro-technical Commission (IEC), European Committee for Standardisation (CEN) and the European Committee for Electro-technical Standardisation (CENELEC) in the harmonisation of standards.

The MHE/4 technical committee is made up of members from trade associations, professional institutions, user groups, government departments, notified bodies and local authorities representing the many different requirements and opinions.

The technical committee is large and to deal with the work efficiently and speed up the decision making process, the MHE/4 technical committee has delegated particular tasks to an Advisory Panel (standing committee) and a number of subcommittees and panels.

The Advisory Panel includes in its terms of reference the possibility to 'take executive decisions on the behalf of MHE/4 where agreed by the chairman.'

The subcommittees and panels include members from the main MHE/4 committee, with a direct interest and specialist knowledge in the particular tasks and it is possible to co-opt persons with a particular expertise, when required. Each subcommittee and panel has its terms of reference and reports back to MHE/4 and its advisory panel on progress and for guidance on policy matters. Chairmen of sub-committees are usually nominated by MHE/4, although it can be left to the subcommittee members to elect their own chairman. Generally, the sub-committees and panels are not permanently constituted and once they have completed their task(s) they are either disbanded or retained to deal with future amendments.

Once national work has been approved by MHE/4 it is edited by BSI and the draft standard or code of practice is circulated as a draft for public comment (DPC). Comments received are collated by the secretary, circulated to the originating sub-committee or panel for resolution. Once this process is complete the draft can be signed-off by the chairman.

Draft CEN standards (prEN) and draft International Standards (DIS) are circulated for comment and dealt with in a similar manner.

It is becoming increasingly clear that purely national work is diminishing and being superseded by international and European harmonised standards work.

17.5.2 Interpretation of standards

The content of British and European Standards is often not clear owing to textual ambiguities or changes in technology. To allow these difficulties to be resolved the responsible committee at the European Standards Committee (CEN/TC10) has a procedure where a user of a standard can make an Interpretation Request.

In the UK such a request is channelled through the responsible MHE/4 committee at BSI. The procedure is for the interpretation request to be made to the Secretary of MHE/4. The Secretary may be able to resolve the query, e.g. advise the correct standard to apply. If the Secretary is not able to do this the query is passed to the Chairman of MHE/4, who with the help of other members of MHE/4 may be able to provide an answer. Should this not be possible then MHE/4 will make a formal Interpretation Request to the appropriate committee at CEN. Usually the Convenor of the appropriate committee proposes an answer, which is circulated for approval and subject to that the answer is published. This process can take some time.

A list of interpretations to EN 81 is given in Annex A3.6.

17.5.3 EN 81 family of standards

A revision of the structure of the EN 81 family of standards was being undertaken at the time of publication of this Guide. This will see the many annexes of the current BS EN 81-1/2[51,52] being moved to other sections. BS EN 81-1/2 will become BS EN 81-20 and will cover both traction and hydraulic lifts in one document. Figure 17.1 (page 17-8) illustrates the new structure and shows where the standards published at the time of publication of this Guide (September 2010) fit into the new structure.

References

1 Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC ('The Electromagnetic Compatibility Directive') *Official J. of the European Union* **L390** 24–37 (31.12.2004) (available at http://ec.europa.eu/enterprise/sectors/electrical/emc) (accessed June 2010)

2 The Electromagnetic Compatibility Regulations 1992 Statutory instruments 1992 No. 2372 (London: Her Majesty's Stationery Office (1992) (available at http://www.opsi.gov.uk/si/si199223.htm) (accessed June 2010)

3 BS EN 61000-6-1: 2007: *Electromagnetic compatibility (EMC). Generic standards. Immunity for residential, commercial and light-industrial environments* (London: British Standards Institution) (2007)

4 BS EN 61000-6-2: 2005: *Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments* (London: British Standards Institution) (2005)

5 BS EN 12015: 2004: *Electromagnetic compatibility. Product family standard for lifts, escalators and moving walks. Emission* (London: British Standards Institution) (2004)

6 BS EN 12016: 2004 + A1: 2008: *Electromagnetic compatibility. Product family standard for lifts, escalators and moving walks. Immunity* (London: British Standards Institution) (2004/2008)

7 BS EN 61000: *Electromagnetic compatibility (EMC). Testing and measurement techniques. Power frequency magnetic field immunity test* (48 Parts) (London: British Standards Institution) (1994–2010)

8 Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work *Official J. of the European Union* **L390** 24–37 (31.12.2004) (available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0391:EN:HTML) (accessed June 2010)

9 The Management of Health and Safety at Work Regulations 1992 Statutory Instruments 1992 No. 2051 (London: Her Majesty's Stationery Office) (1992) (available at http://www.opsi.gov.uk/si/si199220.htm) (accessed June 2010)

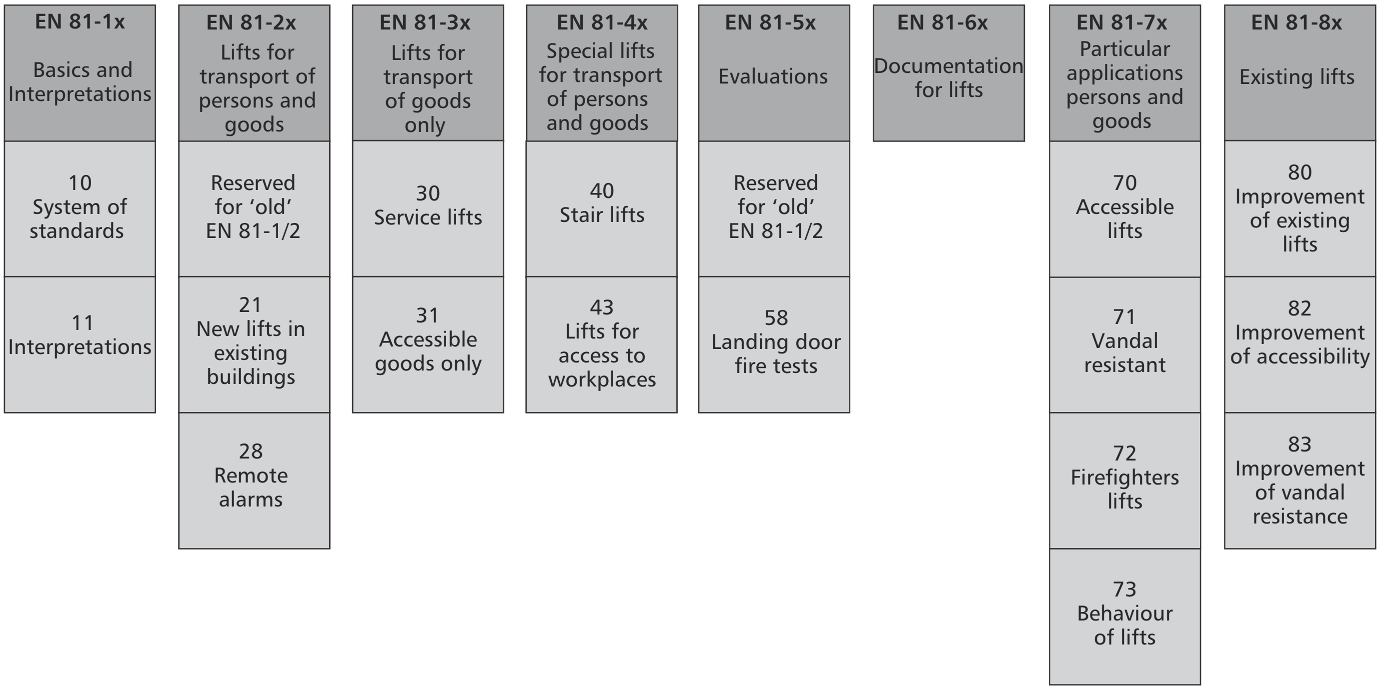

Figure 17.1 Illustration of the proposed new structure for the EN 81 family of standards

10 European Parliament and Council Directive 95/16/EC of 29 June 1995 on the approximation of the laws of the Member States relating to lifts ('The Lifts Directive') *Official J. of the European Union* **L213** 1–31 (07/09/1995) (available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0016:EN:HTML) (accessed June 2010)

11 Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits ('The Low Voltage Directive') *Official J. of the European Union* **L374** 10–19 (27.12.2006)

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18 Construction (Design and Management) Regulations 2007

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Chapter contents

18 Construction (Design and Management) Regulations 2007

18.1 General

The Construction (Design and Management) Regulations were introduced in 1994[1] against a background of improving safety in the construction industry. The Regulations were revised in 2007[2].

The Lift and Escalator Industry Association (LEIA) has published guidance to its members on these Regulations in the form of a Safety Information Sheet, one of a series produced by the LEIA Safety Committee on topics relevant to the lift and escalator industry. The CIBSE is indebted to the LEIA for permission to reproduce this guidance here.

Whilst every effort has been taken in the production of this guidance, it must be acknowledged that it should be read in conjunction with the relevant legislation, codes of practice etc. The guidance presented here should not be taken as an authoritative interpretation of the law, but as guidance to it.

Caution: this chapter attempts to broadly set out the requirements of the Construction (Design and Management) Regulations 2007[2] and the effects particularly relevant to the lift and escalator industry. It does not address every detail of the Regulations and the accompanying Approved Code of Practice (ACoP) L144: *Managing health and safety in construction*[3]. Therefore this guidance must be used with caution, and reference made to the Approved Code of Practice

18.2 Introduction

The Regulations are divided into five parts:

Part 1: Interpretation and application.

Part 2: General management duties applicable to all construction work (see CDM ACoP Regulation 2).

- — Ensuring competence, co-operation and co-ordination of all parties involved. The client's duty in relation arrangements for managing projects and the provision of information. Duties of designers are also covered in this section.
- — These duties apply to all construction projects irrespective of the status of the project (i.e. notifiable/non-notifiable).

Part 3: Additional duties imposed where a construction project is notifiable.

- — These are extra duties imposed when the project is notifiable (see below)

Part 4: Duties relating to health and safety on construction sites (physical aspects rather than managerial).

- — These are the remainder of the Construction (Health, Safety and Welfare) Regulations 1996[4]. Their inclusion within CDM is intended to raise awareness and enforcement in these areas. Again these apply on to all construction projects.

Part 5: General matters including civil liability and transitional arrangements.

18.2.1 Is the project notifiable?

All construction projects can now be divided into 'notifiable' and 'non-notifiable' projects. A project is notifiable (i.e. the HSE must be notified) if it involves more than 30 working days or involves more than 500 person–days. The information that has to be notified to the HSE is set out on form F10(rev)[5], which is available from HSE's local offices, or on the HSE website (http:// www.hse.gov.uk/forms/notification/f10hseoffices.htm). Alternatively, the form can be completed on-line (http://www.hse.gov.uk/forms/notification/f10.pdf). It is not necessary to use this form as long as all the specified information is provided. The notification should be sent to the HSE Office(s) that cover the site where the construction work is to take place.

The trigger for the additional duties imposed by Part 3 of the Regulations in lift and escalator work will usually be 'more than 30 days of work'.

Remember: if a lift or escalator project is less than 30 days Part 3 of the Regulations does not apply, but all other parts do.

18.2.2 Duty holders

The Regulations impose duties on everyone involved in a project. The duty holders identified are:

- — the client
- — the CDM coordinator
- — designers
- — the principal contractor
- — contractors.

The duties of individuals are summarised in the flowcharts in Appendix 18.A1, see pages 18.5 to 18.9.

A common theme throughout the duties imposed on the parties involved is that they must:

— check their own competence and that of others they appoint
— co-operate with others and co-ordinate work to ensure safety
— report obvious risks
— comply with requirements of Schedule 3 and Part 4 of the Regulations for any work under their control.

18.2.3 Competence and training

Information and advice is given on assessing the competence of organisations and individuals appointed under CDM Regulations 2007[2], i.e. CDM co-ordinators, designers, principal contractors and contractors.

Assessment should be based on the needs of the project and be proportionate to the risks, size and complexity of the work. To be competent an organisation or individual must have:

— sufficient knowledge of the specific tasks to be undertaken and the risks which the work will entail
— sufficient experience and ability to carry out their duties in relation to the project; to recognise their limitations and take appropriate action to prevent harm to those carrying out construction work, or those affected by the work.

To assess the competency of organisations it should be carried out as a two-stage process:

(1) an assessment of the company's organisation and arrangement for health and safety
(2) an assessment of the company's experience and track record to establish that it is capable of doing the work.

To ensure a consistent approach in carrying out the assessment a set of 'core criteria' has been agreed by industry and the HSE. Further information is set out in Appendix 4 of the CDM Regulations 2007[2].

18.2.4 Documentation

The documentation involved is as follows:

— pre-construction information (all projects)
— Construction Phase Plan (notified projects only)
— Health and Safety File (notified projects only)
— HSE F10(rev): notification of construction project.

18.2.4.1 Pre-construction information

The client must provide designers and contractors who may be bidding for the work (or who they intend to engage), with project-specific health and safety information needed to identify hazards and risks associated with the design and construction work. This is termed the pre-construction information. This information should be provided as part of the tendering or early procurement process. The client may use the responses to judge the competence of those tendering so the information is required in good time to allow for an appropriate response.

It would be ill-advised to commit to any project until the pre-construction information is studied and consideration to any effects it may have on the work. Attention is drawn to the ACoP[3] (Appendix 2), which details the contents of the pre-construction information.

18.2.4.2 Construction Phase Plan

The Principal Contractor is responsible for ensuring that a suitable Construction Phase Plan is:

— prepared before work starts
— developed in discussion with and communicated to affected contractors
— kept up-to-date as the project progresses.

Contractors are required to provide details of their work for inclusion in this plan so that an appropriate level of co-operation and co-ordination of work can take place prior to the commencement of construction. Attention is drawn to the ACoP[3] (Appendix 3) which details the contents of the Construction Phase Plan. It would be prudent to follow the recommended format.

18.2.4.3 Health and safety file

The health and safety file should contain information needed to allow future construction work, including cleaning and maintenance to be carried out safely. The CDM co-ordinator must prepare the file and hand the file over to the client for safekeeping on completion of the project. Clients, designers, principal contractors and other contractors must all provide information for inclusion in the file.

Attention is drawn to the ACoP[3] (paragraphs 263 and 264) where the contents of the file are described, indicating the information the CDM co-ordinator is likely to require, and also the things that need not be included in the file.

18.3 Summary of Part 4: Duties relating to health and safety on construction sites

18.3.1 Introduction

The following duties apply to all construction work irrespective of a particular project being notifiable or non-notifiable. Those that relate to lift and escalator work are summarised below. Where the lift and escalator company acts as principal contractor, it is important to remember that the duty for health and safety on the site is the company's, and arrangements for managing safety must include the provision of equipment and procedures for managing the safety of all contractors. Most of the duties are qualified by 'so far as is reasonably practicable' (SFAIRP) and the steps taken to fulfil the duties should be proportionate to risk and determined by risk assessment.

18.3.2 Summary of Regulations

Safe places of work (Regulation 26)

Safe access to and egress from all places where work is carried out must be established and maintained. Where access and egress is unsafe it is not to be used. The places where work is actually carried out must also be safe and have sufficient space for persons to work there. These points are applicable to all parts of the lift or escalator installation.

Good order and site security (Regulation 27)

Working areas shall be in good order so far as is reasonably practicable and sites are to be kept secure. The housekeeping within the lift and escalator contractors working area is usually his responsibility. Where the 'site' is a lift, this is usually kept secure by the existing landing doors or, when these are removed, by hoardings. Specific mention is made of timber with projecting nails which must not be left lying around for persons to tread or catch themselves on.

Stability of structures (Regulation 28)

When building up and dismantling parts of a lift, steps must be taken to ensure no instability occurs for example due to excessive out of balance loading. Any temporary platform, (for example a scaffold platform provided to support a lift car) must be designed, installed and maintained so that it is stable and strong enough to withstand the anticipated loading. Platforms must not be overloaded.

Demolition or dismantling (Regulation 29)

In this context demolition or dismantling is considered to mean the removal of a complete lift or escalator installation or perhaps, less likely, a major component. This work shall be planned and carried out as safely as possible with the arrangements recorded in writing (for example in the form of a method statement) before the work starts.

Reports of inspections (Regulation 33)

Under the CDM Regulations 2007[2] these relate to inspections covering excavations and cofferdams and are very unlikely to be encountered in lift and escalator work.

Traffic routes (Regulation 36)

Defined traffic routes are required to ensure vehicles and pedestrians can move safely. Consideration needs to be given by the lift or escalator contractor to unloading and loading arrangements and also parking areas. In many cases because of the temporary nature of work these will be temporary barriers and signage. Where the lift contractor is the principal contractor then they need to ensure arrangements are in place for all contractors involved. Traffic routes which are obstructed are not to be used.

Vehicles (Regulation 37)

This regulation refers to the movement of construction vehicles on an actual site. It seems unlikely this would affect lift and escalator work however there is a requirement that persons in control of vehicles must give warnings to others likely to be at risk. This might affect the lift contractor or their contractors making deliveries or moving material on a construction site.

Prevention of risk from fire etc. (Regulation 38)

Fire risk is the most likely to be encountered in lift work however explosion, flooding and risks from substances likely to cause asphyxiation are also included. Steps are required to prevent risk of injury from fire or similar and could include not allowing combustible materials to accumulate, regular disposal of waste, control of hot work, prohibition of smoking and steps to prevent arson. Emergency arrangements, the provision of firefighting and detection equipment are covered separately.

Emergency procedures (Regulation 39)

Arrangements for foreseeable emergencies shall be prepared — no mention is made within the Regulations of these arrangements being in writing although this would be prudent. The emergency arrangements must include the procedures for evacuation of the site. Likely foreseeable emergencies are fire, personal injury accidents, asbestos release and, possibly, bomb threats or similar.

Emergency procedures could be included within an emergency plan covering:

- responsibilities for actions in an emergency
- means of raising the alarm
- locations of telephones
- names of first aiders
- location of first aid facilities
- location and map showing local hospital with Accident and Emergency (A&E) Department.
- arrangements for warning others on the site
- evacuation procedure and assembly points
- provision of information on the above in site induction.

Emergency procedures need to take account of the number of persons likely to be present, the size of the site, and the locations of those people. Everyone covered by the emergency arrangements must be familiar with them particularly emergency routes. The arrangements must be tested by being put into effect at suitable intervals.

Emergency routes and exits (Regulation 40)

In a lift project within an existing building, it is likely that emergency routes and exits will be established and marked. Where this is not the case or where the lift project has interfered with the existing arrangements emergency routes and exits, leading as directly as possible to a place of safety must be provided, kept clear of obstruction and where necessary provided with emergency lighting. It should be noted that lift work may take the contractor into areas not normally used by the client such as roofs and basements and these areas may not have established and signed routes, which may need to be put in place for the duration of the work.

Fire detection and fire-fighting (Regulation 41)

Where the risk of fire exists then suitable and sufficient fire extinguishers are to be provided with appropriate signage in suitable locations. Some system of detecting and providing an alarm in the event of a fire is also required. The numbers, locations and extent of fire precautions are based on a risk assessment considering the activity in any occupied buildings, the type of work being undertaken (e.g. grinding or similar hot work), equipment being used, any flammable substances or chemicals likely to be present, the numbers and locations of people at work, the spread of the site, and the numbers of other people in the building (or on the site). Bearing in mind a lift project could extend over several floors and different areas of a building these matters need to receive consideration at the planning stage.

Everyone at work is to be instructed in the correct use of extinguishers. Where work may give rise to a particular risk.

Fresh air (Regulation 42)

The provision of sufficient fresh air is not usually a problem in lift projects however where this is provided by artificial means the device providing the air must have a suitable visual or audible warning to indicate any failure.

Temperature and weather protection (Regulation 43)

The temperature of indoor workplaces must be reasonable. It is suggested this be based upon a risk assessment bearing in mind the use of the building and the activity in progress. Where work is undertaken outside, loading and unloading for example, suitable protective clothing giving protection from the weather is to be provided.

Lighting (Regulation 44)

All places where work is carried out must be suitably lit. Natural light although preferable is not always possible, e.g. within a shaft. Any artificial lighting must not adversely affect any health and safety signage and where the failure of artificial lighting could affect a person's safety emergency lighting is to be provided.

References

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2 The Construction (Design and Management) Regulations 2007 Statutory Instruments No. 320 2007 (London: The Stationery Office) (2007) (available at http://www.opsi.gov.uk/si/si200703) (accessed June 2010)

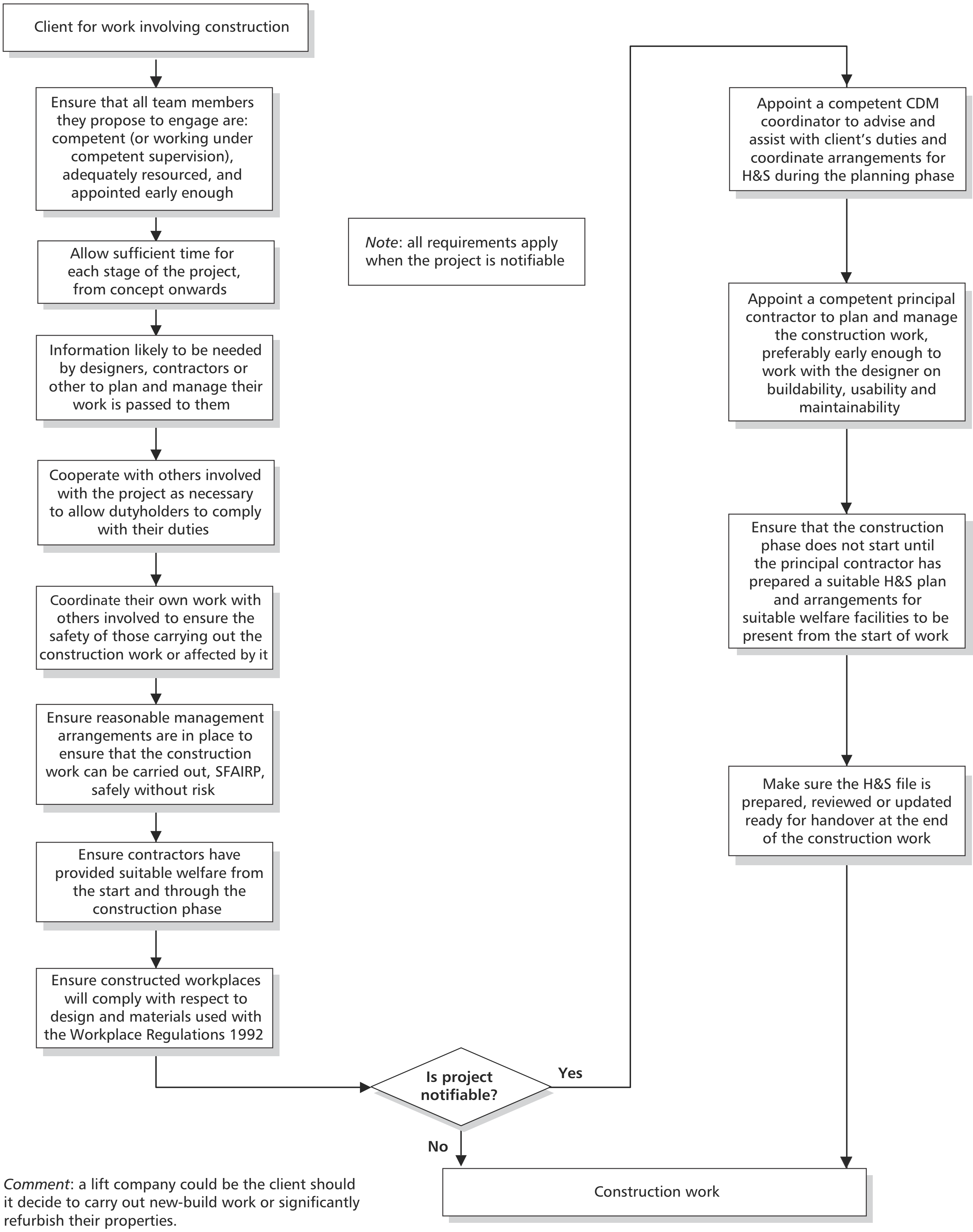
3 *Managing health and safety in construction* HSE Approved Code of Practice L144 (Bootle: Health and Safety Executive) (2007) (available at http://books.hse.gov.uk/hse/public/saleproduct.jsf) (accessed June 2010)

4 The Construction (Health, Safety and Welfare) Regulations 1996 Statutory Instrument No. 1592 1996 (London: Her Majesty's Stationery Office) (1994) (available at http://www.opsi.gov.uk/si/si199615.htm) (accessed June 2010)

5 *Notification of construction project* HSE Form F10 (Bootle: Health and Safety Executive) (available at https://www.hse.gov.uk/forms/notification/index.htm) (accessed June 2010)

Appendix 18.A1: Duties of duty holders

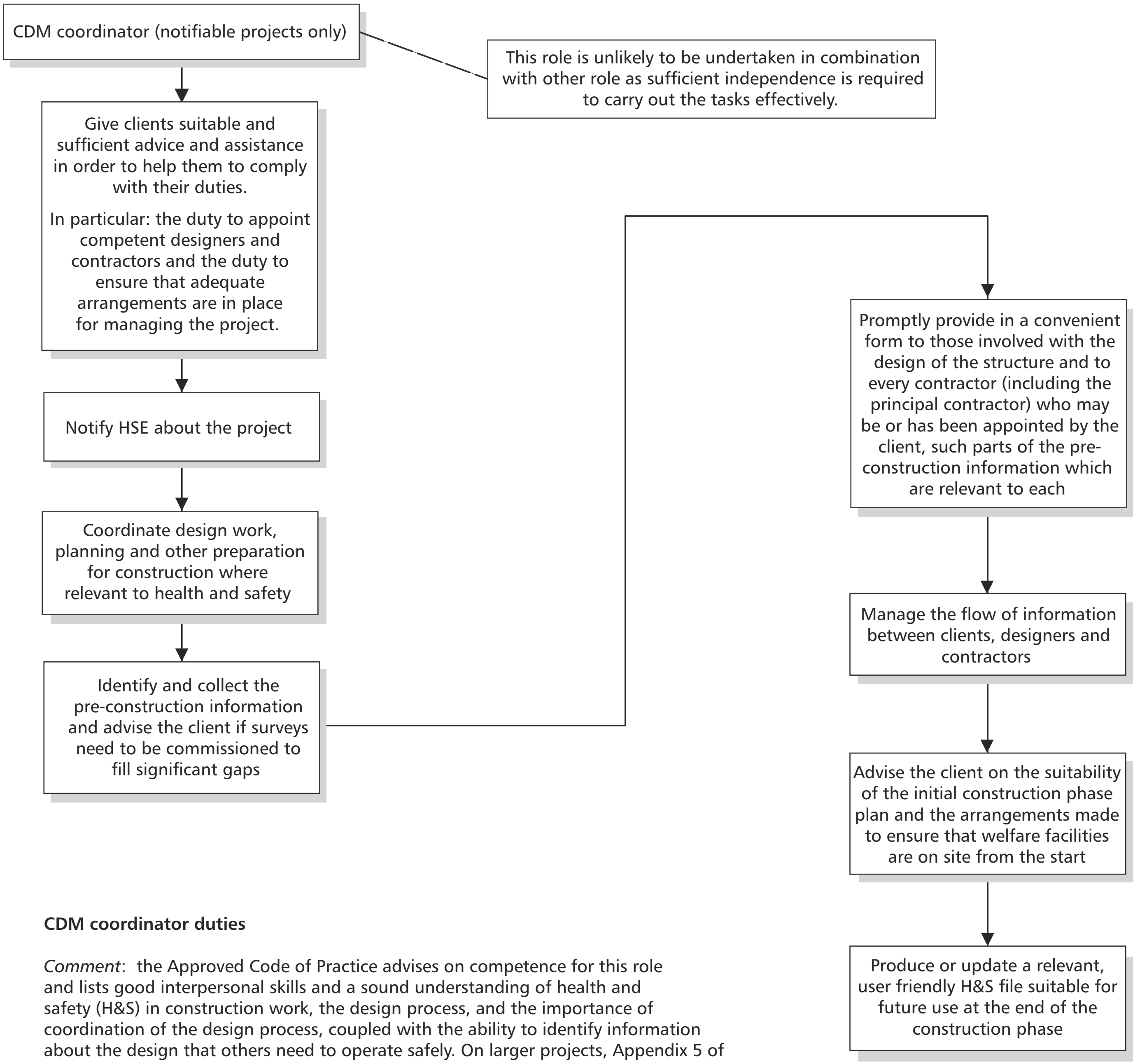
18.A1.1 Client's duties



Comment: a lift company could be the client should it decide to carry out new-build work or significantly refurbish their properties.

Figure 18.A1.1 Client's duties

18.A1.2 CDM coordinator's duties



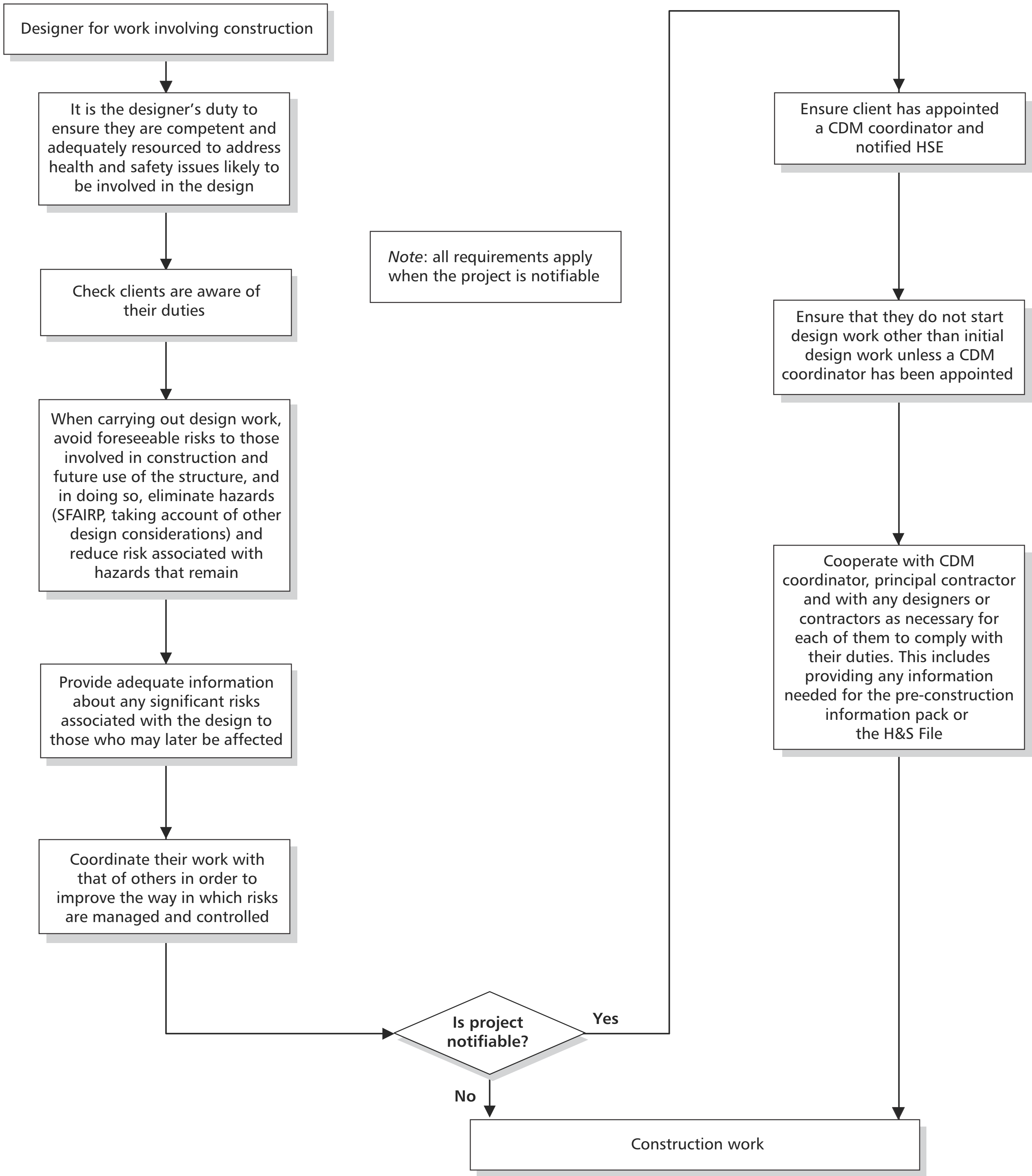
CDM coordinator duties

Comment: the Approved Code of Practice advises on competence for this role and lists good interpersonal skills and a sound understanding of health and safety (H&S) in construction work, the design process, and the importance of coordination of the design process, coupled with the ability to identify information about the design that others need to operate safely. On larger projects, Appendix 5 of the regulations gives guidance on the competence of the CDM coordinator detailing the level of knowledge and experience. This extends to examples of attainment such as professional design qualification, a NEBOSH Construction Certificate and membership of the H&S register administered by ICE, plus evidence of significant work on similar projects. This spread of competence and experience leans towards consultation rather than an individual fulfilling this role.

The Approved Code of Practice also advises an understanding of the client's business, the use that the completed project will be put to and the implications of the proposed work on it. It is unlikely that a lift company could demonstrate these attributes and therefore it is unlikely that they would ever take on this role.

Figure 18.A1.2 CDM co-ordinator's duties

18.A1.3 Designer's duties

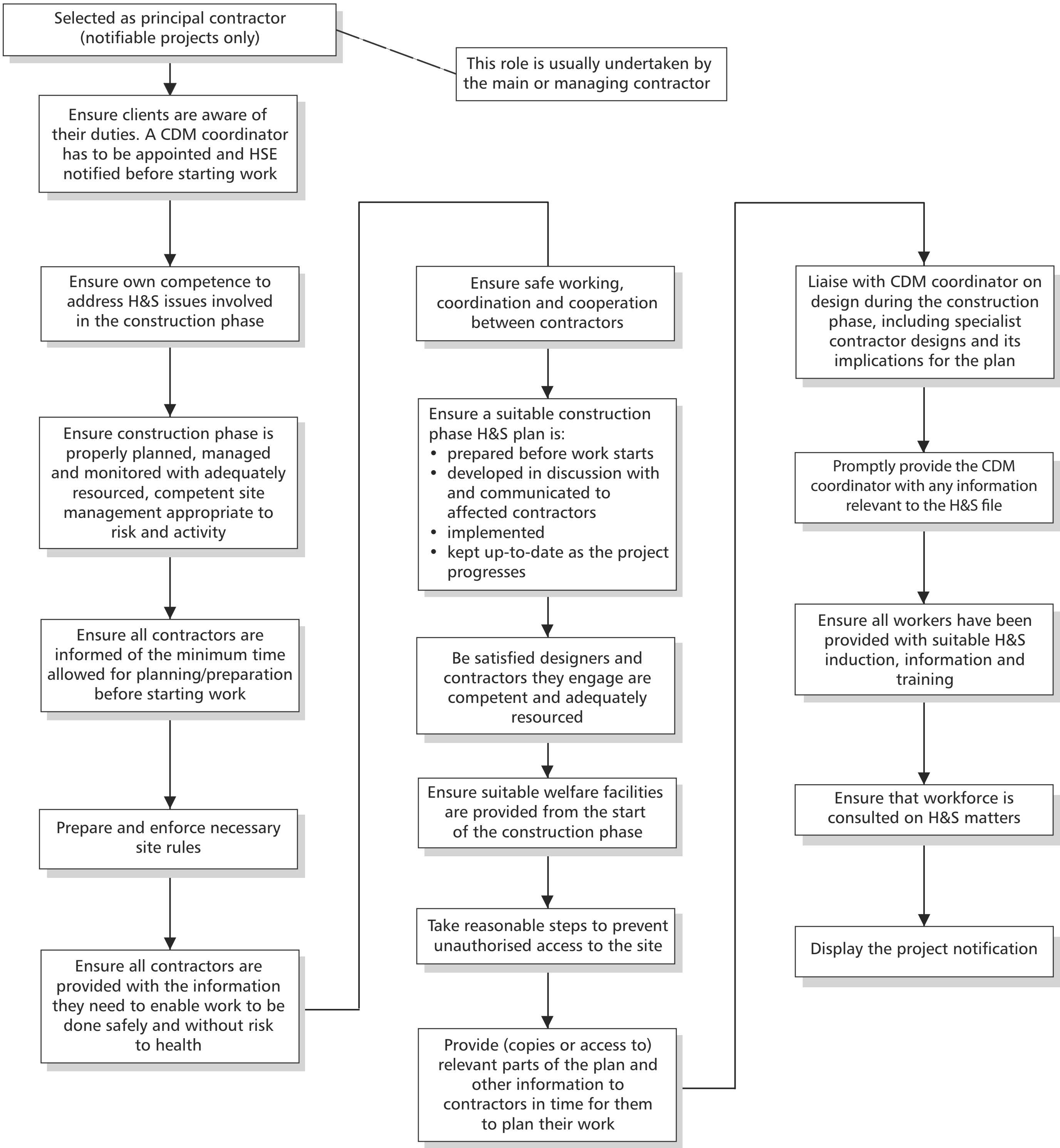


Comment: this is a lift company's typical role in construction work and therefore they must carry out these duties.

Note: lift designers are specifically mentioned in the section of the Approved Code of Practice defining 'Who are designers?' The definition of designer extends to anyone who specifies materials used or methods of work.

Figure 18.A1.3 Designer's duties

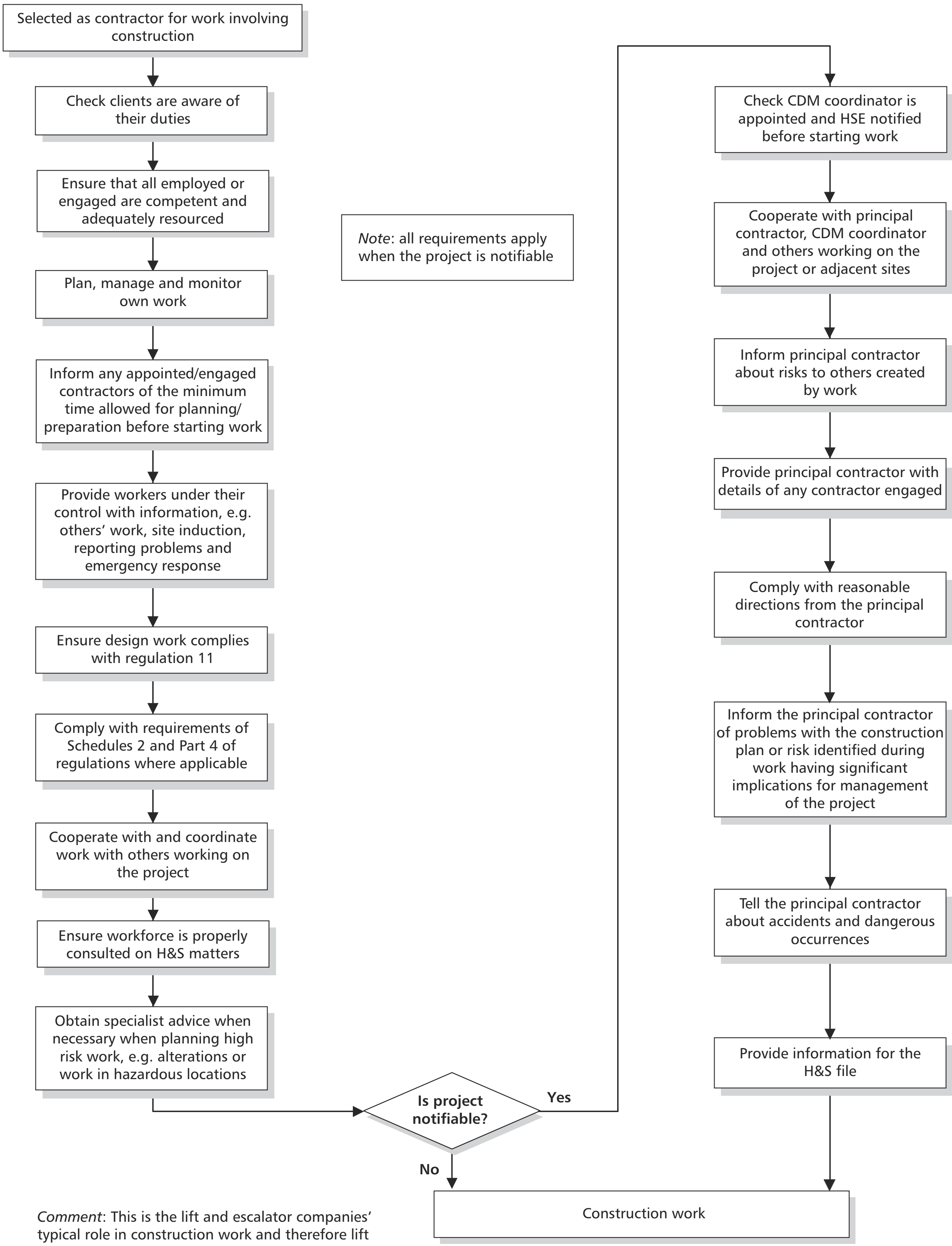
18.A1.4 Principal contractor's duties



Comment: lift companies should carefully consider the implications of the project before taking on this role by ensuring that their core competences enable them to carry out the duties, e.g. ensuring safe working, cooperation and coordination, providing welfare facilities, and arranging and implementing site security.

Figure 18.A1.4 Principal contractor's duties

18.A1.5 Contractor's duties



Comment: This is the lift and escalator companies' typical role in construction work and therefore lift and escalator companies must carry out these duties.

Figure 18.A1.5 Contractor's duties

Appendix A1: Glossary of terms

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Introduction

The following glossary of terms has been reproduced by kind permission, from the *Elevator and Escalator Micropedia* by G C Barney, D A Cooper and J Inglis, published by the International Association of Elevator Engineers, PO Box 7, Sedburgh, LA10 5GE. It contains a glossary defining some 1950 terms and cross references used in the vertical transportation industry, i.e. lifts (*sic.* elevators), escalators and passenger conveyors. These include approximately 1100 electric traction, 250 hydraulic and 500 escalator entries, specific to their speciality, all extensively cross referenced.

The individual entries do not constitute a dictionary definition, as characteristics such as pronunciation and word etymology are not given. Owing to the desire for preciseness and conciseness, the entries are very terse, being the minimum to give a term an authoritative meaning. Nevertheless there are over 35 000 words needed to achieve this objective.

Entries are generally arranged in noun order so that an entry such as:

bail type governor See governor: bail type.

will be found under 'governor' with the definitions for twelve other governor related entries. Occasionally this arrangement is not appropriate, e.g:

inspection unit

where a single entry is made in the normal word order. There should be no difficulty finding a term, owing to the extensive cross referencing.

The entries have been prepared using a number of authoritative sources. The source of each entry is given at the end of the entry, usually in the form of a letter code and a page/chapter reference number. The sources used are as follows:

AS	Donoghue: ANSI/ASME Handbook A17.1(1)
BA	Author (Barney) generated definition
BE	Barney and dos Santos; *Elevator Traffic*(2)
BO	British Standard, BS 2655 series(3)
BS	British Standard, BS 5655 series(4)
BS70	British/European Standard, BS EN 115(5)
BS78	British Standard, BS 7801(6)
CO	Author (Cooper) generated definition
ET	*Elevator Technology*(7)
HH	*Hydraulic Handbook*(8)
J	Janovsky; *Elevator Mechanical Design*(9)
JI	Author (Inglis) generated definition.
LO	London Underground Glossary of Terms (private publication)
N	*Elevator Terms*; NEIEP (private publication); 1980
O	*Shorter Oxford English Dictionary*(10)
P	Phillips; *Electric Lifts*(11)
S	Strakosch; *Vertical Transportation*(12)

References

1 Donoghue E A *Safety Code for Elevators and Escalators* ANSI/ASME Handbook A17.1 (New York NY: American Society of Mechanical Engineers) (1984)

2 Barney G C and dos Santos S M *Elevator Traffic* (2nd. ed.) (London: Peter Peregrinus) (1985)

3 BS 2655: *Specification for lifts, escalators, passenger conveyors and paternosters* (largely superseded by BS 5655) (London: British Standards Institution) (various dates)

4 BS 5655: *Lifts and service lifts* (London: British Standards Institution) (various dates)

5 BS EN 115: 1995: *Safety rules for the construction and installation of escalators and passenger conveyors* (London: British Standards Institution) (1995)

6 BS 7801: 1995: *Safe working on escalators and passenger conveyors in use* (London: British Standards Institution) (1995)

7 *Elevator Technology* (Chichester: Ellis Horwood) (1986)

8 *Hydraulic Handbook* (1st. ed.) (Trade and Technical Press) (date unknown)

9 Janovsky L *Elevator Mechanical Design* (Chichester: Ellis Horwood) (1993)

10 *Shorter Oxford English Dictionary* (Oxford: Oxford University Press) (1973)

11 Phillips R S *Electric Lifts*(London: Pitman) (1973)

12 Strakosch G *Vertical Transportation* (London: Wiley) (1983)

Appendix A1: Glossary of terms

A-side. The left side of an elevator car or hoistway, when viewed by standing in front of the entrance and facing the hoistway. AS12

abstract. A general order or sales summary sheet that indicates duty, control, power supply, machine, signals and all other major features of an escalator or passenger conveyor installation. NE1

AC control. See control: AC

acceptance test. See test: acceptance.

acceptance. A form signed by the owner or his agent which indicates that the contract for installation is essentially complete, and that the customer accepts the equipment. NE1

access door. See doors: access.

accidents. Unintentional incidents, which may cause injury or damage. CO

accumulator. A device that stores hydraulic fluid under pressure so that it can be available immediately for use when required. HH

acoustic noise. See noise: acoustic.

active oil. The amount of oil available in a tank of a hydraulic elevator that can be circulated into a system. JI

actuator. Any hydraulic device which applies force: e.g. a cylinder or motor. HH

adaptor rings. The top and bottom ring in a vee packing assembly. JI

addendum. A change to a previously written specification or proposal, usually published prior to the bid date. NE1

adjacent entrance. An arrangement where an elevator car has two entrances arranged at 90° to each other.

adjunct. An applied section of architectural metal fastened to the edge of the escalator or passenger conveyor decking for the purpose of increasing the effective width. CO

adjustable chain tension device. A carriage usually mounted on rollers located in the lower head which, through springs or weights, maintains proper tension on the step chain of an escalator. CO

adjustable flow control. A valve used to restrict the flow of hydraulic oil whose setting is adjustable, generally from shut off to no restriction. JI

adjustable resistor. See resistor: adjustable.

adjustable track. See track: adjustable.

adjuster. An elevator, escalator or passenger conveyor technician, who carries out the final inspection of new and modernised installations to ensure that all the equipment has been properly installed and set up according to specification. N1

adsil. See anti-friction coating.

advance door opening. See door: advance opening.

air bleed. A device which allows the release of trapped air in the fluid system of an hydraulic elevator. BOpt9

air bleed cock. Enables air to be expelled from the upper parts of the hydraulic system. JI

air bleed line. The small diameter line that is connected to a waste oil container allowing the collection of oil as the air is bled from the system, usually at the cylinder. JI

air bleed screw. See air bleed cock.

air breather. The device usually placed on the tank lid to allow the entry of air into the tank as the oil is discharged and allows the discharge of air to atmosphere as the oil returns to the tank. JI

air cord. Part of the driving mechanism of a door operator, which is made from a small diameter wire rope. N2

air entrapment. Refers to pockets of air that can be left in a system when charging the system with oil. JI

air temperature differential. Is the difference between the ambient air outside the machine room and the air temperature inside the machine room. JI

airborne noise. see noise: acoustic.

alarm bell. See bell: alarm.

alarm system. An emergency system installed on all cars, which comprises a bell, a pushbutton in the car and an uninterruptible source of power, usually a battery. SS145

algorithm. A set of rules, to which a system (often a control system) must conform. BE94

algorithm: group supervisory control. A set of rules defining the control policy that must be obeyed by an elevator supervisory control system in order that it may pick up passengers from their arrival floors and transport them to their desired destination floors. BE94

alteration. Any change to equipment other than maintenance, repair or replacement. CO

ambient temperature. The temperature of the surrounding air at a particular point in time. JI

AND gate. A solid state logic device, where the output value is true, if both the input values are true; and is false, if either, or both, the input values are false. BA

angle bracket. See bracket: angle.

angle of contact. See angle of wrap.

angle of inclination. The maximum angle to the horizontal in which the steps move on the inclined part of an escalator. LO5/32

angle of traction. See angle of wrap.

angle of wrap. The proportion of a sheave, which is in contact with the suspension ropes, measured in degrees of contact. P68

annular space. In the case of a ram and cylinder is the space between the outside of the ram and the inside of the cylinder. JI

annunciator. A signalling device, which provides to passengers information regarding elevator car position etc by means of indicator lamps, audio announcements etc. AS2

anode. A positive terminal. NE4

anti-creep. A feature found on hydraulic elevators, which prevents the car from changing its relative position with respect to the landing floor by compensating for any leakage of oil etc. N4

anti-extrusion rings. A ring of material usually harder than the packing and placed on the side of the packing away from the pressure, which prevents the pressure on the softer packing being extruded through the gap between the ram and gland head. JI

anti-friction coating. An application applied to the skirt panels of escalators and passenger conveyors to reduce the likelihood of static electricity. CO

anti-nuisance device. A device found on some supervisory control systems, whereby the number of passengers in the car are determined, and compared to the number of calls registered, in order that unnecessary trips are prevented. BE97

anti-reversal device. A device provided to prevent the unintentional reversal of an escalator. CO

anti-slide knobs. Material, usually metal, of various shapes and sizes, depending upon manufacture, mounted on the deck boards to prevent riding passengers from sliding packages or baggage on top of the deck boards as they ride the unit. CO

apron: car. A guard installed onto the underside of an elevator car, which employs advance opening doors, to prevent the trapping of objects or passenger limbs, whilst a descending car is levelling at a landing. BOpt9

apron: landing. A guard installed onto the underside of a landing sill to protect against entrapments should a car stop below the landing level. BA

arc. A flame formed by the passage of an electric current between two conductors. NE4

arc quencher. Any device used to eliminate or reduce the arc formed when current carrying contacts are opened. NE5

architect's drawings. Drawings made to show the necessary features of the entire construction of a building. NE5

architrave. The various parts surrounding a doorway, in order to present a neat appearance; a moulding. O59

armature. The member of an electric machine in which an alternating voltage is generated by virtue of relative motion with respect to a magnetic field flux. NE5

arrangement: criss-cross. An escalator installation where the adjacent units have boarding and alighting at opposite ends from each other. CO

arrangement: multiple parallel. An arrangement of escalators where a number of installations running in both directions are located parallel to each other. CO

arrangement: zig-zag. An escalator installation where the adjacent units have boarding and alighting at opposite ends from each other. CO

arrival bell. See bell: arrival.

arrival gong. See bell: arrival.

arrival rate: down peak passenger. The number of passengers arriving at an elevator system for service during a five minute peak period, when traffic is predominately in the down direction. BE220

arrival rate: interfloor passenger. The number of passengers arriving at an elevator system for service during any five minute period, with no dominant traffic pattern. BE238

arrival rate: up peak passenger. The number of passengers arriving at an elevator system for service during a five minute peak period, when traffic is predominately in the up direction. BE11

arrival rate: up peak percentage. The number of passengers arriving at the main floor of an elevator system for service during the worst five minute period during an up peak traffic condition expressed as a percentage of the total building population. BE11

arrow: direction. An illuminated arrival symbol to indicate the direction of travel; see arrow: down and arrow: up. BA

arrow: down. An illuminated arrow symbol either mounted in the rear of an elevator car, or mounted above or alongside the car entrance, or both, which indicates to intending passengers that the direction of travel of the arriving car is to be in the downward direction. AS16

arrow: up. An illuminated arrow indicating an up travelling car in a similar fashion to a down arrow. AS16

astragal. A moulding, usually made of rubber or metal, on the leading edge of hoistway and car doors and extending the full height on centre opening doors or the full width of bi-parting doors, in order to reduce the effects of injury should the doors touch a passenger and to quieten door operation. AS12

astragal: safety. A resilient, incompressible safe edge mounted onto the bottom of the upper section of a bi-parting hoistway door of a freight elevator. AS22

asymmetric relay. See relay: asymmetric.

atmospheric pressure tank. A tank that has an air breather allowing the air in the tank to pass into or out of the tank to atmosphere freely and so preventing pressure build up in the tank as the oil volume varies. JI

attendant. A person who is permanently located in the elevator car in order that passengers do not need to operate the controls, such as the car switch (in older systems), destination pushbuttons and car/hoistway doors (in manual systems). N6

authorised persons/personnel. An individual who has (a) received general elevator, escalator or passenger conveyor awareness/training and competency appropriate to their job function, and (b) been instructed on the detail of the work to be undertaken, and (c) received authority from the client for the work to be undertaken. BS78p1

automatic by-pass. A feature of an elevator supervisory control system, which causes the elevator car to automatically by-pass landing calls under certain circumstances, such as when a car is fully loaded and has no room for further passengers, or a car is making a special trip to serve a demand at a distant floor e.g. lobby service, heavy demand call etc. SS77

automatic closer. See closer: car door.

automatic control. A generic term, which is used to define any error activated, power amplifying, negative feedback, closed loop control system. BI1.2

automatic lubricator. See lubricator: automatic.

automatic pushbutton control. A term used to define the simplest means of automatically controlling a single car, where a car may be called to a floor by the pushing of a landing pushbutton (provided it is not already busy) and commanded to travel to a destination floor by the operation of a car call pushbutton. BE86

automatic remote monitoring system. See system: automatic remote monitoring.

auxiliary brake. See brake: auxiliary.

auxiliary drive chain. See chain: auxiliary drive.

auxiliary isolating switch. See switch: auxiliary isolating.

auxiliary motor. See motor: auxiliary.

auxiliary ram guides. The guiding system attached to the moving heads on telescopic cylinders, designed to prevent buckling of the ram assemblies. JI

auxiliary supply. An alternative supply to the main power supply source. CO

average car load. The total number of passengers carried in one direction of travel, divided by the number of trips in that direction, averaged over a certain time period, usually taken as five minutes, hence up peak or down peak average car load. BE14

axle. A pin or rod in the nave of a wheel(s) on which the wheel turns. LO6/32

B-side. The right side of an elevator car or hoistway, when viewed by standing in front of the entrance and facing the hoistway. AS14

babbit. Soft alloy of tin, antimony and copper used as an anti-friction material for the socketing of wire ropes for elevators. J34

backlash. Excessive clearance between the teeth of the worm and worm gear of a geared machine; it permits a rocking action of the gear when the worm is held stationery. NE8

baggage stops. Protuberances mounted on deck boards of an escalator to prevent passengers from sliding packages or baggage on top of the deckboards as they ride the escalator. NE8

bail type governor. See governor: bail type.

balance line. Is required on twin ram systems where each ram and cylinder has its own pipe rupture valve fitted, which is arranged to balance the pressure between cylinders and ensure both valves close at the same time. JI

balanced traffic. A term used in connection with the interfloor traffic condition to indicate that the traffic flows in both up and down directions are substantially equal. BE9

ball valve. See valve: ball.

balustrade. The side of an escalator extending above the steps, which includes skirt panels, interior panels, decks and handrails. NE8

balustrade bracket. See bracket: balustrade.

balustrade decking. See decking: balustrade.

balustrade lighting. See lighting: balustrade.

balustrade supportwork. The bolted fabricated steel framework that supports the balustrade. LO6/32

bank (1). A number of groups of cars placed physically together, with each group serving a particular zone of a building, where more than one group may serve the same zone and it is possible to have a bank comprising one group only. BE92

bank (2). A number of escalators in close proximity. CO

bar lock. Type of interlock used with manually operated doors. AS13

barney. A small car attached to a rope and used to push cars up a slope. O159

basement service. Service provided to a floor or floors below the main terminal in a building, which may be restricted at times in order to improve the service to other parts of the building. BE95

bearing. A device that supports and minimises the friction between moving and static surfaces. LO6/32

bearing plate. The building support member on which the truss of an escalator is mounted. CO

bed lift. See elevator: bed.

bed-plate. The foundation or support to which the hoist machine is attached, usually made of steel beams: a pedestal. AS13

bell: arrival. A bell either mounted on the elevator car or as part of a fixture on the landing, which signals the arrival of the car at a floor, where it is to pick-up passengers. BA

bell: alarm. A bell, located either in the hoistway, or on a suitable landing, or on the car, which when operated by a passenger pressing a pushbutton inside the car, is used to call attention and assistance. N2

bi-directional. The ability to operate in two directions. CO

bi-parting doors. Consist of two counterweighted panels, which slide vertically, one in the upward direction and one in the downward direction, interconnected so as to move in synchronism, and strongly constructed to facilitate their use in freight elevators (goods lifts). P220

borehole. A vertical hole bored in the elevator pit to accommodate the cylinder assembly of a direct acting hydraulic elevator. BOpt9

borehole liner. See liner: borehole.

bottle cylinder. A cylinder in the shape of a bottle, the displacement ram passes through the gland packing at the top or neck of the bottle. JI

bottom landing. The lower end of an escalator where passengers board or exit. CO

bottom terminal floor. See bottom terminal landing.

bottom terminal landing. The lowest landing in a building, which an elevator serves, where passengers may enter and leave the car. N13

bottom runby: car. See runby: bottom — elevator car.

bottom runby: counterweight. When an elevator car is level with the upper terminal landing, the counterweight bottom runby is the distance between the striking surface of the counterweight buffer and the counterweight buffer striker plate. AS10

box: halfway (1). A junction box mounted in the hoistway near the halfway point of the elevator car travel to which the stationary ends of the travelling cables(s) are attached. AS18

box: halfway (2). A terminal box provided in an escalator installation to run wiring to for onward connection to the controller. CO

bracket: angle. Formed steel mechanical component used to securely attach guide-rails to the building structure or to securely attach two or more components together. N4

bracket: balustrade. One of the several structural steel members which support the escalator balustrade. NE9

bracket: guide-rail. Formed steel mechanical components to which guide-rails are attached. AS18

bracket: spreader. A U-shaped bracket fastened to two counterweight rails in order to strengthen them. AS23

brake. An electro-mechanical device, consisting of a spring assembly, which is held in compression by the energising of an electro-magnet, and which holds the friction shoes from contact with the brake drum or disc, thus allowing the elevator car or escalator step band to move. See also brake: elevator and brake: escalator and passenger conveyors. J86/CO

brake arm. The lever that supports and transfers movement to the brake shoes. LO6/32

brake armature. The magnetic part of the brake mechanism which, when attracted to the brake coil, moves the levers and linkages to release the brake. LO6/32

brake callipers. An assembly of two pivoted levers, linked by a tie rod at one end and fitted with brake pad carriers at the other, released by an electromagnet or hydraulic pressure assembly and applied by compression springs. LO6/32

brake coil. The coil that when energised provides the force to cause the brake to lift, either by movement of the solenoid core or the brake armature. LO7/32

brake cooling switch. See switch: brake cooling.

brake dashpot. The dashpot that dampens the braking action of an electromagnetic brake. LO7/32

brake drum. A smooth surface usually mounted on the hoist machine drive shaft, with which the brake shoes make contact whenever the brake magnet is de-energised, in order to absorb the energy of motion. AS13

brake: elevator. In the event of the elevator car exceeding its rated speed, or a power failure, or a control system demand to hold the car stationary, the brake is de-energised and the brake operated, thus stopping the car in safe distance or holding the car in position. J86/CO

brake: escalator and passenger conveyors. In the event of the operation of any one of a number of safety devices and/or a power failure, the brake operates and stops the escalator in a safe distance. J86/CO

brake lift detector. The switch used to detected mechanically that the escalator brake has fully released (lifted). LO7/32

brake lining. Material used to line brake shoes, which has a high coefficient of friction. AS13

brake magnet. A magnet usually provided in the form of a solenoid, which is used to cause the brake shoes to move away from the brake drum, whenever it is energised. J87

brake motor. See motor: brake.

brake pad. The high friction replaceable material that acts on the brake disc comprising two pads held in carriers to act on either side of the disc when applied. LO7/32

brake release lever. A lever used to automatically release the brake during handwinding. LO7/32

brake shoes. See shoes: brake.

brake solenoid. The solenoid whose core moves to operate the levers and linkages to release the brake. LO7/32

brake-stopping distance. The distance taken for the escalator to stop upon application of the brake. CO

brake: auxiliary. A fail safe brake, which is used to stop an escalator under all normal conditions or under certain fault conditions only. It is typically situated on one side of the main drive shaft. LO6/32

brake: disc. An assembly where lined pads slow, by friction, a disc mounted on a rotating shaft, which is spring applied, or electro-magnetically or hydraulically released and is only used as an auxiliary brake at present. LO11/32

brake: emergency. An auxiliary mechanically automatically operated brake, which will stop a fully loaded escalator, if the drive chain breaks. NE48

brake: main. A fail safe brake sometimes provided which is used to stop an escalator under all normal conditions or under certain fault conditions only, typically situated on one side of the main drive shaft. LO6/32

brake: operational. See brake: service.

brake: rated load. The load which the brake of the escalator must be designed to stop and hold. CO

brake: service. An electro-mechanical device, consisting of a spring assembly, which is held in compression by the energising of an electromagnet and which holds the friction shoes from contact with the brake drum or disc, thus allowing the escalator step band to move. In the event of the operation of any one of a number of safety detection devices and/or a power failure, the brake is de-energised and the brake automatically operates, thus stopping the escalator in a safe distance and holding the step chain in position. CO

bridge rectifier. A type of full wave rectifier using four diodes. NE14

broken handrail switch. See switch: broken handrail.

broken step chain safety switch. See switch: broken step chain safety.

broken drive chain switch. See switch: broken drive chain.

brush applicator. Attached the end of feed pipes these apply lubricant to a chain by means of light contact. LO7/32

brush: deflector. A brush provided above the escalator steps and affixed to the skirt panels which is designed to keep passengers feet away from the gap between the edge of the steps and the skirt panels. CO

brush: newel entry. A brush provided at the newel end of an escalator to cover the internal components of the newel entry switch and to prevent passengers fingers entering this space. CO

buffer. Device capable of absorbing the kinetic energy of motion of a descending car or counterweight, when they have passed a normal limit of travel by providing a resilient stop, and comprising a means of braking using fluids or springs (or similar means). AS3/BSpt1

buffer return spring. Spring used to return an energy dissipation type of buffer back to its operating position. J143

buffer switch (1). A switch which is activated should a buffer be operated, which removes power to the elevator drive system. AS14

buffer switch (2). A switch, which is activated should the oil in an oil buffer fall below a minimum allowable level and which prevents further operation of the elevator. AS14

buffer: car. A final emergency device to bring an elevator car to rest by absorbing the energy of motion should the car pass the normal downward limit of travel. J134

buffer: counterweight. A final emergency device to bring a counterweight to rest by absorbing the energy of motion should the counterweight pass the normal downward limit of travel. J134

buffer: energy accumulation type. A buffer where the kinetic energy of motion is stored in the gradual compression of a spring, which provides a progressive retarding force. J135

buffer: energy dissipation type. A buffer where the kinetic energy of motion is dissipated, by converting the energy into heat by the flow of oil through a series of holes, and hence applying a constant force of retardation. J142

buffer: oil. An energy dissipation type of buffer. J142

buffer: spring. An energy accumulation type of buffer. J135

buffer: stroke. The distance that a buffer can be compressed. N15

building population. See population: building.

building: commercial. A building in which people work; such as offices, stores, industrial. BE55

building: institutional. A building in which people receive a service; such as hospitals, school, universities, public buildings. BE55

building: residential. Buildings in which people live; such as houses, hotels, flats, hostels. BE55

building: retail. A building from which a product or service is sold. CO

bulkhead. See safety bulkhead.

bumper. Device other than a spring or oil buffer capable of absorbing the kinetic energy of motion of a descending car or counterweight, when they have passed a normal limit of travel. AS3

bunching. A traffic pattern, where a number of elevators move around a building together, instead of being evenly separated about the building, often caused by a sudden heavy traffic demand or to an inadequate traffic supervisory system. SS446

burst pressure. See rupturing pressure.

busbar. A heavy, rigid metallic conductor usually insulated and used to carry a high current and make a common connection between several circuits. LO7/32

bush. A cylinder sleeve forming a bearing surface for a shaft or pin, usually as a lining. It has two diameters and the cylindrical length is usually greater than the larger diameter. LO8/32

button. See pushbutton.

button: car call. See pushbutton: car call.

button: door close. See pushbutton: door close.

button: door open. See pushbutton: door open.

button: landing call. See pushbutton: landing call.

button: push. See pushbutton.

button: stop. See pushbutton: stop.

by-pass floors. Floors, which are by-passed in a building, as a result of a supervisory control action or because the car is fully loaded. SS77

by-pass valve. See valve: by-pass.

cab. That part of an elevator car, comprising a self contained enclosure, mounted on an elevator platform, in which passengers or goods are carried. N17

cabin. See car.

cable. A wire for carrying electric current. CO

cable end box. The junction box used for the connection of the incoming electrical supply prior to distribution to each switchboard. LO8/32

cable: trailing. See cable: travelling.

cable: travelling. A cable made up of electrical conductors, which trails behind the car of an elevator, dumbwaiter or material lift to provide an electrical connection between the car and a fixed outlet in the hoistway or machine room. AS11

CAD. See computer aided design.

call. A demand for service by a passenger, which is entered into an elevator supervisory control system, by the passenger pressing either a landing or car call pushbutton. AS14

call accepted. The acceptance of a landing or car call by an elevator's supervisory control system. BA

call accepted indicator. An indicator contained within or adjacent to a landing or car call pushbutton, which is illuminated by an elevators supervisory control system when it accepts a call. AS14

call allocation. The action of an elevator supervisory control system, when allocating a landing call to a specific car for service. BE112

call button. See call pushbutton.

call back. A service visit, at the request of an elevator, escalator or passenger conveyor operator, made by a maintenance technician, which is not scheduled, and which arises because the equipment has gone out of service owing to a fault condition. N17

call memory. Part of an elevator supervisory control system, where all landing and car calls are stored before being serviced. BA

call pushbutton. A pushbutton situated either in car or on a landing, on which passengers may indicate their travelling intentions. BA

call registration. The action of registering a call. BA

call registration indicator. See call accepted indicator.

call: car. A passenger demand registered from within a car requesting that the car stop at a specified landing. N18

call: down. A passenger demand registered on a landing, requesting transportation by an elevator in the down direction. BA

call: hall. See call: landing.

call: heavy duty. In some circumstances a landing call is given extra emphasis by the elevator supervisory control system, when either (1) a new landing call is registered within a short predefined time, or (2) several cars have left the floor fully loaded, or (3) too many landing and car calls have been assigned to a single car, thus requiring the supervisory control system to take special priority action. BE106

call: highest reversal. The highest landing that an elevator visits during a trip in the upward direction before reversing its direction of travel. BE88

call: landing. A passenger demand registered on a pushbutton on a landing for transportation to other floors in a building. N63

call: lowest reversal. The lowest landing an elevator visits during a trip in the downward direction before reversing its direction of travel. BA

call: registered. See call accepted.

call: up. A passenger demand registered on a landing, requesting transportation by an elevator in the up direction. BA

cam. Piece of machinery used to convert linear motion into circular motion employed in elevator installations to operate (1) hoistway door interlocks (2) hoistway floor selectors (3) car mounted terminal switches (4) hoistway mounted terminal switches. AS14

cam: door. [syn: vane] Device mounted on a car door and used to unlock and drive the landing doors. AS16

cam: retiring. A cam mounted on an elevator car, which remains in a retracted or retired position, whilst the car is moving, until the car is about to stop, when it drops, in order to unlock the landing door interlock. AS21

canopy. The top of an elevator cab, which is supported by the walls and contains the ceiling. AS14

canopy: car. See canopy.

cantilevered car frame. See frame: cantilevered car.

capacitor. An electrical device made of two flat conductors separated by a thin insulator capable of retaining or storing electrical energy after the charging voltage is disconnected. NE18

capacity: contract. See capacity: rated.

capacity: handling (elevator). The total number of passengers that an elevator system can transport in a period of five minutes during the up peak traffic condition with a specified car loading, usually taken as 80% of rated capacity. BE12

capacity: rated. The maximum legal load, which an elevator car is permitted to carry measured in a number of passengers or a specific weight in kg. BOpt9

capacity: theoretical escalator handling. The total number of passengers that an escalator system can transport in theory in the knowledge of factors such as step width, speed, rise, etc. CO

car. The load carrying unit comprising enclosure (cab), car frame, platform and door(s). AS3

car allocation. The action of an elevator supervisory control system, when allocating a specific car to a set of landing calls for service. BE94

car apron. See apron: car.

car bounce. Where the ride in the car of an hydraulic elevator is not smooth, but exhibits an irregular motion (bounce) often caused by air entrapped in the system being compressed and expanded as the pressure in the system changes. See also stick-slip. JI

car buffer. See buffer: car.

car button. See pushbutton: car call.

car call. See pushbutton: car call.

car call panel. See panel: car operating.

car call stop. See stop: car.

car canopy. See canopy.

car control panel. See panel: car operating.

car coming indicator. See indicator: car coming.

car counterweight. A counterweight roped directly to the elevator car in a drum drive installation and approximately equal to 70% of the weight of the car. AS14

car despatch. A term used to indicate the type of supervisory control system employed, where cars are despatched from terminal floors in a building at scheduled intervals. BE97

car door. See door: car.

car door closer. See closer: car door.

car door lock. See lock: door.

car door interlock. See interlock: car door.

car enclosure. See enclosure: car.

car entrance. See entrance: car.

car fan. See fan: car.

car floor. See floor: car.

car frame. See frame: car.

car isolation. The isolation of the car platform by means of rubber or other sound absorbing material in order to reduce or absorb the transmission of vibration and noise. N73

car operating panel. See panel: car operating.

car panel. See panel: car operating.

car platform. See platform: car.

car position indicator. See indicator: car position.

car preference. A system used on simple traffic controllers, where for a period of time a car call can be registered preferentially before a landing call. Also see service: independent.

car push button. See pushbutton: car call.

car safety gear. See safety gear.

car sling. See frame: door.

car stop. See stop: car.

car switch. See switch: car.

car top. The top of the car enclosure. AS146

car top clearance. See clearance: car top.

car top control station. See station: car top inspection.

car top inspection station. See station: car top inspection.

car travel distance. The distance that the car of an hydraulic elevator travels from the lowest landing to the top landing, excluding overruns or ram travel. JI

car ventilation. See ventilation: car.

car: free. A car to which the supervisory control system has not allocated any further calls and is therefore free to be given a new assignment. BE131

car: next. Usually the next car to leave a main floor as defined by the group supervisory control system. BE37/95

car: rear opening. Where the car is furnished with doors at the rear of the car in addition to the normal doors provided at the front. SS192

car: side opening. Where the car is furnished with doors at the side of the car in addition to the normal doors provided at the front. SS48

car: through. A car which is fitted with doors to the front entrance and a further set to the rear of the car. BA

carriage. A carriage usually mounted on rollers located in the lower head which through springs or weights maintains proper tension on the escalator step chain. CO

carriage gap. The smallest gap between a fixed member of the escalator truss and the carriage frame. LO8/32

carriage rollers. The four vertically mounted rollers that support the weight of the tension carriage and permit its longitudinal movement within the escalator truss. LO8/32

carriage shaft. The driven shaft in the tension carriage carrying two sprockets that tension and reverse the direction of the escalator step chains. LO17/32

carriage switch. See switch: carriage.

carriage tensioners. Compression springs or weighted levers linked to the carriage to provide the tension on the escalator step chains. LO8/32

carriage track. The tracks that support and give lateral and horizontal restraint to the tension on the escalator step chains. LO8/32

carriage: return. A carriage usually mounted on rollers located in the lower head which though springs or weights maintains proper tension on the escalator step chain. CO

carriage: sliding lower. A carriage usually mounted on rollers located in the lower head which though springs or weights maintains proper tension on the escalator step chain. CO

carriage: tension. The mobile assembly (carriage) in which the running track is mounted to guide the escalator steps around return sprockets mounted on the idler shaft within it comprising two carriage tensioners within the assembly provide the tension on the step chains which is mobile to account for the elongation of the step chains over time. LO28/32

carrying capacity. See capacity: rated.

castell key. The unique key that operates the castell lock often provided at the escalator switch. LO p8/32

castell lock. See lock: castell.

catenary roller. One of a series of rollers fitted in the roller bow of an escalator. LO9/32

cathode. A negative terminal. NE18

caution signs. Signs provided to draw attention to risks and/or hazards. CO

cavitation. A noise created when the available oil at the pump intake is less than the nominal pump output, thus creating a vacuum condition and a very loud noise. HH

central ram. A ram and cylinder placed under the car platform in a central location. JI

centre decking. The decking between escalators. LO9/32

centre opening doors. See doors: centre opening.

centrelines. A basic reference line used in the erection of elevators and escalators. NE21

centrifugal governor. See governor: centrifugal.

chain. Connected flexible series of metal or other links. O309

chain anchors. Devices to allow the step chains to be locked by providing a physical link between the chain and a fixed part of the escalator. LO9/32

chain anchor switch. See switch: chain anchor.

chain drive (elevator). Alternative means of suspension to wire ropes for electric and hydraulic elevators. S464/P96

chain drive machine. An indirect drive machine having a chain connecting the driving motor to the drive sheave. N21

chain guide. A solid strip that sits within the step chain link plates to give lateral (side) guidance to the escalator step band. LO9/32

chain lubrication. An application applied to a chain for the purposes of lubrication to prevent premature wear and also to achieve noise reduction. CO

chain roller. The wheel mounted on either side of the escalator step on the chain wheel axle used to support the weight of the step band and passenger loading. LO9/32

chain sheave. See sheave: chain.

chain stretch switch. See switch: chain stretch.

chain wheel. The wheel mounted on either side of the escalator step on the chain wheel axle used to support the weight of the step band and passenger loading. LO9/32

chain wheel axle. Generally the common axle that links the escalator step frame with the two step chains and is supported at either end by a chain wheel; on some machines separate stub axles are used instead of a common axle. LO9/32

chain wheel track. The chain wheel running and upthrust track. LO9/32

chain: auxiliary drive. A chain driving an auxiliary piece of equipment such as a countershaft, handrail, lubricator, governor, etc especially on an escalator. LO6/32

chain: compensating. A chain used to offset the varying effect of the hoisting ropes, one end of which is attached to the underside of the elevator car and the other to the counterweight or to a fixed point in the hoistway. AS15

chain: drive (escalator). The chain provided to transmit power from the worm reduction unit to the escalator step band and thus cause rotation. CO

chain: handrail. A chain provided to drive the handrail. CO

chain: ladder. Left and right hand sections of an escalator step chain that are supplied joined at every three pitches by a step axle. LO18/32

chain: step band drive. The chain provided to transmit power from the worm reduction unit to the escalator step band and thus cause rotation. CO

check valve. See valve: check.

chevron packing. See vee packing seal.

choke line. A restriction or hydraulic resistance deliberately introduced to restrict the flow. JI

chord members. The longitudinal members of the escalator truss assembly. NE22

cill. See sill.

circuit. The path of an electric current. NE22

circuit breaker. A device designed to open a circuit when excessive current flows in that circuit. NE23

circuit protective conductor (CPC). An earthing cable connecting an exposed conductive part of an installation to the main earth terminal. LO9/32

circulation. The process by which persons in a building move around the building in both horizontal and vertical modes. G

cladding. A covering. CO

clearance. The space by which one object avoids contact with another object. G

clearance: bottom car. When the elevator car rests on its fully compressed buffers the bottom car clearance is the clear vertical distance from the pit floor to the lowest structural part, mechanical part, equipment or device installed beneath the car platform, with the exception of guide shoes, guide rollers, safety jaw assemblies, platform aprons and platform guards. AS3

clearance: counterweight top. When the elevator car floor is level with the bottom landing floor the top counterweight clearance is the shortest distance between any part of the counterweight structure and the nearest part of the overhead structure or any other obstruction. AS3

clearance: running. The clearance between fixed and moving or rotating components, e.g. the distance between the elevator car sill and the hoistway entrance sill. AS22

clearance: step to comb. The gap between the tread of an escalator step or pallet and the underside of a comb plate. CO

clearance: step to balustrade. The gap between the edge of a step or pallet and the escalator skirt panel. CO

clearance: step to step. The gap between the escalator steps or pallets. CO

clearance: top car. When the car floor is level with the top terminal landing floor, the top car clearance is the shortest vertical distance between the top of the car crosshead, or car top if no crosshead is provided, and the nearest part of the overhead structure or any other obstruction. AS3

cleat. The tread section teeth or the slats. LO9/32

cleated riser. See riser: cleated.

closed pilot valve. See valve: closed pilot.

closer: car door. A mechanical device attached to a car door whose function is to ensure the car door automatically closes after use, using the stored energy in a set of weights or a spring. AS4

closer: landing door. A mechanical device attached to a landing door whose function is to ensure the landing door automatically closes after use, using the stored energy in a set of weights or a spring. AS4

code. [syn: standard] A system of rules or regulations. O361

coil. A number of turns of insulated wire on a former, typically used in relays and contactors, solenoids, transformers and chokes. LO9/32

collective control. See control: simplex collective.

collective selective control. See control: directional collective.

comb. The aluminium sections, or steel plates with teeth that mesh with the escalator step tread as the step passes underneath. LO9/32

comb assembly. The assembly of aluminium comb sections (or steel plate type comb) and treadplate, mounted upon the comb plate. LO9/32

comb light. See light: comb.

comb lighting. See lighting: comb.

comb plate switch. See switch: comb plate.

comb plate. The section of floor plate on which the comb teeth segments are mounted at the upper and lower landings of an escalator where the teeth are mounted on the inner edge while the outer edge butts against the floor plate. NE25

comb release tool. A special tool or screwdriver that is used to release and/or lift the comb or comb sections. LO9/32

comb section. A replaceable section of the comb. LO9/32

comb switch. See switch: comb plate.

comb teeth. A series of teeth which ride the grooves of the escalator step tread as the step passes underneath and are designed to be extremely brittle which allows them to break off if a wedging action should occur at their point of contact with the step tread. CO

commercial building. See building: commercial.

common sector. See sector: common.

compact escalator. See escalator: compact.

compatibility. The compatibility characteristics of hydraulic oils such that they can be mixed. JI

compensating chain. See chain: compensating.

compensating rope. See rope: compensating.

compensating rope sheave. See sheave: compensating rope.

competent person. A person with enough theoretical and practical knowledge to be able to detect defects and their seriousness. CO

compound motor. See motor: compound.

comprehensive maintenance contract. See maintenance: comprehensive.

compression line fitting. A fitting designed to join or terminate solid pipe lines using a special compression ring that cuts into the pipe due to the tapered fitting compressing the ring as it is tightened. JI

computer aided design (CAD). A system where a digital computer carries out the tedious and time consuming aspects of an engineering design. BE152

concentric newel. See newel: concentric.

conduit. Part of a closed system, of connecting tubes and junctions forming an enclosure for the protection of cables. Usually of circular cross section. LO10/32

constant flow rate. Where the oil flow from a pump or through a valve in a hydraulic system remains substantially constant, despite any changes in pressure and oil temperature. The acceptable variation should be specified at the time of selecting the components. JI

constant velocity ram. See telescopic ram.

contact angle. See angle of wrap.

contact: door. An electric switch device operated by a door panel, which is closed when the door panel is in the closed position, allowing the operation of the elevator car. N38

contact: gate. A mechanically operated switch, which prevents the operation of the elevator unless the elevator gate is closed. N58

contactor. An electromagnetic device for making and breaking a power circuit. NE28

contactor: directional. A contactor with its contacts arranged so as to provide power to the main motor in a pre-set direction (i.e. up or down) CO

contactor: down. A contactor with its contacts arranged so as to provide power to the main motor to rotate the escalator step band in a down direction. CO

contactor: main. A contactor provided to supplement a directional contactor in the motor circuit. CO

contactor: up. A contactor with its contacts arranged so as to provide power to the main motor to rotate the escalator step band in an up direction. CO

contaminated oil. Oil that has been over heated; used at excessive pressure for long periods of time; has previously been used and has not been filtered; contains dirt or other foreign matter; or condensation in the tank has introduced water into the oil (which creates a bacteria that causes odours when heated). JI

contract speed (escalator). See speed: rated (escalator).

contract speed (elevator). See speed: rated (elevator).

contract capacity. See capacity: rated.

contract load. See capacity: rated.

contraction of oil. Changes in oil temperature which cause a change in the volume of oil, and in the case of an hydraulic elevator can cause the car to move a short distance. JI

control component. An electrical device used to control elements of escalator operation; either by the switching of circuits or the altering of supplies. LO10/32

control logic. The defined sequence and precedence of escalator operations, both manually and automatically initiated for normal, maintenance and fault conditions. LO10/32

control: AC. A form of motion control achieved by the use of an AC motor to drive the hoist machine or escalator step band. N1

control: attendant. Where the direction of travel, door closing and car starting are under the control of an attendant. N6

control: automatic pushbutton. Where the travelling passengers are able to command an elevator car to move from floor to floor without the need of an attendant, as door control and car direction and starting are all automatic. BE86

control: collective. See control: simplex collective.

control: DC. A form of motion control achieved by the use of a DC motor to drive the hoist machine or escalator step band. N33

control: directional collective. Where landing calls are registered on a set of up and down landing call push buttons, the landing and car calls being registered in any order but are answered strictly in floor sequence in the direction of travel, taking account of the direction of travel of the registered landing calls. BE88

control: door. The control system which opens and closes the car and landing doors of an elevator installation. BA

control: down collective. See control: up-distributive, down-collective.

control: drive. The system which controls the starting, stopping, direction of motion, acceleration, retardation, and speed of the elevator car or escalator. AS4

control: full collective. See control: directional collective.

control: group supervisory. A control system which commands a group of interconnected elevator cars with the aim of improving the elevator system performance. BE93

control: group collective. A simple form of group control system, where two (duplex) or three (triplex) cars are interconnected and collectively controlled, but providing a means of allocation of the best placed car to each landing call. BSpt6

control: non-collective. The simplest form of control whereby a car will only answer a landing call if it is available. BSpt6

control: on-call. An elevator supervisory control system where cars are despatched to serve landing calls according to a fixed or tunable algorithm. BE97

control: scheduled. An elevator supervisory control system where cars are despatched to serve landing calls according to a fixed schedule from terminal floors. BE97

control: simplex collective. [syn: non-selective] Where landing calls are registered on a single set of landing call push buttons, and landing and car calls may be registered in any order, but are answered strictly in floor sequence in the direction of travel, passengers being unable to indicate their desired direction of travel. BE87

control: supervisory. An open loop control system which is used to manage a plant or process, such as an elevator traffic control system. G

control: up-distributive, down-collective. Where a single set of landing push buttons indicate a down demand on floors within a building, thus allowing the elevator system to distribute upward going passengers when travelling in the up direction and to collect downward going passengers when travelling in the down direction. BE87

controller. A controlling device in the form of an electrical panel, normally located in the upper head of a compact escalator and consisting of the electrical devices required to assure proper operation of the drive mechanism. CO

controller: programmable. A controlling device which can have its operating rules altered by means of a program. G

conveyor. An endless moving belt for the movement of goods or people. CO

cooler. See heat exchanger.

cooling core. A core constructed with metal fins arranged around the pipes carrying the oil, similar in design to a car radiator. JI

cooling switch. See switch: cooling.

cooper. A maker of wooden vessels. O421

cord: air. [syn: aircraft cable] A small diameter wire rope frequently used as part of the driving mechanism on door operators, door hangers, gates and selector devices. AS12

corridor. A passage or covered way between two places. O431

countershaft drive chain switch. See switch: countershaft drive chain.

countershaft. The intermediate shaft used to transmit power from main drive or idler shaft to the handrail drive. LO10/32

counterweight. A component which is employed to ensure traction between the drive sheave and the suspension ropes and which comprises a set of weights to balance the weight of the car and a proportion of the load in the car often taken as 50% of the rated load. AS15

counterweight buffer. See buffer: counterweight.

counterweight filler. A metal component of predetermined size and weight which when stacked with other fillers in the counterweight frame forms the counterweight assembly. AS15

counterweight guard. A screen installed in the pit, and sometimes at the mid point of the hoistway, to prevent persons from encroaching into the counterweight runway space. AS15

counterweight header. A weight component larger than a standard filler, which extends around the counterweight guide-rails and guides the counterweight. AS15

counterweight safety. A mechanical device attached to the counterweight frame designed to stop and hold the counterweight in the event of an overspeed or free fall or the slackening of the suspension ropes. AS10

counterweight: car. A counterweight, which is directly roped to the elevator car on a winding drum installation, and which is approximately 70% of the car weight. AS14

counterweight: guide-rails. Steel T-shaped sections which guide the counterweight in its vertical travel in the hoistway. N31

cover: plates. The cover plate at top and bottom landings of an escalator, which is flush with the building floor and the comb plate and is removable for access to the equipment. NE55

cranked link. A step chain link that can be incorporated to enable the escalator to be installed with an odd number of steps (and odd number of chain links). LO11/32

creep. The small downward movement of a hydraulic elevator owing oil leakages or temperature changes. BA

criss cross arrangement. See arrangement: criss cross.

cross beam. See crown bar.

crown bar. The upper member of the car frame of an elevator car. AS15

curved track. See track: curved.

cushioned stop. See stop: cushioned.

cylinder. The outermost lining of a hydraulic jack. AS15

cylinder (displacement type). A single-acting cylinder where the cylinder ram is sealed at the cylinder gland against fluid losses and where the output force is proportional to the ram area. BOpt9

cylinder (piston type). A single-acting or double-acting cylinder, where the piston, which is attached to the cylinder ram, seals against the inside of the bore of the cylinder tube and where the output force is proportional to the piston area in one direction and to the piston area minus the ram area in the other direction. BOpt9

cylinder: double acting. A cylinder in which pressure can be applied at either end, so giving complete hydraulic control. HH

cylinder gland. The seal used to prevent loss of fluid. BOpt9

cylinder head. The part of the cylinder that holds the seal and guiding rings that make contact with the ram as it moves in and out of the cylinder. JI

cylinder head guide yoke. The guide fitted to intermediate stages of telescopic cylinders to maintain the alignment and prevent the buckling of the ram and cylinder assembly when extended. JI

cylinder ram. The smooth circular moving part of a hydraulic jack, which is forced out of the cylinder by fluid pressure. BOpt9

cylinder tube. See cylinder.

dado. A decorative moulding or facing on the lower part of a cab wall. O305

dashpot. A mechanical device comprising a piston moving in a cylinder against air or oil, used to control or cushion the movement of an arm, lever or rod particularly those used to prevent the slamming of doors. AS16

data-logging. The process of logging (acquiring) and analysing data automatically using a digital computer based equipment. BE

DC control. See control: DC.

deck board. The capping member of the balustrade of an escalator, usually considered as that portion of the balustrade extending from the handrail outward to the exterior line of the escalator. NE34

deck. The transverse members of the balustrade with a high deck located immediately below the handrail stand and a low deck located immediately above the skirt panel and having an interior and/or exterior section. CO

deck: inner. A second deck of glass balustrade escalator covering from the glass inward to the inner face of the skirts. CO

deck: outer. The deck of a glass balustrade escalator covering from the glass to the outermost edge of the escalator. CO

decking. The top cover to the balustrade beneath handrail level. LO11/32

decking: balustrade. The cladding affixed to the balustrade. CO

decking cover strip. A strip or moulding joining the balustrade decking of two adjacent escalators. LO11/32

dee track. See track: dee.

deflector. A metal plate fitted to each dust tray access. It deflects dust and debris into the dust tray. LO11/32

deflector device. An additional device to minimise the risk of trapping between the escalator steps and the skirting. BS95p5

deflector sheave. See sheave: deflector.

demand sector. See sector: demand.

demarcation lights. See lights: demarcation.

demarcation line. Located near the edge of the step tread, consisting of a machined groove or contrasting material provided to assist passengers in boarding the escalator by designating the step outline as the step band profile unfolds. CO

despatch floor. See floor: despatch.

despatch interval time. See time: despatch interval.

despatch signal. See signal: despatch.

despatcher panel. See panel: despatcher.

detector: passenger. An automatic electronic device, which causes door re-opening whenever a passenger is detected in the threshold using photo-electric, electromagnetic, electrostatic or ultrasonic detection methods. AS20

detritus. A flammable accumulation of oil and grease, which can easily accumulate in an escalator truss. CO

device: anti-nuisance. A device which attempts to reduce the effect of mischievous or malicious passengers registering more car calls than there are passengers in the car or attempting to send a car away when no passengers are present in the car. BE138

device: door re-opening. A device which detects the obstruction of automatic power doors and causes them to either re-open or go into another mode of operation such as nudging. AS16

device: hoistway door locking. Means of securing the closed hoistway door and preventing it from being opened from the landing except under specified conditions. AS6

device: levelling. A mechanism, which will move an elevator car, when it is in the levelling zone, at a reduced speed towards a landing and stop it there. BOpt9

device: signalling. An annunciator (light, indicator, bell, buzzer, etc), which provides information to passengers about car direction, car position, car arrival, call acceptance etc. AS10/11

devices: earthquake protection. A device or group of devices which regulate the operation of an elevator or group of elevators during or after an earthquake. AS499

diamond stop. See stop diamond.

die cast step. See step: die cast.

differential pressure valve. See valve: differential pressure.

dip stick. The measuring stick or rod usually fitted to the filler cap, which allows the depth of oil in the tank to be measured. JI

direct coupled pump. See pump: direct coupled.

direct drive. See drive: direct.

direct drive machine. See machine: direct drive.

direct on line start (DOL). Motors that are connected directly to the full voltage without some form of resistance or other current or voltage limiting device in the circuit. JI

direct plunger driving machine. See machine: direct plunger driving.

direction arrow. See arrow: direction.

direction indicator. See indicator: landing direction.

directional contactor. See contactor: directional.

directional collective control. See control: full collective.

directional limit switch. See switch: directional limit.

directional sector. See sector: directional.

directional start switch. See switch: directional start.

disc brake. See brake: disc.

discrete electrical components. Devices such as diodes, capacitors or resistors used as distinct control elements in electrical circuits. LO11/32

displacement piston. See displacement ram.

displacement type governor. See governor: displacement type.

diversity factor. A factor which may be applied to reduce the sizing of services, for example electric power cables, on the basis of a mathematical probability that not all connected equipment will require serving at the same time. SS179

diverter. See pulley: diverting.

dividing screen. Screen installed between the paths of travel of two elevators sharing the same hoistway to enable the safe working on one elevator whilst the other elevator is still operational. BA

door. The movable portions of the car or hoistway entrance, which control the safe access to and from the moving car. AN4

door cam. See cam: door.

door close button. See button: door close.

door close limit. See limit: door close.

door closed time. See time: door closed.

door closer: car. See closer: car door.

door closing time. See time: door closing.

door contact. See contact: door.

door control. See control: door.

door dwell time. See time: door dwell.

door gib. See gib: door

door guide. See gib: door.

door guide-rails. See guide-rails: door.

door hanger. See hanger: door.

door hanger sheave. See sheave: door hanger.

door hanger track. See track: door hanger.

door header. See header: door.

door holding time. See time: car call dwell and time: landing call dwell.

door interlock. See interlock: door.

door interlock zone. See zone: door.

door limit switch. See switch: door limit.

door linkage. See linkage: door.

door lock. See lock: door.

door open time. See time: door open.

door open button. See push button: door open.

door operator. See operator: door.

door power operator. See operator: door.

door premature opening. See door: advance opening.

door re-opening device. See device: door re-opening.

door sill (cill). See sill: door.

door switch. See switch: door.

door track. See track: door.

door vane. See vane: door.

door zone. See zone: door.

door: access. Means of access to equipment areas and other spaces pertaining to an elevator or escalator installation such as machine rooms, overhead machine spaces, etc and with access usually restricted to authorised persons. AS12/NE1

door: advance opening. The initiation of door opening whilst a car is slowing into a floor, under normal operating conditions, usually when the car is in a door zone of plus or minus 200 mm of floor level and such that the car is substantially level at the floor before passengers can attempt to exit. AS16

door: car. The door, which is part of the passenger carrying enclosure, and serves to protect passengers from contact with the hoistway walls and equipment. BA

door: hoistway. The door sealing access to the hoistway from the landing floors. AS4

door: inspection. Means of access to equipment areas and other spaces pertaining to an escalator installation such as machinery spaces etc and with access usually restricted to authorised persons. CO

door: landing. See door: hoistway.

door: multiple panel (leaf). Door(s) comprising two or more panels which are arranged to telescope behind each other as the door(s) opens. P219

door: pre-opening. See door: advance opening.

door: side opening. A single or multiple panel, horizontally sliding door. P216

door: single panel (leaf). A horizontally sliding, side opening door comprising a single leaf. P216

door: slide up-down. See doors: bi-parting.

door: two speed. An arrangement, for either side or centre opening doors, where one panel slides behind the other panel at twice the speed, in order that both panels arrive at the opening position simultaneously. P216

doors: bi-parting. A vertically sliding door, often found on freight elevators, which consists of two sections, so interconnected that they open simultaneously away from each other. AS4

doors: centre opening. A horizontally sliding door, with two or more panels, so interconnected that they open simultaneously away from each other. AS4

double acting cylinder. See double acting rams.

double acting rams. Rams which incorporate a piston head and two cylinder connections one at each end, where connecting the pressure line to one and the exhaust line to the other causes the piston and ram to move in one direction; and reversing the oil connections causes the piston and ram to move in the opposite direction. JI

double acting seal. See seal: double acting.

double deck(er) elevator. See elevator: double deck(er).

double wrap. See wrap: double.

down peak. A down peak traffic condition exists, when the dominant or only traffic flow is in the downward direction, with all or the majority of the passengers leaving the building at the main terminal floor of the building. BE7

down peak interval. See interval: down peak.

down peak passenger arrival-rate. See arrival-rate: down peak passenger.

down peak traffic. See traffic: down peak.

down arrow. See arrow: down.

down collective control. See control: up-distributive, down-collective.

down contactor. See contactor: down.

down stop. See stop: down.

drain line. See oil drain line.

dress guard. See guard: skirt.

drip pan. See drip tray.

drip tray. A pan which is welded or bolted to the truss of an escalator along its full length and width. NE42

drive chain. See chain: drive.

drive control. See control: drive.

drive controller. A separate controller provided on some larger escalators containing electrical and/or electronic components or devices which interpret the outputs from the logic controller and set the drive motors speed and direction. CO

drive machine (elevator). A power unit which provides the means for raising and lowering the car and which comprises: the electric motor or hydraulic power unit; gearing, brake; sheave or drum; couplings and bedplate. J14

drive machine (escalator). The combination of motor and gear reduction unit which forms the drive mechanism for all moving parts on an escalator. NE42

drive sheave. See sheave: drive.

drive unit. See drive machine.

drive wheels. The sprockets over which the escalator drive chain or chains and step chain(s) pass. CO

drive: direct. A drive where the driving part is directly connected to the driven part, either with or without intermediate gears. AS7

drive: drum. A positive elevator drive system whereby the car and the counterweight are secured to a multi-grooved drum, such that as one set of ropes unwind from the drum the other set of ropes wind on. J71

drive: indirect. A drive system where the driving part is connected to the driven part by means of V-belts, tooth drive belts, or drive chains. AS181

drive: linear. A drive which utilises the electromagnetic propulsion, provided by a linear motor, between a fixed part (often the guides) and a moving part (often the car) with or without a counterweight. BA

driving station. The area of free space within the truss at the top/drive end of the escalator or passenger conveyor for use by maintenance and inspection personnel. BS78p2

dropped step support. The ramps that act on the escalator trailer wheel axle or step frame and step chain and support the steps through the comb in the event of one or more wheels or their tyres becoming detached. LO12/32

dropped step switch. See switch: dropped step.

drum. The cylinder of a drum type driving machine, on which the hoisting ropes wind and unwind, when raising or lowering the elevator car. AS17

drum brake. See brake drum.

drum drive. See drive: drum.

duck board. An insulated platform/stand for raising operative personnel above floor level, and provide insulation protection to earth. (Used in machine room areas where there is a possibility of moisture or water ingress). LO12/32

dumbwaiter. An elevator used for the vertical transportation of materials only and comprising a car whose dimensions are such as prevent the transportation of passengers, and which moves in guides, often situated beneath a counter or sited at counter top level. AS4/BSpt9

duplex. Two interconnected cars, sharing a common signalling system, controlled under a simple group control system operating under directional collective principles. BE88

dust tray. A metal tray supported under the main drive and tension carriages that catches any small objects and dust that falls from the steps as they return under the escalator. LO13/32

duty range. The designed performance range of an escalator or passenger conveyor. CO

dwell time. See time: door dwell.

dynamic oil pressure. The oil pressure during the starting and/or running of the system, which (owing to system friction) will always be higher than the static oil pressure. JI

dynamic seal. See seal: dynamic.

dynamic sector. See sector: dynamic.

earth. The main terminal used to connect the installations earthing and bonding system to the conductive mass of earth normally by a conductor provided as part of the power distribution. LO13/32

earth leakage circuit breaker. A circuit breaker designed to break the supply in the event of a current flowing to earth. LO13/32

earthing. The act of connecting the exposed conductive parts of an installation to earth. LO13/32

earthquake protection devices. See devices: earthquake protection.

earthquake sensors. Sensors which can detect the incidence of earthquake ground waves prior to the actual earthquake shock and which are used to operate control devices in order to bring the elevator safely to rest. S391

eccentric ram loading. The loading on the ram, which occurs when the load does not press directly on the centre of the ram, or when the direction of the load is not in-line with the axes of the ram. JI

electrical drawings. Plans showing electrical circuits. CO

electrical interference. See interference: electrical.

electrical noise. See noise: electrical.

electro-mechanical brake. See brake.

electronic valve. See valve: electronic.

elephant ear. The 'ear-shaped' replaceable rubber insert that forms part of the handrail entry guard on some escalators. LO13/32

elevator. [syn: lift] A permanent lifting equipment, serving two or more landing levels, provided with a car or platform for the transportation of passengers and/or freight, running at least partially in rigid guides either vertical or inclined to the vertical by less than 15 degrees. J13

elevator: bed. Elevators for the conveyance of patients being moved on beds or stretchers in hospitals, clinics, nursing homes etc with a platform shape which is narrow and deep, capable of carrying a load of 20 persons or more and equipped with solid doors of a width of at least 1300 mm and capable of excellent levelling accuracy. P52

elevator: direct-plunger hydraulic. A hydraulic elevator having a plunger or cylinder directly attached to the platform or car frame. AS5

elevator: direct acting. See elevator: direct-plunger hydraulic.

elevator: double decker. An elevator having two compartments located one above the other. SS337

elevator: electric. A power elevator, which uses an electrical drive machine to provide energy for the movement of the car. AS5

elevator: electro-hydraulic. A direct plunger machine, where liquid is directly pumped under pressure into the cylinder by a pump driven by an electric motor. AS5

elevator: firefighting. An elevator, which may be supplied with additional fire resistant protection, installed in a fire protected zone and designated to have controls that enable it to be used under the direct control of the firefighting services for emergency purposes. BA

elevator: fireman's. An elevator, which may or may not be supplied with additional fire resistant protection, designated to have controls that enable it to be used under the direct control of the firefighting services for emergency purposes. BSpt6

elevator: freight. An elevator primarily used to transport freight and goods, where only the operator and persons necessary to load and unload the freight are permitted to travel. AS5

elevator: gravity. An elevator where gravity is used as the motive force to move the car. AS5

elevator: hand. An elevator where manual energy is used to move the car. AS5

elevator: hydraulic. A power elevator, which uses the energy stored in a liquid under pressure to provide the energy for the movement of the car. AS5

elevator: inclined. An elevator which travels at an inclination to the vertical of 15° or more. BSpt1

elevator: indirect acting. A hydraulic elevator where the plunger or cylinder is indirectly connected to the platform or car frame by ropes or chains. BA

elevator: maintained-pressure hydraulic. A direct plunger elevator where liquid under pressure is available for application to the cylinder at all times. AS5

elevator: multideck. An elevator having two or more compartments located above each other to form a multi-level stack. AS5

elevator: observation. An elevator designed as an architectural feature to give passengers a panoramic view while travelling in a partially enclosed well. BSpt6

elevator: passenger. An elevator primarily used to carry passengers other than the operator (if any). AS5

elevator: passenger/freight. An elevator of such dimensions that only goods and restricted classes of passengers (such as freight handlers, employees) may be carried. AS175

elevator: power. An elevator utilising energy other than gravitational or manual to provide motion for the car. AS5

elevator: roped-hydraulic. A hydraulic elevator where the piston is connected to the car by means or wire ropes. AS5

elevator: service. A passenger elevator used to transport materials, which conforms to the standards for passenger conveyance, but is often specially strengthened to carry freight or goods. SS307

elevator: sidewalk. An elevator of the freight type used to carry materials, except automobiles, between a street level and a level or levels below AS5

elevator: stair. Elevators provided for persons with impaired mobility, which can be permanently or temporarily installed on a stairway, which provide a seat for the person to ride on. SS351

elevator: wheelchair. A platform elevator, which can be fitted to a stairway for the transportation of wheelchairs and which generally can be folded away when not in use. SS350

elongated newel. See newel: elongated.

EMC. Electromagnetic compatibility: comprises immunity and emission. BA

emergency brake. See brake: emergency.

emergency coils. See emergency solenoids. JI

emergency hand pump. See pump: emergency hand.

emergency lighting. See lighting: emergency.

emergency solenoids. Solenoids provided with two coils in the one housing, with one coil for normal operation and a low voltage coil for emergency operation from a battery in the event of a mains supply failure. JI

emergency stop switch. See switch: emergency stop.

enclosure: car. The top and the walls of the car resting on and attached to the car platform. AS5

encoder shaft. A rotary digital encoder, which when rotated by a toothed tape attached to the car can provide a very accurate value for the position of a car in a hoistway, as a binary number. BI115

energy accumulation type buffer. See buffer: energy accumulation type.

engineer. A person who is capable of innovation and possesses graduate academic qualifications and subsequent responsible experience in the industry. BA.

engineer surveyor. A person who undertakes a periodic thorough examination of equipment. CO

entrance: car. The protective assembly which closes the hoistway enclosure openings normally used for entrance to and exit from the car. AS5

entrance floor. See floor: main.

entrapped air. See air entrapment.

EPROM A device of storing computer data in a semi permanent form, erased using an electrical signal. LO13/32

equal lay. See lay: equal.

erection working line. The theoretical line parallel to the escalator step nose line between erection working points. LO14/32

erection working point. The theoretical point on the intersection of escalator centre line, finish floor level and erection working line. LO14/32

escalator. A power driven endless moving stairway inclined at between 28° and 35° for the short range upward and downward transportation of passengers. AS5/BS70p5

escalator: compact. An escalator with the drive machine incorporated within the bounds of the truss and typically without separate machine areas. LO10/32

escalator flight time. See time: escalator flight time.

escalator: heavy duty public service. A public service escalator with major non wearing components suitable for operating for 40 years in an underground railway environment. LO17/32

escalator: spiral. An escalator that can follow a curved path. BA

escalator: wheelchair. An escalator designed to transport a wheelchair. BA.

escutcheon rubber. The 'ear-shaped' replaceable rubber insert that forms part of the handrail entry guard on some escalators. Also known as the elephants ear. LO13/32

excess load indicator. See indicator: excess load.

exhaust flow. The oil being drained back to the tank from cylinders, actuators or other parts of the system usually via a valve. JI

expansion of oil. See oil expansion.

expansion chamber. [syn: muffler] A large chamber placed in the pressure line, usually close to the pumping unit, which allows the pulsation waves in the pipeline to expand when entering the chamber and which causes their amplitude and frequency not to revert to the original form on leaving the chamber. JI

express jump. The distance between the main terminal floor of a building and an express zone terminal floor. BA

express lobby. See lobby: express.

express zone. See zone: high rise.

express zone lobby. See floor: express zone terminal.

express zone terminal floor. See floor: express zone terminal.

express-run. When a car makes an non stop run from its current floor to a destination floor ignoring any possible stopping floors on the trip. BE17

extended heads. Extensions of the truss proper at either the lower or upper head to reach the building support steel when it is located beyond the standard dimensional requirements of the escalator. CO

extended newel. See newel: extended.

exterior panels. Covering on the escalator truss on the exterior side of the balustrading. CO

external pump. See pump: external.

fan: car. A means of mechanically ventilating the passenger car enclosure of an elevator, aiding the air movement through the vent openings provided. AS147

fault condition switch. See switch: fault condition.

fender casting. The casting that forms a corner piece at the end of the skirting, on some escalators, and to which the handrail entry guard is fitted. LO14/32

filter. A fine mesh panel or tube located in the oil or air flow path to prevent the entry or expelling of foreign or unwanted materials that could damage the system moving parts. HH

filter contamination detection. The detection of the contamination of hydraulic oil by means of a pressure gauge or other method of detecting a pressure increase at the inlet side of the filter. JI

final limit switch. See switch: final limit.

finish floor level. The level of the floor adjacent to the escalator landing. LO14/32

fire shutter. An automatic or manual fireproof horizontal rolling steel curtain completely enclosing the escalator wellway in case of fire within the building and to eliminate the stack effect created by the wellways in the event of fire. CO

fire shutter switch. See switch: fire shutter.

fireman's elevator. See elevator: fireman's.

fireman's lift. See elevator: fireman's.

fireman's service. See service: fireman's.

fireman's switch. See switch: fireman's.

fishplate. A flat steel plate, which is machined on one side, used to connect together, in rigid alignment, two end to end sections of elevator guide-rail or sections of escalator tracking. AS17

fixed flow control. Pumps or valves designed to transfer fluid at a fixed flow either by the design characteristics or pressure and/or temperature compensation. JI

fixed sector. See sector: static.

fixture. Term used to denote a variety of signalling and indicating devices, such as landing and car call pushbuttons, position indicators, direction indicators, card access devices etc. BA

fixture: intelligent. A fixture commonly the car operating panel or lobby call registration panel, which has the ability to present information to passengers in an interactive manner and which may be able to process its input-output via a computer communication bus instead of via a multi pair travelling cable. BA

fixture: talking. A fixture which is programmed to provide passengers with information by means of a simulated speech output. BA

flared joint. A system designed to prevent a hydraulic pipe and its fitting from separating under pressure, where the ends of pipes are flared to match the pipe fitting. JI

fleet angle. Angle of deviation at which the rope leaves the centre of the sheave groove, usually less than two degrees. BA

flexible conduit. A pliable conduit which can be bent by hand with a reasonable small force, but without other assistance, and which is intended to flex frequently throughout its life. LO15/32

flexible guide clamp safety. See safety: flexible guide clamp.

flexible pressure line. See hose, flexible.

flight. A number of escalators, and/or stairs within the same shaft. LO15/32

flight time. See time: flight.

float switch. See switch: float.

floor. The layer of boards, brick, stone etc, on which people tread; the under surface of the interior of a room. O771

floor plate. A removable steel plate finished with a hard wearing floor material, typically situated above the escalator trusswork, where there is insufficient clearance for floor trays. LO15/32

floor population. See population: floor.

floor selector. See selector: floor.

floor stopping switch. See switch: floor stopping.

floor to floor cycle time. See time: cycle.

floor to floor height. See interfloor distance.

floor to floor time. See time: flight.

floor tray. The removable steel tray infilled with concrete or ribbed aluminium and finished with a hard wearing floor material. LO15/32

floor: bottom terminal. Lowest floor in a building zone from which elevator cars can load and unload passengers. AS7

floor: bypass. Floors at which a landing call has been registered, but which are passed by the elevator car under circumstances when the car is fully loaded (load bypass) or when the car has other higher priority duties to perform (control bypass). SS77/103

floor: car. The under surface of the interior of an elevator car, on which passengers stand. BA

floor: dispatch. Floors in an elevator zone, often the terminal floors, from which cars were dispatched under the control of the scheduling supervisory control system. BE97

floor: entrance. See floor: main.

floor: express zone terminal. The lowest floor of a high rise zone in a building which is served by an elevator car after it leaves the main terminal floor. BE92

floor: heavy duty. A floor at which a considerably larger than average number of passengers are demanding service often detected by successive cars leaving the floor fully loaded or the immediate re-registration of a landing call as soon as a car has left a floor. BE133/340

floor: highest. The highest, occupied or otherwise, floor within a building. CO

floor: highest reversal. The floor at which a car reverses direction, when travelling in an upward direction having completed its last car call, in preparation to serve registered down landing calls. BSpt6

floor: lowest. The lowest, occupied or otherwise, floor within a building. CO

floor: lowest reversal. The floor at which a car reverses direction, when travelling in a downward direction having completed its last car call, in preparation to serve registered up landing calls, particularly during an interfloor traffic condition. BA

floor: lowest terminal. See floor: bottom terminal.

floor: main. The main or principal floor of a building. BA

floor: main terminal. See floor: main.

floor: parking. A floor at which an elevator car is parked when it has completed serving its car calls and the supervisory control system does not reallocate it to serve further landing calls. BE96

floor: terminal. The highest and lowest floors at the extremities of travel of an elevator car within a building zone. AS7

floor: top terminal. Highest floor in a building zone from which elevator cars can load and unload passengers. AS7

floor: upper terminal. See floor: top terminal.

flow fuse. See pipe rupture valve.

flow restriction valve. See valve: pipe rupture.

flow divider. Where the oil line is divided into two or more lines either through branching pipe fittings or a manifold. JI

fluid level switch. See switch: float.

flyball governor. See governor: flyball.

flywheel. A rotating mass usually attached to the electric motor shaft, sized to provide inertia in the system sufficient to prevent a sudden stop of the low inertia motor rotor, if the power is removed from the motor when running full speed. JI

flywheel (1). A disc located on the motor shaft of an elevator and normally used for hand winding. CO

flywheel (2). A disc located on the motor shaft of an escalator. CO

footlight. See light: foot.

foundation. The reinforced concrete base on which the escalator truss supports are mounted. LO15/32

four way traffic. See traffic: four way.

frame: cantilevered car. The type of frame that is only guided or supported on one side, with the cabin support beams cantilevered out from the uprights. See also rucksack elevators. JI

frame: car. [syn: sling] A supporting frame consisting of stiles, cross beam, safety plank and platform to which the guide shoes, car safety and hoisting ropes or hydraulic plunger or cylinder is attached. AS3

frame-size. Commonly used to indicate the size of an electrical drive motor. BA

free car. See car: free.

freight elevator. See elevator: freight.

front. The front (of an elevator car) is the side in which the entrance is situated or in the case of multiple entrances the side containing the entrance nearest to the car operating panel. N57

frothing (of oil). The condition of hydraulic oil that has air entrapped in it (aeration), due to the bad design of the components and their piping often where air bleeding is inadequate or air bleeding systems are not installed, which seriously effects system performance. JI

full collective control. See control: directional collective.

full load current. Maximum continuous operating current. LO15/32

full wave rectifier. A rectifier that allows current to pass in one direction through the load during the full cycle of AC. NE57

fuse. A safety device that opens the electrical feed line to a circuit of more than the designated amount of current should flow through it. NE57

gate. See door.

gate closer. See closer: car door.

gate contact. See contact: gate.

gate operator. See operator: door.

gate power operator. See operator: door.

gear pump. See pump: gear.

gear. Wheels working one upon another, by means of teeth (or otherwise) for transmitting or changing motion and power. O838

gear: helical. Gear wheels running on parallel axes with the teeth twisted obliquely to the gear wheel axles. BA

gear: safety. A mechanical device attached to the car frame or to the counterweight designed to stop and hold the elevator car in the event of free fall or of a predetermined overspeed or rope slackening. BOpt9

gear: worm. A gear, used to connect non-parallel, non-intersecting shafts, with the teeth of the intersecting wheels cut on an angle. BA

gearbox. Wheels working one upon another, by means of teeth (or otherwise) for transmitting or changing motion, power and/or speed (often called a worm reduction unit). CO

geared machine. See machine: geared traction drive.

geared traction machine. See machine: geared traction drive.

gearless traction machine. See machine: gearless traction drive.

generator. An electromechanical device which converts mechanical energy in the form of motion into electrical energy strictly as DC power. BA

gib: door. A door component fixed to the bottom edge of a sliding door panel which runs in a machined groove in the sill to guide and correctly hold the door panel in position. AS18

gib: guide shoes. A liner for car or counterweight guide shoes. AS18

gland. A mechanical component which is used to hold the sealing material, that prevents oil leakage between the ram and cylinder, but still allows the ram to move freely into or out of the cylinder. JI

gland packing. The sealing material that forms a seal between a fixed and moving part, i.e. the seal between the cylinder and ram. JI

gland seal. See gland packing.

gong. See hall lantern and gong.

goods lift. See: elevator: freight.

governor drive chain switch. See switch: governor drive chain.

governor rope. See rope: governor.

governor switch. See switch: governor.

governor. Strictly a mechanical device which is a closed loop, error activated means of automatically controlling the speed of a machine, but in the elevator context it is used to detect an overspeed situation. BA

governor: bail type. Horizontal shaft type governor. AS165

governor: centrifugal. A mechanical device which utilises the effects of centrifugal forces operating on weights rotating in a horizontal or vertical plane to provide a movement which can in turn be used to operate a control device. BA

governor: displacement type. Horizontal shaft centrifugal type governor, which uses the movement of weights mounted on the governor sheave to operate the rope gripping device. AS165

governor: flyball. Vertical shaft centrifugal type governor, which utilises the movement of a pair of flyballs, driven by the vertical shaft, to lift a collar or sleeve, which in turn operates the rope gripping device. AS165

governor: horizontal shaft. Governor where the activating shaft rotates in the horizontal plane. BA

governor: overspeed. A governor used to detect the occurrence of a predetermined speed. BA

governor: pull through. Governors of any type where the rope is gripped by spring loaded jaws and can 'pull through' rather than being solidly locked to the rope gripping jaws thus preventing damage to the rope. AS165

governor: vertical shaft. Governor where the activating shaft rotates in the vertical plane. BA

groove. A long narrow channel machined into a surface. BA

groove: 'U'-profile. A groove cut into a drive sheave, which is semi circular in shape, and of a radius which is approximately equal to the diameter of the suspension rope. P66/7

groove: undercut. A groove cut into a drive sheave, which is a modified 'V'-groove having the lower sides cut in the shape of a 'U'. N152

groove: 'V'-cut. A groove cut into a drive sheave in the shape of a 'V'. N155

group supervisory control. See control: group supervisory.

group supervisory control algorithm. See algorithm: group supervisory control.

group. A group of cars is a number of cars placed physically together, using a common signalling system and under the control of a supervisory control system. BE89

guard. A device placed over or enclosing an item where access is to be prevented for reasons of safety or security. CO

guard: counterweight. Unperforated metal guards installed, whenever necessary, in the pit, on all open sides of a counterweight runway AS49

guard: dress. See guard: skirt.

guard: handrail. A guard usually made of brush or rubber, that fits over the outside of the handrail where it enters or leaves the balustrade and designed to keep a person's fingers out of the handrail opening. CO

guard: intersection. A triangular shaped piece, usually plastic, located at the point where the escalator decking intersects the horizontal underside portion of the ceiling in the wellway, in order to prevent injury to passengers if they are looking over the side of the escalator and a part of their body should enter this intersecting angle. CO

guard: sheave. A protective guard around a rope carrying sheave. N128

guard: sight. A vertical strip of material, which is mounted adjacent to the leading edge of a side sliding landing door and used to block out any view of the hoistway space, whenever the elevator doors are in the open position. N130

guard: sill. [syn: toe guard] A smooth often bevelled apron, extending downwards from the sill of the landing or car entrance, with the intention of removing shear hazards to passengers from structural members projecting into the hoistway. BS/ENpt1

guard: skirt. A continuous rubber strip attached to the escalator skirt panel to deflect feet and long clothing away from the edge of a step. CO

guard: toe. See guard: sill.

guard: wedge. A piece of triangular shaped material located at the point where the decking on an escalator intersects the underside of a wellway ceiling. NE158

guide bracket. See bracket: guide-rail.

guide: door. See gib: door.

guides. See guide-rail.

guides: handrail. Polished metal guides on which the handrail runs throughout its entire travel. CO

guide-rail. A set of vertical machined surfaces installed in the hoistway to guide the travel of an elevator car or counterweight. AS18

guide-rail: car. Guide-rails used to direct the travel of an elevator car in a hoistway. AS18

guide-rail: counterweight. Guide-rails used to direct the travel of a counterweight in a hoistway. AS18

guide-rail: door. Vertical tracks used to guide the travel of bi-parting freight doors. N38

guide-shoes. Devices used to guide the movement of doors, cars and counterweights along their associated guide-rails. N61

guide-shoes: door. Guiding devices mounted on both horizontal and vertically moving doors to guide their travel. N62

guide-shoes: slipper. Guide-shoes used to guide an elevator car or counterweight, which are 'U' shaped so that the gibs surround and bear onto the machined surfaces of the tongue part section of the guide-rails. AS132

guide-shoes: roller. Guide-shoes used to guide an elevator car or counterweight, which are constructed of a set of rollers (three or six) which run on the machined surfaces of the guide-rails. AS131

half track. See track: half.

halfway box. See box halfway.

hall. [syn: floor, e.g. floor call; landing, e.g. landing push-button; corridor, e.g. corridor call.]

hall call. See call: landing.

hall direction indicator. See indicator: landing direction.

hall lantern and gong. Unit providing a visual and acoustic indication of the availability of an elevator car to accept passengers for a specific direction of travel, which is mounted adjacent to each elevator. BA

hall push button. See push button: landing.

hall stop. See stop: landing call.

hallway. The lobby or entrance passage to a building and other floors a corridor or passage. O917

hand lowering. The action of lowering an hydraulic elevator in the event of an emergency. BA

hand powered lift. See lift: hand powered.

hand pump. See pump: hand.

hand pumping. The action of raising an hydraulic elevator in the event of an emergency. BA

hand rope. See rope: hand.

handling capacity. See capacity: handling (elevator).

handrail. The moving handhold provided for escalator passengers which moves over the top of the balustrade and newel. NE63

handrail brush. A brush provided at the newel end to cover the internal components of the newel entry switch. CO

handrail drive. The mechanism including sprockets, chains and wheels which drives and directs the travel of an escalator handrail. NE63

handrail entry switch. See switch: handrail entry.

handrail guard. See guard: handrail.

handrail guides. See guides: handrail.

handrail spacers. Inserts of contrasting colour to indicate direction and speed of the handrail. CO

handrail speed detector. A device that measures the handrail speed and in the event of underspeed or overspeed opens a switch in the safety circuit. LO16/32

handrail support moulding. The extruded section of the balustrading that connects the vertical interior panelling to the horizontal decking and supports the handrail track. LO16/32

handrail tensioning device. The assembly of components, and their adjustable fixing, used to tension handrails. LO16/32

handrail track. See track: handrail.

handwinding. The action of using a manual device to permit the emergency movement of an electric traction elevator or the manual movement of an escalator. BOpt9

handwinding device. The mechanical means provided to manually rotate the escalator step band or to wind an elevator up or down. CO

handwinding instructions. A notice showing instructions how to operate the handwinding equipment in the event of an elevator or escalator failure. LO17/32

handwinding ratchet. A ratchet that is fitted to the end of the drive motor shaft and turned by hand to move the escalator. LO17/32

hanger: door. An assembly, which is fastened to the top of a door panel, supporting and permitting the sliding movement of the door panel(s), comprising the hanger sheave and hanger track. AS18

hanger sheave. See sheave: door hanger.

hanger track. See track: door hanger.

hatch. See hatchway.

hatchway. An obsolete term used to describe the elevator hoistway, derived from the use of a framed and covered opening in a floor; a miniature access door. AS19

hauling rope. See rope: hauling.

head. The area under the landing plates at either end of an escalator. NE65

head jamb. See jamb: head.

head room. The dimension from the escalator step tread to the underside of the wellway opening immediately above. CO

header: door. A horizontal structural member located on the hoistway side of an elevator entrance used to support the door hanger. AS16

headroom. Clear working space provided above machinery. N65

heat dissipation. Is the ability of the tank housing and cylinder to lower the temperature by natural or artificial means. JI

heat exchanger. Device that causes hot oil to be cooled to the desirable working temperature by circulating the oil through pipes fitted with cooling fins, or through a form of radiator core, sometimes assisted by a fan to increase the efficiency of the cooling system. JI

heat transfer. The transfer of heat between the equipment and the air, to ensure good hydraulic performance, where in some cases additional items such as heat exchangers and cooling systems may be required. JI

heavy duty call. See call: heavy duty.

heavy duty floor. See floor: heavy duty.

heavy duty public service escalator. See escalator: heavy duty public service.

helical gear. See gear: helical.

helper. In USA the lowest classification of an employee working in an elevator company. N65

high call reversal. See call: highest reversal.

high chord truss. See truss: high chord.

high rise zone. See zone: high rise.

highest floor. See floor: highest.

highest reversal floor. See floor: highest reversal.

hoist machine. See machine.

hoistway. A vertical opening through a building or structure in which elevators, material lifts, dumbwaiters etc travel extending from the pit at the bottom to the underside of the roof or machinery space above. AS6

hoistway door. See door: hoistway.

hoistway door combination mechanical lock and electrical contact. A device with two functions where (*a*) the operation of the driving machine is prevented unless the hoistway doors are in the closed position and (*b*) the hoistway doors are locked in the closed position to prevent them being opened from the landing side unless the car is in the landing zone. AS6

hoistway door (electrical) contact. See contact: door.

hoistway door interlock. See interlock: hoistway door.

hoistway door mechanical lock. See lock: door.

holding time. See time: door dwell.

hollow rams. Rams manufactured from tubes compared with solid round material. JI

honed finish. A machining system that improves the surface finish of rams or the bores of cylinders. JI

hood. The solid protective screen projecting upwards from the roof of a paternoster car, which continues with the apron of the paternoster car above, to form a continuous cover over the space between cars. BOpt9

horizontal shaft governor. See governor: horizontal shaft.

hose, flexible. Hoses used to transmit fluid between parts, which move relatively to each other, sometimes made of synthetic rubber reinforced with wire or canvas to give strength and provided with union-type end fittings, often fitted by the hose manufacturers. HH

hydraulic lift. See elevator: hydraulic.

hydraulic lift: direct acting. See machine: direct plunger driving.

hydraulic lift: suspended type. See machine: roped hydraulic drive.

hydraulic power unit. Part of the elevator drive system and comprising pump, pump motor, control valves and fluid storage tank. BOpt9

hydraulic synchronised rams. See telescopic rams.

idler shaft. The driven shaft in the tension carriage carrying two sprockets that tension and reverse the direction of the escalator step chains. LO17/32

idler sheave. See sheave: idler.

idler sprocket. A sprocket used to change the direction of chain movement. LO17/32

inch. To move an escalator at maintenance speed. LO17/32

inch directional contactors. The up and down interlocking contactors that connect the escalator power supply to the drive motor for maintenance, permit inching speed and fix the mode of rotation. LO17/32

inch speed. The escalator speed used for inspection and maintenance purposes, typically a quarter of rated speed. LO17/32

inching (1). A manual operation, usually carried out on freight elevators, where a car switch or a push button is used to cause the car platform to move in small increments until it is level with the landing sill. AS19

inching (2). A manual operation carried out under maintenance situations, where the escalator step band is rotated in small increments. CO

inclination. The angle to which the escalator is manufactured. CO

incline. The sloped area between the upper and the lower landings/machine rooms. LO17/32

inclined section. The portion of an escalator which is inclined, in general trigonometric terms could be referred to as the hypotenuse. CO

inclined transportation. Means of moving people or goods which is not on a level plane. CO

independent service. See service: independent.

index: performance. Term used in control engineering where a variable is selected and its performance is maximised. BA

indicator: call accepted. An indicator adjacent to or contained within a landing call or car call push button, which is illuminated when the elevator supervisory control system has accepted the call into its memory. BA

indicator: call registration. See indicator: call accepted.

indicator: car coming. An indicator adjacent to or contained within a landing call push button, fitted on installations which are controlled by very simple supervisory control systems, and which is illuminated whenever the elevator car is coming to the calling landing. BA

indicator: car position. An indicator adjacent to or above a car or landing entrance, which is illuminated to indicate the position of the elevator car in the hoistway. BA

indicator: direction. See indicator: landing direction.

indicator: direction landing. An indicator adjacent to or above a car entrance, which is illuminated whenever that car is to stop at that landing and which indicates the intended direction of travel for the car. BA

indicator: excess load. An indicator located on the car operating panel, which is illuminated whenever the passenger load in the car exceeds the rated value. BA

indicator: lift in use. An indicator adjacent to or contained within a landing call push button, which is illuminated whenever the elevator is busy serving a demand, usually fitted on installations controlled by a very simple supervisory control system. BA

indicator: lift coming. See indicator: car coming.

indicator: next car. An indicator adjacent to a car entrance or installed inside an elevator car, which illuminates to indicate the next car, in a sequence, to leave a specific floor. BA

indicator: overload. An indicator, usually installed inside an elevator car, which indicates by an acoustic alarm together with an illuminated sign, that the passenger load in the car is in excess of the rated value. BA

indicator: position. See indicator: car position.

indirect coupled pumps. See pumps: indirect coupled.

indirect drive. See drive: indirect.

indirect drive machine. See machine: indirect drive.

inductor. An electrical device made of a coil of wire on a former, which is capable of storing energy and which tends to oppose the current flowing in it. BA

in-line filter. A filter assembly mounted in the main piping system to prevent foreign material passing into the valve or cylinder usually of the high pressure type. JI

inner deck. The second deck of a glass balustrade escalator; covering from the glass inward to the inner face of the skirts. NE71

inspection door. See door: access.

inspection outlet. A hard wired socket provided in various locations of an elevator or an escalator for the connection of the inspection unit. CO

inspection unit. A portable plug-in unit used to control the inching of an escalator during inspection and maintenance. LO17/32

institutional building. See building: institutional.

insulation resistance. The electrical resistance between a conductor and earth. CO

integrated rupture valve. See valve: integrated rupture.

intensive duty traffic. See traffic: intensive duty.

interface: mechanical. Resistance to motion provided by friction and/or mechanical means or devices. CO

interference: electrical. Unwanted signals transmitted via the electrical supplies or as electromagnetic radiation, which can interact with properly generated signal sequences to produce incorrect or hazardous operation of equipment. BA

interfloor distance. The vertical distance between two adjacent landing floors. BA

interfloor flight time. See time: flight.

interfloor jump time. See time: flight.

interfloor passenger arrival-rate. See arrival-rate: interfloor passenger.

interfloor traffic. See traffic: (balanced) interfloor.

interior panel. The major panel portion of the balustrade located immediately above the skirt panel, canted outwards and extending from the skirt panel to the deck boards. CO

interlock: car door. A device which prevents the operation of the driving machine unless the hoistway doors are closed. BA(EITB)

interlock: door. A switch provided to mechanically and/or electrically lock a door, generally fitted to a car or hoistway door, usually a mechanically operated electrical contact, which prevents the operation of the driving machine unless certain conditions are satisfied. BA

interlock: hoistway door. A device having two functions, where the operation of the driving machine is prevented unless the hoistway doors are in the closed position *and* the hoistway doors are locked in the closed position and prevented from being opened unless the elevator car is within the landing zone. AS6

interlock: landing door. See interlock: hoistway door.

intermediate support. Often required on escalators with extreme rises to give additional support at a point near the centre of the longitudinal length of the truss thus reducing the loading on the building members at each end of the escalator. CO

internal pump. See pump: internal.

internal ram pressure. A pressure created when hollow rams are used and the oil either flows through the ram as in the case of telescopic rams or is allowed to fill the inside of the ram of the displacement type. JI

intersection guard. See guard: intersection.

interval. The average time between successive car arrivals at the main terminal (or other defined) floor with no specified level of car loading or traffic condition. BE14

interval: down peak. The average time between successive car arrivals at the main terminal (or other defined) floor with no specified level of car loading during a down peak traffic condition. BE213

interval: loading time. See time: passenger loading.

interval: loading. The minimum time an elevator car is held at the main terminal (or other defined) floor, under the up peak traffic condition, after the first passenger has registered a call, before it is allowed to depart. BE163

interval: up peak. The average time between successive car arrivals at the main (or other defined) floor with cars assumed to be loaded to 80 percent of rated capacity during the up peak traffic condition. BE15

interval: waiting. A term sometimes used to designate the up peak interval and at other times to designate the time a passenger waits for service. BE14

isolation: car. Means of isolating the passenger cabin from vibration and sound borne noise. BA(fem)

isolator. A manually operated mechanical switch used to open or close electrical circuits under no load conditions. LO17/32

jack. The plunger and cylinder of a hydraulic elevator. AS19

jamb. The two vertical side posts of an elevator entrance, strike jamb and return jamb, plus the 'lintel' or head jamb. AS19

jamb: head. The horizontal member of the three members constituting an elevator entrance, which connects to the side vertical members. AS19

jamb: return. A vertical member of the three members constituting an elevator entrance, behind which the sliding portion of the door passes, whenever it opens and closes. AS21

jamb: slide. See return jamb.

jamb: strike. A vertical member of the three members constituting an elevator entrance, against which a side sliding door closes. AS23

jaws. Parts of overspeed safety gear, which grip the governor rope (in the case of an overspeed governor) and grip the machined surfaces of the guide-rails (in the case of car or counterweight safeties). N75

jewel. A coloured or translucent, lens or protective cover, which is placed in front of a signal indicator. BA

joint moulding. Metal extrusion used to cover and support the joint between two panels. LO17/32

jointed ram. See ram joint.

journey time. See time: passenger journey.

jump time. See time: flight.

junction box. An enclosure for the protection of electrical terminals and conductors. LO17/32

key switch. See switch: key.

kick(er) plate. See plate: kicker.

kinked link detector. The switch that detects kinked escalator step chain links and provides either alarm or protection. LO18/32

ladder chain. See chain: ladder.

laminar flow. The flow of fluids, where the original stratification of the fluid is not disturbed and which occurs below certain critical velocities, usually where the Reynolds number is less than 1500. See also Reynolds number. HH

landing. A portion of floor or corridor adjacent to elevator car entrances or escalator terminal end, where passengers may board or exit. BA

landing apron. See apron: landing.

landing call. See call: landing.

landing door. See door: hoistway.

landing door closer. See closer: landing door.

landing door combination mechanical lock and electrical contact. See contact: landing door combination mechanical and electrical.

landing door electrical contact. See contact: door.

landing door interlock. See interlock: hoistway door.

landing door locking device. See device: hoistway door locking.

landing door mechanical lock. See lock: door.

landing lantern and gong. See hall lantern and gong.

landing plates. See floor plate.

landing push button. See push button: landing call.

landing stop. See stop: landing call.

landing zone. See zone: door.

landing: bottom terminal. See floor: bottom terminal.

landing: direction indicator. See indicator: landing direction.

landing: terminal. See floor: terminal.

landing: top terminal. See floor: top terminal.

Lang's lay. See lay: Lang's.

lay. The twisting of yarn (wires) to form a strand or the twisting of strands to form a rope. O1187

lay: equal. The wires in the strand are so spun that they all have an equal lay length. J21

lay: Lang's. The direction of the lay of the wires in the strand is the same as the direction of the lay of the strands in the rope. J21

lay: left. The strands of a rope are spun in an anticlockwise direction. J22

lay: ordinary. The direction of the lay of the wires in the strand is opposite to the direction of the lay of the strands in the rope. J21

lay: regular. See lay: ordinary.

lay: right. The strands of a rope are spun in a clockwise direction. J22

lay: rope. See lay.

leakage. The amount of fluid lost out of a system due to faulty joints or seals designed to contain the fluid under specific pressures and temperatures. JI

levelling. An operation which improves the accuracy of stopping at a landing, and which ensures the car platform is level with floor. BS/ENpt1

levelling device. See device: levelling.

levelling zone. See zone: levelling.

lift. [syn: elevator.] See elevator.

lift car. See car.

lift coming indicator. See indicator: car coming.

lift in use indicator. See indicator: lift in use.

lift machine: drum machine. See machine: winding drum.

lift machine: geared machine. See machine: geared traction drive.

lift machine: gearless machine. See machine: gearless traction drive.

lift management. The management of elevator systems to provide in-service indication, equipment diagnosis, traffic monitoring and supervisory controller optimisation. BE361

lift well. See well.

lift: bed. See elevator: bed.

lift: firemans. See elevator: fireman's.

lift: goods. See elevator: freight.

lift: hand powered. See elevator: hand.

lift: hydraulic. See elevator: hydraulic.

lift: passenger. See elevator: passenger.

lift: passenger/goods. See elevator: passenger/freight.

lift: service. See elevator: service.

lift: wheelchair. See elevator: wheelchair.

lifting lug. A point provided from which to lift or raise the escalator, normally only used during installation. CO

lifting beam. A iron or steel beam that is suitable for attaching lifting tackle and that has been certified for a safe working load (SWL). LO18/32

light duty traffic. See traffic: light duty.

light emitting diode. A device consisting of a semiconductor junction enclosed in a plastic case, which emits light when an electric current is passed through it, in one direction only. LO18/32

light: comb. Small flush type light panels located in the skirt panels on both sides of the unit at both upper and lower head and immediately adjacent to the comb teeth. These lights illuminate the comb and step tread to assist in boarding and alighting the escalator. CO

light: foot. Small flush type light panels located in the skirt panels on both sides of the unit at both upper and lower head and immediately adjacent to the comb teeth, which illuminate the comb and step tread to assist in boarding and alighting the escalator. CO

lighting: balustrade. A lighted panel running the length of the balustrade, newel to newel, located parallel to immediately above the skirt panel, or full height plastic panels with lighting systems located behind them. NE9

lighting: comb. Lighting provided at comb level at a terminal end of an escalator or passenger conveyor. CO

lighting: emergency. Lighting provided in an elevator car in the event the car becomes stationary between floors and supplied from a standby generator or emergency batteries. S145

lighting: step demarcation. The illumination provided by multiple light fixtures located under the steps at the lower and upper landing of an escalator or at the entrance and exit of a moving walk, which provide demarcation between the step treads as the light shines up through the steps. CO

lighting: under step. The illumination provided by multiple light fixtures located under the steps at the lower and upper landing of an escalator or at the entrance and exit of a moving walk which provide demarcation between the step treads as the light shines up through the steps. CO

lights: demarcation. Green fluorescent lamps mounted under the escalator steps in front of the comb teeth at both landings, which are visible between the leading edge of one step and the riser of the adjacent step. CO

limit switch. See switch: limit.

limit: door close. A contact mounted on the door operator, which is actuated when the doors are fully closed and reduces or removes the power from the door operator. AS16

limit: door open. A contact mounted on the door operator, which is actuated when the doors are fully opened and reduces or removes the power from the door operator. AS16

line: pilot. A line for fluid actuating a control. HH

linear drive. See drive: linear.

liner: borehole. A rigid capped tube inserted into the borehole of a hydraulic elevator to prevent its collapse or the ingress of water. BOpt9

liner: guide shoe. The replaceable part of a sliding guide shoe, sometimes called a gib, which slides against the guide-rails and steadies the car in its travel. AS18

liner: hydraulic. An insert placed inside the original cylinder of a hydraulic jack to stop leaks. N82

lining: brake. The lining of the brake shoes of an elevator made of material possessing a high coefficient of friction. J87

linkage: door. Connecting links controlling the motion of the doors and associated with the door operator or the door closer. AS16

lintel. The horizontal member of an entrance frame used to support the load above the entrance. O1219

load. The weight of passengers inside an elevator car. BA

load chord truss. A truss design where most of the supporting steel is located below the escalator step line. CO

load relieving ramp. A ramp with low friction insert that acts on the step chains to reduce the load on the chain wheels as they move round the upper curves of the escalator. LO18/32

load weighing. Process of determining the number of passengers in an elevator car by weighing the load of the car and passengers. BE277

load: average. The weight of passengers carried in an elevator car averaged over the number of trips made in a five minute period. BE14

load: brake. The load which the brake of the escalator must be designed to stop and hold. CO

load: contract. See load: rated.

load: percentage. The weight of passengers carried in an elevator car expressed as a percentage of the rated capacity. BA

load: rated. The weight of passengers which the elevator car is certified to carry. BE14

loading interval. See interval: loading.

loading supports. Points upon which the load of an escalator or passenger conveyor are imposed, normally at or close to the terminal ends of the unit. CO

loading time. See time: passenger loading.

lobby. [syn: main terminal (floor), foyer, ground (UK), first (USA).] An entrance or corridor used as a waiting place. O1228

lobby panel. See panel: despatcher.

lobby: express. See floor: express zone terminal.

lobby: sky. A terminal floor at the highest floor served by a low zone group of elevators, where passengers may wait for service by a high rise group of elevators. S331

local zone. See zone: local.

lock: bar. A form of door lock used on manually operated doors. AS13

lock: car door. See lock: door.

lock: castell. A mechanical interlock that ensures that when the key is removed the circuit breaker and isolator cannot be closed. LO8/32

lock: door. A mechanical lock of any type which is used to prevent the opening of a car or hoistway door, unless the car is in the door zone. BOpt9

lock: hoistway door. See lock: door.

loom: wiring. A group of wires cut to pre determined lengths and running parallel to each other. CO

low oil level protection. Generally an electrical float switch used to signal a low level of oil in the hydraulic reservoir. JI

low pressure switch. See switch: low pressure.

low step switch. See switch: low step.

lower head. The horizontal portion of the truss at the lower end of the escalator. CO

lower landing. The area at the bottom end of an escalator or passenger conveyor. CO

low(est) call reversal. See call: low(est) reversal.

lowest floor. The bottom floor of a building. CO

lowest reversal floor. See floor: lowest reversal.

lubrication. A fluid or grease applied to moving components for the purpose of noise reduction, friction reduction and to reduce operating temperatures. CO

lubrication float switch. See switch: lubrication float.

lubricator: automatic. A device to supply lubricant through non-corrosive seamless metallic feed pipes to various parts of an escalator or passenger conveyor. It is normally located in a readily accessible position in the upper tank or machine room. LO5/32

lubricators. Applicators located to assure proper lubrication by depositing oil on the various moving mechanisms located within the escalator. CO

M-G set. See motor generator set.

machine. A device for doing work. CO

machine room. A room or space in which the machine(s) and associated equipment are located. BS/ENpt1

machine room stop. A manually operated switch used to stop an escalator from the machine room area. CO

machine: basement drive. Where the elevator drive machine is located at the bottom of the elevator hoistway. BA

machine: belt drive. An indirect drive machine using a belt as the means of connection. AS8

machine: chain drive. An indirect drive machine using a chain as the means of connection. AS8

machine: direct drive. An electric driving machine where the motor is directly connected mechanically in elevators to the driving sheave, drum or shaft and in escalators to the step band, without intermediate mechanical gearing. AS7

machine: direct plunger driving. A hydraulic driving machine, where the cylinder is directly connected to the car. AS8

machine: driving. The power unit which provides the energy necessary to rotate the escalator step band or to raise and lower an elevator, material lift or dumbwaiter comprising some or all of: an electric motor or hydraulic motor; mechanical gearing; brake; sheave, drum or chain sprockets; couplings, shafts, journals and bearings; machine frame. J14

machine: drum. See machine: winding drum.

machine: electric drive. A driving machine where the energy is supplied by an electric motor. AS7

machine: geared. A machine utilising a gear for energy transmission. CO

machine: geared traction drive. A traction drive machine utilising a gear for energy transmission. AS8

machine: gearless traction drive. A traction drive machine with no intermediate gearing. AS8

machine: hydraulic drive. A driving machine where the energy is supplied by the stored energy in a hydraulic fluid applied by means of a moving ram in a cylinder. AS8

machine: indirect drive. An electric driving machine, where the motor is connected indirectly by means of belts, chains etc to the sheave, shaft or gearing. AS8

machine: overhead. Where the elevator drive machine is located at the top of the elevator hoistway. N101

machine: rack and pinion drive. An electric drive machine, where the movement of the car is achieved by power driven pinions mounted on the car travelling on a stationary rack fixed in the hoistway. AS8

machine: rated load. The load which the machine of the escalator, passenger conveyor or elevator must be designed to move. CO

machine: roped hydraulic drive. A hydraulic driving machine where the cylinder is connected to the car by roping. AS8

machine: screw. An electric driving machine where the motor drives a screw assembly to raise and lower the car. AS8

machine: traction. A direct drive machine, where the motion of the car is obtained through friction between the suspension ropes and the driving sheave. AS8

machine: winding drum. A geared drive machine, where the suspension ropes are fastened to a winding drum. AS8

machine: worm geared. A direct drive machine where the energy is transmitted to the elevator sheave or drum, or escalator step band, via worm gearing. AS8

machinery space. Space available for the various components required which form the escalator or passenger conveyor. CO

magnet: brake. A solenoid which, when energised, causes the brake shoes to move away from the brake drum. AS13

main brake. See brake: main.

main circuit breaker. The circuit breaker used to switch the main electrical supply for each elevator or escalator. LO19/32

main contactor. A contactor with its contacts arranged so as to provide power to the main motor to back up the directional contactors. CO

main directional contactors. The interlocking changeover contactors used for final connection of the drive motor to the incoming supply and directional control. CO

main floor. See floor: main.

main isolator. The isolator used to open or close the main electrical supply for each escalator or elevator. CO

main motor. The prime mover. CO

main supply. Power provided from which the prime mover power is derived. CO

maintenance. The action of preservation without impairment or the keeping in being. O1261

maintenance: breakdown. Maintenance undertaken in order that components and equipment may be returned to satisfactory operation. ET197

maintenance: comprehensive. A form of maintenance contract, where the system is inspected, oiled and greased, adjusted and breakdowns repaired during normal working hours, but excluding call backs outside normal working hours, repairs due to vandalism and work arising from legislation. ET201

maintenance: full (FM). See maintenance: comprehensive.

maintenance: performance guaranteed. A contract offered to an elevator, escalator or passenger conveyor owner, which guarantees certain performance, (for example: no of elevators simultaneously in service, high mean time between failures (MTBF), low periods of down time) and on the failure to perform results, in the lowering of the premium paid to the maintainer. ET201

maintenance: planned. Preventative maintenance scheduled to be performed at specified intervals of time or for specified numbers of operations. ET197

maintenance: preventative. Maintenance provided to ensure the satisfactory operation of components and equipment by delaying or preventing or reducing the severity of any breakdown that may occur. ET199

maintenance: replacement. The replacement of components and materials, which have worn out or reached the end of their useful life. ET198

maintenance: scheduled. See maintenance: planned.

manifold. A metal block in which passages are formed and on which valves are mounted permitting the elimination of many, but not all, interconnecting pipes and shortening the length of the fluid passages. HH

manual control switch. See switch: manual control.

manual lowering device. See handwinding: device.

mechanic. A person who is capable of maintaining the status quo, but not of innovation (engineer); a skilled elevator operative who has followed a prescribed plan of training and education. N88

mechanical interference. Resistance to motion provided by friction and/or mechanical means or devices. CO

mechanically synchronised. Hydraulic elevators which use a telescopic ram assembly to maintain constant velocity due to the rope or chain synchronising external to the cylinder. JI

medium duty traffic. See traffic: medium duty.

micron filter. Filters, where the size of the particles that the filter will reject is determined in microns. JI

microprocessor. An electronic device which provides methods of control by reacting to input signals in accordance with an algorithm to provide predetermined output signals. CO

modernisation. The process of improving an existing system by bringing it 'up to date'. BA

modernisation overlay. See overlay: modernisation.

monitoring: remote. The signalling over a distance of the events (faults, passenger activity, elevator activity etc) occurring in an elevator installation. BE361

motor. A device which can convert electrical energy into mechanical energy. BA

motor generator set. A device comprising an AC motor driving a DC generator and therefore capable of converting one form of electrical energy to another using a mechanical coupling. BA

motor overload. An automatic device to protect a motor against damage as a result of electrical overload. CO

motor protection. An automatic device to protect a motor against damage as a result of electrical overload. CO

motor thermistor protection. Is where the electric motor is protected from overheating by thermistor junctions being placed on the winding of the motor, allowing the temperature to be monitored very accurately and without delay. JI

motor: auxiliary. A motor used for driving parts of an escalator, but not the main drive. LO6/32

motor: brake. A motor sometimes provided to open the brake shoes. CO

motor: compound. A motor with shunt and serious coils giving combined characteristics of shunt and series type motors (e.g. high starting torque and limited maximum speed). LO10/32

motor: main. The prime mover. CO

mouldings. Extruded aluminium shapes which through hidden fasteners position and lock in place the interior panels of an escalator. CO

moving walkway. A type of passenger carrying device on which passengers stand or walk, and in which the passenger carrying surface remains parallel to its direction of motion and uninterrupted. NE90

moving walkway: belt pallet type. A moving walkway with a series of connected and power driven pallets, which form a continuous belt treadway. NE91

moving walkway: edge supported belt type. A moving walkway with the treadway supported near its edges by succession of rollers. NE91

moving walkway: pallet type. A moving walkway with a series of connected and power driven pallets which together constitute the treadway. NE91

moving walkway: roller bed type. A moving walkway with the treadway supported throughout its width by a succession of rollers. NE91

muffler. See expansion chamber.

multi stage cylinders. See telescopic ram and cylinder.

multiple leaf door. See door: multiple (panel) leaf.

multiple parallel arrangement. See arrangement: multiple parallel.

multiplying pulley. See pulley: multiplying.

needle valve. See valve: needle.

newel base. The flat vertical portion of the newel assembly supporting the newel overhang. CO

newel entry switch. See switch: newel entry.

newel entry brush. A brush provided at the newel end to cover the internal components of the newel entry switch and to prevent passengers fingers entering this space. CO

newel wheel. A cast iron or steel wheel that carries the handrail around the top and bottom end of an escalator or terminal ends of a passenger conveyor. NE93

newel. Extensions of the balustrade of an escalator at both the lower and upper limits of travel located to assist passengers in boarding and alighting the escalator. NE93

newel: concentric. A newel configuration which utilises a semi-circle as its basic shape. CO

newel: elongated. A newel configuration which utilises a parabolic shape for its design, not to be confused with the extended newel which is required by the ANSI/ASME code. CO

newel: extended. A newel design, not associated with the shape of the newel, where the outer end of the newel extends beyond the comb teeth of the escalators. CO

newel: stand. An upright metal mounting that supports the newel wheels on an escalator or passenger conveyor. NE93

next car. See car: next.

next car indicator. See indicator: next car.

nib. See nosing.

no load start. A procedure whereby a hydraulic elevator motor can start under no load condition, by allowing the pump flow to pass direct to the tank during motor stating until the motor has reached nominal full speed, when the control valve closes to slowly cause the flow to be directed to the cylinder. JI

noise: acoustic. Noise which is transmitted through air and which may be generated by parts of: either an elevator installation, such as the machine, car movement, ropes and chains in the hoistway; or of an escalator installation, such as the machine, and transmitted via parts of the structure to remote parts of a building. P42

noise: electrical. Noise generated in power devices such as M-G sets, thyristor (SCR) controllers, etc and which is transmitted by electromagnetic radiation. See also interference: electrical. BA

non reversal device. A device provided to prevent the sudden reversal of an escalator or passenger conveyor. CO

nose line. The line formed by the intersection of the escalator step of the riser with the step tread. CO

nosing. Rounded edge of a step or cover for the edge of a step. O1415

notices. Written or pictographic signs placed on or near an escalator to warn of hazards. CO

nudging. With automatic door operation should the doors remain open for longer than a specified time then the doors are compulsorily closed at reduced speed, with the intention of removing any obstruction. AS20

'O'-ring. An endless packing ring of circular cross-section (toroidal ring) normally mounted in a groove in such a manner that the effectiveness of sealing increases with the pressure. HH

observation elevator. See elevator: observation.

oil buffer. See buffer: oil.

oil cooler. See heat exchanger.

oil cushion stop. See stop: cushioned.

oil drain line. The line that carries overflow oil, oil leakage from gland and exhaust oil from the valve pilot system back to a container but not to the tank if the oil is likely to be contaminated. JI

oil drip pan. See drip tray.

oil level indicator. The means to monitor the oil level in the tank of a hydraulic elevator to ensure that there is sufficient oil for the elevator car to reach the top floor, which can be in the form of a sight glass or dip stick. JI

oil temperature detection. The detection of unacceptable oil temperature rises by detection devices which are usually either thermistor or bi-metal sensors placed in the oil tank. JI

on-call control. See control: on-call.

one-to-one roping. See roping: one-to-one.

open pilot valve. See valve: open pilot.

opening: door advance. See opening: door pre-opening.

opening: door premature. See opening: door pre-opening.

opening: door pre-opening. The initiation of the door opening sequence, whenever the elevator car is within the door zone, in order to reduce the floor to floor cycle time. S129

operational brake. See brake: service.

operator. Person who rides in the elevator car and controls the movement of the car and the opening and closing of the doors. N100

operator: door. A power operated device which opens and closes the hoistway and/or the car doors, where the power is not derived from springs, car movement or manual means. AS4

OR gate. A solid state logic device, where the output value is true, when any input is true and is only false when both inputs are false. BA

ordinary lay. See lay: ordinary.

outer deck. The deck of a glass balustrade escalator covering from the glass to the outermost edge of the escalator. NE100

overhead. The upper end of the hoistway. N101

overhead beam. The steelwork and reinforced concrete located at the top of the elevator well, which supports the elevator equipment. BOpt9

overhead machine. See machine: overhead.

overhead structure. See overhead beam.

overlay: modernisation. Where a new control system is installed over the top of the existing control system and which takes over the function of the original controller. BA

overload. A condition where the rated capacity of a piece of equipment has been exceeded. BA

overload indicator. See indicator: overload.

overspeed. A condition which is said to occur when an elevator exceeds it rated speed by a specified amount or the step band or treadway of an escalator or passenger conveyor exceeds the nominal rated speed. CO

overspeed governor. See governor: overspeed.

overspeed governor switch. See switch: governor overspeed.

overtravel. The safe distance that a moving object may travel past its normal point of movement, without hitting any fixed objects. (See clearance.) N102

packing. The wearing material fitted into a gland assembly to provide an oil seal between the ram and cylinder. JI

pads: sound insulating. See pads: sound isolating.

pads: sound isolating. Pads made of a dense resilient material, which can be inserted between a noise/vibration producing equipment such as a machine, control cabinet or electrical transformer and their fastenings with the building structure, to reduce the intensity of the noise transmitted into a building structure and the air. S402

pallet. One of the series of rigid platforms which together form an articulated treadway or the support for a continuous treadway on a moving walkway. CO

panel: car call. See panel: car operating.

panel: car operating. An assembly of push buttons and indicators mounted on a panel inside an elevator car including, amongst other things: car call, door open/close, alarm and mechanics control push buttons; car call, position, direction and information indicators, together with a number of key operated switches for use by authorised persons. PXII

panel: despatcher. Combined starters' and building supervisors' panel comprising, amongst other things, indication of up/down car and landing calls, car position, direction and status together with a number of key operated switches for use by authorised persons. P262

panel: exterior. The panel enclosing the exterior side of the balustrade. CO

panel: vision. Small window located in elevator doors fitted with safety glass which permits passengers to see when a car has reached a landing. AS24

parallel installation. An escalator installation where the units are mounted directly parallel and in line with each other. CO

parking. Action of moving an elevator car to a specified floor or leaving it at its current floor, whenever the car has no further calls (landing or car) assigned to it for service. AS20

parking floor. See floor: parking.

parking zone. See zone: parking.

passenger. Any person transported by an elevator car. BS/ENpt1

passenger arrival rate. The rate at which passengers arrive for service by an elevator system. BE47

passenger average time to destination. See time: passenger average to destination.

passenger conveyor. A power driven installation with endless moving walkway (e.g. pallets, belts) for the conveyance of passengers either on the same or between different traffic levels. BS70p5

passenger elevator. See elevator: passenger.

passenger emergency stop switch. See switch: emergency stop.

passenger/freight elevator. See elevator: passenger/freight.

passenger/goods lift. See elevator: passenger/freight.

passenger journey time. See time: passenger journey.

passenger lift. See elevator: passenger.

passenger loading time. See time: passenger loading.

passenger transfer time. See time: passenger transfer.

passenger transit time. See time: transit.

passenger unloading time. See time: passenger unloading.

passenger waiting time. See time: passenger waiting.

paternoster. Form of lift machine, available in Europe but now obsolete, where a low speed (0.4 m/s) loop of continuously moving horizontal platforms, running in a dual hoistway, allow agile passengers to enter and leave the cars through open entrances. PXVIII

pawl device. A mechanical device used in hydraulic elevators to prevent creep. BA.

peak oil pressure. The maximum pressure developed in a system, usually caused by sudden stops and starts of the system, shock loading and/or waterhammer. JI

peek-a-boo. A method of door operation during firefighting service, where a constant pressure is required on the door open button, in order to cause the doors to open at a landing; the release of the pressure causing an immediate closure of the doors. CO

percentage load. See load: percentage.

performance guaranteed maintenance. See maintenance: performance guaranteed.

performance index. See index: performance.

personal protective equipment (PPE). Equipment provided to or purchased by maintenance or other personnel for protection, such as safety helmets, goggles etc. CO

PRFF. See relay: phase failure or reversal.

phase failure relay. See relay: phase failure.

phase reversal relay. See relay: phase reversal.

photo-electric passenger detector. See detector: passenger.

pilot line. Small lines or passages that carry the oil that controls larger valves. JI

pilot line filter. A fine mesh that prevents small particles of foreign matter entering and or blocking the pilot lines and valves. JI

pilot valve. A small valve that controls the fluid flow in the pilot lines. JI

pipe coupling. The connection between lengths of pipe. JI

pipe rupture valve. See valve: pipe rupture.

piston rod. The rod that moves in and out of the gland packing, and is attached to the piston head inside the cylinder. See ram, for large diameter rods. JI

piston seal. A plastic or composition material with good wearing properties, suitable for the fluid being used in the cylinder, fitted to the piston and to prevents oil passing the piston head during operation. JI

piston stroke. There are two different strokes associated with hydraulic elevators, (1) the total stroke of the cylinder, (2) the working stroke of the cylinder. See car travel distance. JI

piston type cylinder. See cylinder: piston type.

pit (1). That part of the hoistway or well situated below the lowest landing served by the elevator car. BSpt5

pit (2). A recess in the floor to receive that portion of the lower head and the lower end of the incline section which occurs below the floor line when there is no floor under the escalator such as in a basement. CO

pit stop switch. See switch: pit.

pit switch. See switch: pit.

pit tanking. Means of preventing the ingress of water into the pit area, which is normally situated at the lowest level in a building. BA

plastic flow. When excessive pressure is placed on a seal the seal is extruded through (plastic flow) the small space between the ram and the gland housing. JI

plate: kick(er). Plate used at the bottom of doors, cabinets and risers of steps and car enclosures to protect them from shoe marks. BA(EITB)

platform: car. Load bearing floor of the car enclosure. AS3

plunger. See ram.

plunger joint. See ram joint.

plunger stop. See stop: plunger.

police circuit. A circuit which maintains the directional contactors after the brakes have been lifted and the starting sequence is complete. CO

poppet valve. See valve: poppet.

population: building. Total population of a building. BE43

population: floor. Population of a specific floor in a building. BE161

position indicator. See indicator: car position.

positive head. Where the oil level in the tank is sufficiently above the pump intake, to ensure the pump is always supplied with enough oil to avoid cavitation. JI

PPE. See personnel protective equipment.

pre-formed groove. See groove: 'U'-profile, and groove: 'V'-profile.

pre-load on seals. Where the space provided for the seal or 'O'-rings is always slightly smaller in the direction of sealing than the dimension of the seal; the other dimension has to be slightly larger than the seal to allow expansion of the seal under pressure. JI

pressure compensated valve. See valve: pressure compensated.

pressure hose. See hose, flexible.

pressure line filter. The filter, usually of the high pressure type, placed in the main pressure line to filter oil in one or both directions. JI

pressure line. A line that carries the fluid at system pressure, which can be either metal tube or flexible hose, selected to suit the highest system plus a factor of safety. JI

pressure tank. A tank that does not open to atmosphere, and uses the fluid to build up pressure in the tank. JI

pressure: differential. Where a hydraulic component has a different pressure on either side; this difference is often referred to as pressure drop or pressure loss. JI

pressure: relief. See relief valve.

preventative maintenance. See maintenance: preventative.

probable stops. [syn: expected stops] See stops: probable .

process switch. An electromechanical device used to detect a physical condition as part of a control sequence. CO

profiled groove. See groove: 'U'-profile, and groove: 'V'-profile.

progressive safety gear. See safety-gear: progressive.

public service type. A type of escalator generally forming part of a public traffic system and of a more sturdy construction that a standard store type escalator. CO

pull down cylinder. An arrangement used on hydraulic elevators fitted with a counterweight whereby the counterweight is pulled down by a piston rod in tension operated by a ram unit installed in the pit. To allow space for a pull down cylinder to be installed under the counterweight the car is roped 1:1 and the counterweight roped 3:1 or 4:1. JI

pull through governor. See governor: pull through.

pulley. Simple mechanical device consisting of a grooved wheel over which a rope or similar may pass for the purpose of changing the direction of applied power. O1705

pulley: diverting (1). An idler pulley used to change the direction of the rope lead where the drive sheave diameter is less than the distance between the pick up points of the car and counterweight. BOpt9

pulley: diverting (2). An idler pulley used to change the direction of an escalator chain. CO

pulley: governor. The pulley, located with the overspeed governor in the machine room around, which the governor rope passes. J118

pulley: multiplying. A pulley mounted on the car frame or counterweight round which the suspension ropes pass in order to gain a 2:1 mechanical advantage. BOpt9

pulley: overhead. Pulleys used to alter the pick up points for the car and counterweight where the machine room is positioned other than directly above the hoistway. BA(EITB)

pulley: tension. The pulley, which is part of the governor tension sheave assembly located in the pit, around which the governor rope passes. J118

pulsation. The throbbing or vibrating effect set up in fluids, often induced by the design of the pump, and which can cause damage to the system, if not damped. JI

pump: direct coupled. A type of hydraulic pump arranged to be directly connected to the electric motor by either a solid or a resilient in-line coupling. JI

pump: emergency hand. Fitted to hydraulic elevators of the indirect type to enable the car to be lifted out of the safety gear during a power failure or to other types of hydraulic elevators to enable a car to be raised to a landing, in order to rescue trapped passengers. JI

pump: external. A pump located outside the oil tank where both the suction and pressure ports of the pump are connected to the system by pipelines or flexible hoses. JI

pump: gear. A pump which has two intermeshing gears inside a housing such that the oil is transported around the gear in the cavity formed between the teeth and the housing. JI

pump: hand. A pump that is operated by hand. See also pump: emergency hand. JI

pump: internal. A pump, which is submerged in the oil tank and is always covered with oil, thus allowing the direct entry of oil into the suction filter mounted on the end of the pump. JI

pump: screw. A pump where two or three intermeshing screws mounted parallel to each other in a casing impel the liquid along the thread as they rotate, the screws also acting as mutual seals to prevent leakage. HH

pump: vane. A rotary pump where the oil is moved by axially sliding vanes set eccentrically on the rotating part. JI

pumps: indirect coupled. Pumps connected to an electric motor via a belt drive or gear system. JI

pushbutton. An insulated button which operates electrical contacts when pushed. BA

pushbutton: car call. A pushbutton which generates a car call, when pushed. BA

pushbutton: door close. A pushbutton which causes the car doors to close, when pushed. BA

pushbutton: door open. A pushbutton which causes the car doors to open, when pushed. BA

pushbutton: landing call. A pushbutton which generates a landing call, when pushed. BA

pushbutton: stop (1). A pushbutton which causes the elevator car to stop, when pushed. BA

pushbutton: stop (2). A push button, normally located in the same place as the escalator directional start switches, as part of the stop/start switch assembly. CO

quadruplex. A group of four cars sharing a common signalling system. BE88

quality of service. The passengers perception of the efficiency of an elevator installation measured in terms of passenger waiting time. BE14

quantity of service. The handling capacity of an elevator installation. BE14

queue. An orderly line of persons waiting their turn. O1729

rail. See guide-rails

ram. The male member of a substantial cylinder assembly. HH

ram coupling. See ram joint.

ram cushion stop. See stop: cushioned.

ram follower. The guide fitted to the ram and guided to prevent the ram buckling when it is extended and arranged to follow the ram at half the extended length. JI

ram joint. The screwed connection between sections of a ram allowing shorter sections to be assembled, thus forming one long ram. JI

ram stop. See stop: ram.

rated load. See load: rated.

rated load: brake. The load which the brake of the escalator must be designed to stop and hold. CO

rated load: machinery. The load which the machine of the escalator must be designed to move. CO

rated load: step. The load which the escalator step must be designed to support. CO

rated load: structural. The total stated load imposed on the structure of the building. CO

rated load: truss. The load which the truss of an escalator must be designed to support. CO

rated speed: elevator. See speed: rated (elevator).

rated speed: escalator. See speed: rated (escalator).

rated speed: moving walkway. See speed: (rated moving walkway).

RCD. See residual current device.

re-levelling. After an elevator car has stopped level at a floor, an operation permitting the stopping position to be corrected (if necessary) during unloading and unloading, by successive car movements. BS/ENpt1

reaction. Signifies the load imposed on the building structure by the escalator. CO

recessed floor pans. Pan type construction being used as a substitute for floor and landing plates, This construction allows the consumer to fill the pans with another material duplicating the floor surrounding. CO

registered call. See call accepted.

registration: call. Action of the passenger in the registration of a car or landing call. BA

regular lay. See lay: ordinary.

relay. An electromechanical device that is operated by a change in one electric circuit and serves to make or break one or more connections in the same or other electrical circuit. CO

relay: asymmetric. A relay provided to detect the failure of one or more supply phases and/or the incorrect sequencing of those phases. CO

relay: phase failure. Relay which detects a failure of a phase of an incoming electrical supply and which causes the elevator system to be shut down. BA

relay: phase failure or reversal. A relay provided to detect the failure of one or more supply phases and/or the incorrect sequencing of those phases. CO

relay: phase reversal. Relay which detects a phase reversal of an incoming electrical supply and, which causes the elevator system to be shut down. BA

relay: time delay. A relay which acts as a timing device by delaying the application of a control signal. BA

relief valve. See valve: relief.

remote monitoring. See monitoring: remote.

reserve oil. The oil in a tank that is in excess of the minimum oil required to operate the system. JI

residential building. See building: residential.

residual current device. A circuit breaker designed to break the supply in the event of a current flow to earth. LO13/32

resistor: adjustable. A resistor that has taps, sliding bands or a wiper which, when moved, allows all or part of the resistor to be used. NE1

retail building. See building: retail.

retiring cam. See cam: retiring.

return. To take or lead back at an angle, often 90 degrees, upon a former direction. O1818

return carriage. See carriage: return.

return jamb. See jamb: return.

reverse phase relay. See relay: phase reversal.

reversible. An escalator or passenger conveyor which has the ability to run in either direction. CO

Reynolds number. A dimensionless number used in considerations of fluid flow and given by the relationship: fluid velocity multiplied by pipe diameter divided by kinematic viscosity. HH

right hand lay. See lay: right.

rise. The vertical distance between two steps in a stair; the vertical distance between boarding and alighting levels of an escalator. BACO

riser. The upright part of a step; the vertical piece connecting two treads in a stair. O1837

riser: cleated. Vertical cleats on an escalator step riser, which mesh with slots on the adjacent step tread as the steps move from incline to the horizontal. NE23

riser: electrical. A vertical enclosed space in a building from which electrical distribution is made. BA

riser: step. The vertical portion or front of a step. NE139

roller guide shoes. See shoes: roller guide.

roller: step. The roller fitted to the escalator step which runs on a track to determine the profile of the escalator. CO

rope lay. See lay.

rope. A construction of twisted fibres or wire (wire rope) to form continuous load bearing element. N120

rope: compensating. Wire rope used to counterbalance or partially counterbalance the weight of the suspension ropes as the elevator car moves up and down the hoistway. AS10

rope: governor. A wire rope attached to the elevator car, which drives the governor. J117

rope: hand. A control rope passing through an elevator car allowing the travelling passenger to start and stop the car; now obsolescent. N64

rope: hauling. An endless rope used to manually raise and lower a hand powered elevator. BOpt9

rope: safety. A rope used on hydraulic elevators to actuate the safety gear, where one end is connected to the safety gear actuating arm at the car end, passing over a sheave mounted on the main ram sheave assembly to the pit equipment at the other end. JI

rope: shipper. See rope: hand.

rope: suspension. The ropes in an elevator system used to suspend the car and counterweight in the hoistway. BA

rope: tail. See rope; safety.

rope: wire. Rope made by twisting wires around an inner core. AS21

roping: one-to-one. An arrangement of ropes, where the mechanical advantage is one and hence the suspension ropes, car and counterweight all travel at the same speed. Jcp3

roping: two-to-one. An arrangement of ropes, where the mechanical advantage is two and hence the rope speed is twice that of the car and counterweight. Jcp3

rotary selector switch. See switch: rotary selector.

round trip time. See time: round trip.

rucksack elevators. The name given to elevators, where the car is only supported on one side. JI

runby. The unobstructed distance a car or counterweight may travel at the extremes of the hoistway before an obstruction is encountered. BA

runby: bottom — elevator car. The distance between the car buffer-striker-plate and the car-buffer striking-surface, when the elevator car floor is level with the bottom landing. AS10

runby: top — direct-plunger hydraulic elevator. The distance the elevator car can run above the highest terminal landing, before it strikes the mechanical stop. AS10

running clearance. See clearance: running.

rupture valve. See pipe rupture valve.

rupturing pressure. The pressure at which a hydraulic component bursts or leaks through fault cracks, when subjected to pressure test. JI

safe-edge. A mechanically actuated door re-opening device mounted on the leading edge of a car door which on colliding with a passenger or other object causes the car and landing doors to re-open. AS22

safety. A generic term used to describe the safety features employed in elevator installations. BA

safety astragal. See astragal: safety.

safety bulkhead. A second base or bulkhead welded inside the bottom of the cylinder of a hydraulic elevator (which is buried in the ground and could suffer corrosion) to prevent the sudden loss of oil in the event of a failure of the lowest bottom plate of the cylinder. JI

safety circuit switches. See switches: safety circuit.

safety edge. See safe-edge.

safety-gear. Mechanical devices used to stop a car or counterweight under specific conditions. Jcp8

safety-gear: instantaneous. A safety gear which applies a rapidly increasing pressure on the guide-rails during the stopping period. J117

safety-gear: instantaneous with buffered effect. A safety gear which applies a rapidly increasing pressure on the guide-rails during the stopping period, but with a buffered effect provided by oil buffers interposed between the lower members of the car frame and the safety plank. J117

safety-gear: progressive. A safety gear which applies a limited pressure on the guide-rails during the stopping period. J117

safety plank. Bottom member of the car frame supporting the car guide shoes and safety gear. AS22

safety rope. See rope: safety.

safety test. See test: safety.

safety: car. Mechanical device attached to the car frame to stop and hold the car should any of three conditions, free fall, predetermined overspeed or rope slackening, occur. AS10

safety: counterweight. Mechanical device attached to the counterweight frame to stop and hold the counterweight should any of three conditions, free fall, predetermined overspeed or rope slackening, occur. AS10

safety: flexible guide clamp. A form of car safety where a pair of wedge shaped jaws are actuated under unsafe conditions and grip the guide-rails to bring the car to a safe stop. J128

SAPB. See single automatic push button.

scheduled control. See control: scheduled.

SCR. See thyristor.

screw machine. See machine: screw.

screw pump. See pump: screw.

seal: double acting. Seals which are required to retain the oil pressure on either side, e.g. on the piston head of a double acting cylinder. JI

seal: dynamic. A seal placed between a fixed and moving part for example: a gland seal for a ram or piston. JI

seal: gland. See gland packing.

seal: ring. See 'O'-ring.

seal: static. A seal between two static parts to prevent oil leakage for example: a cover plate or mounting components together. JI

secondary sheave. See sheave: secondary.

sector. A group of landings or of landing calls considered together for elevator car allocation or parking purposes. BE94

sector: common. Static sector defined for both up and down landing calls originating from a number of contiguous landings. BE98

sector: demand. A sector in which there is a demand for service indicated by the registration of landing calls. BE98

sector: directional. Static sector that includes a number of contiguous landings defined for one landing call direction only. BE99

sector: dynamic. Sector whose boundaries are defined by the position of the cars and hence are continually changing. BE100

sector: static. Fixed number of landings grouped together. BE98

segments. The radius portions of the escalator assembly. CO

seismic sensor. See sensor: seismic.

seismic switch. See switch: seismic.

selector: floor. Part of the control system of some elevators which determines the position of the car in the hoistway and automatically stops it at the required landing. BOpt9

self re-levelling. See re-levelling.

sensor: seismic. Sensor capable of detecting the onset of an earthquake. BA

service brake. See brake: service.

service elevator. See elevator: service.

service switch. See switch: service.

service: basement. The provision of passenger service to the basement or basements of buildings on a special or regular basis. BE95

service: fireman's. Elevator, which serves all floors in a building, and which can come under the sole command of a fireman in the event of a fire in the building. P61

service: independent. Operation of an elevator such that it only answers car calls and which is brought into operation by the use of a special key switch located in the car. AS19

service: intensive duty. Where an elevator system makes 180 or more starts per hour. PcpVI

service: light duty. Where an elevator system makes 90 or less starts per hour. PcpVI

service: medium duty. Where an elevator system makes from 90 to 180 starts per hour. PcpVI

service: quality. See quality of service.

service: quantity. See quantity of service.

shaft encoder. See encoder: shaft.

shaft. See hoistway.

shaftway. See hoistway.

sheave. A wheel having a groove or grooves in its circumference, in order to receive a rope or ropes; a pulley. O1969

sheave guard. See guard: sheave.

sheave guide. A guide attached to the sheave located on the top of the ram of hydraulic elevators of the indirect type for diverting the ropes; the guide prevents lateral movement of the sheave assembly. JI

sheave: chain. Sheave with rectangular shaped groove over which a chain may run. AS15

sheave: compensating rope. A pit-mounted grooved sheave which guides and maintains the tension on the compensating ropes. AS15

sheave: deflector. Grooved sheave used to deflect ropes in order to place them in the correct lifting positions. AS16

sheave: door hanger. Small grooved sheave which runs on the door track and which allows the door to slide easily. N64

sheave: drive. A wheel, the rim of which is grooved to receive the suspension ropes, and which allows the motion of the driving machine to be transmitted to the ropes by friction. BOpt9

sheave: governor tension rope. A weighted pit-mounted sheave used to maintain tension on a governor control rope. AS23

sheave: hanger. See sheave: door hanger.

sheave: idler. Grooved sheave used to guide, to change direction or to apply tension to a rope. N70

sheave: secondary. A groove used to permit the double wrapping of the suspension ropes in order to increase traction. AS22

sheave: tension. A sheave used to maintain tension on a rope. BA

shim. A piece of metal or other material used to fill out a space. NE129

shim: kicker. Small slotted plate used to pack out, align or square-up guide-rails. N77

shim: trouser leg. A small slotted plate used to pack out, align or square up manufactured in the shape of the pair of trousers. CO

shipper rope. See rope: hand.

shock loads. See peak oil pressure.

shoes: brake. The moving component of a brake, to which the brake linings of high coefficient of friction material are fixed and which when in contact with the brake drum causes an elevator car, escalator or passenger conveyor step band to be held in a stationary position or brought to rest. AS13/J87

shoes: roller guide. Component used to guide an elevator car or counterweight along the guide-rails comprising a set of three (or six) spring loaded rubber tyred rollers. J114

shoes: slide. See shoes: slipper guide.

shoes: slipper guide. Component used to guide an elevator car or counterweight along the guide-rails comprising a set of swivel shoes lined with a low coefficient of friction material running against greased guide-rails. J112

side opening door. See door: side opening.

side ram. Rams installed at the side instead of under the car platform, in order to reduce or eliminate the need to drill bore holes in the case of long ram and cylinder units. JI

side stile. See stile.

sight glass. A small glass or plastic panel placed on the side of oil tank, in order to observe the oil level is sufficient. JI

sight guard. See guard: sight.

signal: despatch. Signal given to the elevator power control system to cause the elevator car to move. BA

signalling device. See device: signalling.

signalling system. See system: signalling.

silencer. See expansion chamber.

silicon controlled-rectifier. See thryistor.

sill. Lower horizontal part of a doorway. O1996

sill guard. See guard: sill.

sill-stop. Support member fastened to the guide-rails of vertical bi-parting doors. AS22

sill: door. Lower horizontal member of a landing entrance. AS16

simplex collective control. See control: simplex collective.

simulation. The development and use of models to aid in the evaluation of ideas and the study of dynamic systems or situations. BE151

single automatic push button. An automatic push button control system, where only one button is provided on the landing to indicate both directions of travel. BE87

single leaf door. See door: single panel (leaf).

skip-stop operation. Where a duplex pair of elevators in a building share a common lobby but one car serves even floors and the other serves odd floors. BA

single stage ram. A tube or solid column that has a constant diameter for the full length of its travel or stroke. JI

single wrap. Roping arrangement, where one end of the suspension rope is fastened to the car, passes over the drive sheave and is then fastened to the counterweight. J44

skirt. The panels located immediately adjacent to the escalator steps or treadway. CO

skirt guard. See guard: skirt.

skirt panel. The lowest panel within the balustrade, located immediately adjacent to the escalator steps and running parallel to the step travel on both sides. CO

skirt switches. See switches: skirt.

skirting (board). Narrow boarding placed at the base of a wall. O2011

sky lobby. See lobby: sky.

slack rope switch. See switch: slack rope.

slenderness ratio. A dimensionless number given by the relationship: the length of a column or ram divided by the radius of gyration of the member. JI

slide jamb. See jamb: return.

slide up-down door. See door: slide up-down.

sliding lower carriage. See carriage: sliding lower.

sling. Device for hoisting bulky or heavy articles. O2019

sling: car. See frame: car.

slipper guide shoes. See shoes: slipper guide.

slope: moving walkway. The angle which the treadway makes to the horizontal. CO

socketing. The preparation of suspension rope end fastenings. J33

soffit. The under horizontal surface of an architrave, cornice, lintel, arch or escalator truss. O2041

soft start. Uses a form of electrical control equipment that limits the current and/or voltage during the starting cycle of the motor, to reduce the starting current and provide a smooth acceleration. JI

solenoid. An electromagnetic device consisting of a movable iron core (or cores) surrounded by a coil, where the core (often referred to as plunger) is magnetically attracted to the centre of the coil when the coil is energised. CO

solenoid valve. See valve solenoid.

solid rams. A ram or piston made from solid bar not tube. JI

solid state. Electronic circuits making use of semiconductor physics. BA

sound isolating pads. See pads: sound isolating.

speed governor. A device provided to detect an overspeed condition of the escalator step band. CO

speed reduction unit. Wheels working one upon the other, by means of teeth (or otherwise) for transmitting or changing motion, power and/or speed (often called a worm reduction unit). CO

speed: contract (elevator). See speed: rated (elevator).

speed: contract (escalator). See speed: rated (escalator).

speed: rated (elevator). The linear car speed in the hoistway, which the elevator manufacturer contracts to supply. BOpt9

speed: rated (escalator). The rate of travel of the steps measured along the angle of inclination, with rated load on the steps, but in the case of reversible escalator the rated speed shall be the rate of travel of the steps in the 'up' direction. CO

speed: rated (moving walkway). The rate of travel of the treadway measured along the angle of inclination, with rated load on the treadway. In the case of the reversible inclined moving walkway the rated speed shall be the rate of travel of the treadway in the 'up' direction. CO

split seal. A circular shaped seal, which assists jack assembly as it has been cut to allow the placing of the seal around a ram or piston so that the two ends can come together. JI

spool valve. See valve: spool.

spreader bracket. See bracket: spreader.

spring buffer. See buffer: spring.

spring: buffer return. Spring used to return an energy dissipation type of buffer back to its operating position. J143

spud. See gib: door.

stair climber. A form of stair climbing elevator on which a mobility impaired person can sit in order to reach another floor. S351

stanchions. The vertical members of the truss assembly. CO

stand: newel. See newel: stand.

standard. An authoritative or recognised exemplar of correctness, perfection, or some definite degree of any quality. 02107

star delta starter. The interlocking changeover contactors used to start two speed AC drive motors. CO

starter. Originally a person who manually operated and despatched elevators, supervised attendants and directed passengers, but now is a piece of control equipment to stop and start the M-G set. AS23

starter switching solenoid (Watford starter). An accelerating rheostat unit that shorts out resistance in a stepped operation by means of solenoid operated actuation. CO

starts per hour: electric traction elevator. For an electric traction elevator the number of starts per hour is the number of motor starts per hour and is the sum of starts in both up and down directions. BA

starts per hour: hydraulic elevator. For a hydraulic elevator the starts per hour is the number of pump motor starts per hour, i.e. to move the elevator in the up direction. JI

static friction (stiction). Is the friction or holding power between parts that move during the operation of the hydraulic elevator e.g. ram and cylinder packing is the major example of static friction. See also dynamic friction and stick-slip. JI

static oil pressure. The oil pressure in a stationary ram holding a load, when the elevator is not moving and in a standby or holding position ready to be operated. JI

static seal. See seal: static.

station: car-top inspection. Control panel situated on the top of the car which allows the elevator to be removed from service and controlled from the car top. AS14

station: mechanics. A control panel, very often plugged in, situated in the ends of an escalator allowing the step band to be rotated under controlled conditions by a mechanic. CO

stationary switch. See switch: stationary.

steel tape. See tape: steel.

step. The moving platform on which an escalator passenger rides. NE139

step axle. A shaft connecting the escalator step chains on each side and fastened to the step at the front end of the step frame and on which the chain wheels are installed. NE27/32

step band. The mobile assembly of steps and two loops of step chains within the escalator. LO27/32

step chain. Heavy section steel roller chain, through which step axles pass, linking the main drive at the top of the escalator and the lower (tension) carriage at the bottom of the escalator and comprising two chains to each escalator handed for each side of the steps. LO27/32

step chain wheel. The wheel mounted on either side of the escalator step on the chain wheel axle used to support the weight of the step band and passenger loading. LO9/32

step demarcation lighting. See lighting: step demarcation.

step frame. The escalator steel framework upon which axles, wheels, riser and treads are mounted to form the step assembly. LO27/32

step journey time. See time: escalator flight time.

step nose line. The theoretical line that intersects the nose of each step on the useable part of an escalator or in a stairway. LO27/32

step plan. The pressed steel escalator frame that forms the tread and the riser which combined with the step yokes forms the step frame. LO27/32

step riser. See riser: step.

step roller. See roller: step.

step tracks. See tracks: step.

step tread. The cleated surface of the escalator step assembly that meshes with the comb. LO27/32

step upthrust switch. See switch: step upthrust.

step wheels. The wheels of an escalator step which are secured to and driven by the step chain. NE139

step yoke. The side of the escalator step frame that may be integral with the frame or a separate steel forging or pressing. LO27/32

step: die cast. A type of escalator step thus called due to its manufacturing process. CO

step: rated load. The load which the escalator step must be designed to support. CO

stick-slip. A phenomenon caused when rams are operating through the gland packing, particularly at slow speed, when the difference between the static friction and the sliding friction causes a gripping and then a release effect on the ram movement. JI

stile. Vertical member of the car frame. AS23

stop diamond. A design of passenger emergency stop device used principally on London Underground escalators. CO

stop push. A latching push button and switch used to interrupt the safety circuit, and stop the escalator. LO27/32

stop push button. See push button: stop.

stop switch. Switch: stop.

stop: car call. See stop: car.

stop: car. A stop by an elevator car at a floor resulting from a car call. BA

stop: cushioned. A stop fitted to the end of ram stroke inside the cylinder, which prevents the ram stop hitting the end of the cylinder. JI

stop: down. A stop by an elevator car whilst travelling in the down direction. BA

stop: hall call. See stop: landing call.

stop: landing call. A stop by an elevator car resulting from a landing call. BA

stop: plunger. A fixed stop fitted at the end of the plunger inside the cylinder of hydraulic elevators thus preventing the plunger being forced out of the gland and packing. JI

stop: ram. The internal or external stop on a ram to prevent the ram being pushed out of a cylinder at the end of its stroke. JI

stop: up. A stop by an elevator car whilst travelling in the up direction. BA

stops: probable. The average number of stops an elevator car makes, during a round trip under up peak traffic conditions, calculated using statistical methods. BE18

stretcher gear. The pair of wheels and system of weights used to tension the handrails on some escalators. LO27/32

strike jamb. See jamb: strike.

stroke: oil buffer. Distance the buffer piston or plunger moves, excluding the travel of the buffer plunger accelerating device. AS3

stroke: spring buffer. Distance the contact end of the spring moves, before all the coils are in contact or a fixed stop is reached. AS3

submersible electric motor. See under oil motor.

suction intake. The common term for the oil being sucked into the pump. JI

suction line. The pipe line that is used to supply the pump with sufficient oil. JI

supervisory control. See control: supervisory.

supervisory panel. See panel: despatcher.

supply distribution. A system comprising busbar trunking and a cable end box used to feed individual switch boards. CO

supply switch gear. The group of switchboards electrically connected to the supply distribution systems and to individual escalator controllers. LO27/32

suspension rope. See rope: suspension.

sweep track. See track: curved.

switch. A device which makes, breaks or changed connections in an electrical circuit. LO28/32

switch: auxiliary isolating. A switch located in the vicinity of the escalator machine, or in the return station, or in the vicinity of the control devices, which interrupts the supply to the motor without cutting the supply to the socket outlets needed for maintenance and inspection purposes. BS78p2

switch: brake cooling. The switch which causes a reduction in the brake coil current to prevent overheating of electromagnetic brakes. LO p7/32

switch: broken drive chain. A switch provided to detect the failure of the escalator drive chain being also activated under slack chain or sudden impact conditions. CO

switch: broken handrail. A switch in the safety circuit that opens when a break in the escalator handrail is detected. LO7/32

switch: broken step chain safety. A switch in the safety circuit that opens when a break in the escalator step chain is detected. NE14

switch: buffer. A mechanically operated switch, which removes power from the elevator drive system, whenever the oil buffer is compressed. AS14

switch: car. An attendant operated switch mounted in the elevator car used to control the motion (starting and stopping) of the car. P249

switch: carriage. One of a pair of switches in the safety circuit which open when the escalator tension carriage moves beyond set limits. LO8/32

switch: chain anchor. The switch in the safety circuit which detects that the chain anchors have been removed prior to the starting of an escalator. CO

switch: chain stretch. A switch provided to detect the stretch of an escalator chain or chains. CO

switch: collision. See switch: displacement.

switch: comb plate. A switch in the safety circuit that opens when excessive force or deflection is detected on the escalator comb or combplate. LO9/32

switch: cooling. The switch that causes a reduction in brake coil current to prevent over heating on electromagnetic brakes. LO10/32

switch: countershaft drive chain. A switch in the safety circuit that opens when a break in the countershaft drive chain is detected. LO10/32

switch: derailment. See switch: displacement.

switch: directional start. A key operated switch located generally in the newel bases at both upper and lower landings, which allows the designated authority to select the movement of the stairs for up and down direction and is sometimes located in the adjacent walls or columns. CO

switch: displacement. Switch actuated by the displacement of the counterweight used to signal to the control system that a collision is possible. AS499

switch: door. Switch operated by the movement of a door. BOpt9

switch: door limit. Switch which limits the travel of a door. AS16

switch: dropped step. A switch provided to detect a dropped escalator step situation. CO

switch: emergency stop (1). Switch located in the elevator car which when operated causes the power to be removed from drive machine and brake. AS6

switch: emergency stop (2). A separate stop button usually located in adjacent walls, columns or within the balustrading providing the facility for a passenger or observer to stop the escalator, in the event of an emergency. CO

switch: fault condition. A solid state/electro mechanical device used to detect faults in an escalator and to provide either protection or warning. CO

switch: final limit. Emergency switch used to stop an elevator automatically, in the event that the car travels a predetermined distance past the terminal landing. BOpt9

switch: final terminal stopping. A mechanically operated switch, which automatically causes the power to be removed from the elevator drive machine and brake, independent of the normal terminal stopping switch, car switch, push button or any other control device. AS182

switch: fire shutter. A switch fitted to detect the release of a fire shutter and to stop the escalator. CO

switch: fireman's. Switch which when operated brings the designated elevator car under the control of the fire fighting service. BSpt6

switch: float. The combined arrangement of a float that moves with the change in oil level in the tank, and operates a switch at pre-adjusted levels. JI

switch: floor stopping. Switch or switches used to bring a elevator car to rest at or near a designated floor. BOpt9

switch: governor. A mechanically operated switch mounted on the governor that removes power from the escalator motor and brake when an escalator overspeed condition occurs. NEp60

switch: governor drive chain. A switch on the safety circuit that opens when a break in the governor drive chain is detected. LO16/32

switch: governor overspeed. Mechanically operated switch located on the governor, which removes the power from the elevator drive machine and brake, whenever an overspeed condition occurs. AS18

switch: handrail entry. A switch provided at the newel entry aperture where the handrail passes through and designed to trip and cut off power to the main motor in the event of an obstruction being detected. CO

switch: key. Switch which can only be operated by means of a key. BA

switch: limit. Switch placed in the hoistway to indicate to the control system that a specified limit has been passed. BA

switch: low pressure. An electrical switch actuated by hydraulic pressure and used to signal a reduction in pressure in the hydraulic system. JI

switch: low step. The switches in the safety circuit, that open when a low escalator step is detected approaching or leaving either comb. LO19/32

switch: lubrication float. The switch that detects a low level of lubricant on an escalator and provides either alarm, or protection. CO

switch: manual control. A manually operated switch used to select a single escalator control option. CO

switch: newel entry. A switch provided at the newel entry space to stop the escalator or passenger conveyor should a passengers fingers enter this space. CO

switch: normal terminal stopping. Switch of any type which causes the elevator automatically to slow down and stop at or near the terminal landing, independent of the car switch, push button or any other control device. AS182

switch: oil buffer. Switch used to indicate the level of oil in an oil buffer is below a specified level and prevent operation of the elevator. AS14

switch: pit. Emergency stop switch located in the elevator or escalator pit, which when operated causes power to be removed from the drive machine and brake. AS188

switch: rotary selector. A device that makes, breaks or changes connections in an electrical circuit. CO

switch: seismic. Switch activated by ground movement to signal the possibility of an earthquake. AS499

switch: service. Key operated switch which is not operative whilst the elevator car is in motion, used to take the elevator out of service. BOpt9

switch: slack rope. Switch or switches arranged to stop the elevator should the suspension ropes slacken by a predetermined amount. BOpt9

switch: slow down. Hoistway mounted switch used to control the slow down sequence of a elevator car to a landing. BA

switch: stationary. A switch in the safety circuit forming part of some governors that opens as the escalator step band speed decreases to zero. CO

switch: step upthrust. A switch designed to shut down an escalator in the event of a step being forced upwards off its intended plane of travel. CO

switch: stopping. Switch actuated by the movement of the elevator car, at predetermined points in the hoistway, and which causes power to removed from the drive machine. BOpt9

switch: terminal slow down. A limit switch located at a terminal landing, which initiates a slow down sequence in the event the normal slow down system fails to function. AS24

switch: terminal stopping. See switch: normal terminal stopping and switch: final terminal stopping.

switch: underspeed. A switch in the safety circuit forming part of some governors that opens when the step band speed falls below a set limit. LO30/32

switch: wedge breaker roller. A switch that monitors the resetting of an escalator brake prior to restart. CO

switchboard. An enclosure containing the main circuit breaker, main isolator, and in some cases the mechanical locking system used to switch on and off, isolate (and lock off) the electric supply to each escalator. CO

switches: safety circuit. Electrical circuit switches located at various points within the unit which will cause the escalator to shut down in order to prevent accidents to passengers or damage to the escalator itself. CO

switches: skirt. Safety switches located immediately behind the escalator skirt panels at the lower landing, which are activated if a wedging action occurs between the steps and skirt panels. CO

synchronised rams. See telescopic rams.

synchronising valve. See valve: synchronising.

system response time. See time: system response.

system: alarm. See alarm system.

system: automatic remote monitoring. A system of remote monitor units on each machine, central processor, software and video display units that send, read, interpret and display operating and fault information from the monitored machines. LO6/32

system: signalling. Means of indicating landing calls to the supervisory control system using a common riser of landing push buttons. BA

tail rope. See rope: safety.

tail shaft. The driven shaft in the tension carriage carrying two sprockets that tension and reverse the direction of the escalator step chains. LO17/32

tandem operation. Escalators used in series with common intermediate landings. CO

tangent track. See track: adjustable.

tank discharge. See exhaust flow.

tank return. Either the exhaust line from the main valve or, the pilot valves discharging oil back to the tank. JI

tape: steel. Tape, usually toothed, used to drive tachometers, position sensors and governors. BA

teagle. Early form of British lift (*c*.1845) driven by a belt from line shafting in industrial premises and controlled by a hand rope. S6/8

telescopic ram and cylinder. An arrangement of rams and cylinders, which may be of different diameters, working in synchronism, where the synchronism may be hydraulically or mechanically arranged for constant speed. JI

temperature compensated. Electrical or thermal devices fitted to a hydraulic elevator control system, in order to change the valve settings, and compensate for any change in oil temperature and bring the performance back to an acceptable level. JI

tension carriage. See carriage: tension.

tension pulley. See pulley: tension.

tension sheave. See sheave: tension.

terminal final stopping switch. See switch: final terminal stopping.

terminal floor. See floor: terminal.

terminal landing. See floor: terminal.

terminal normal stopping switch. See switch: normal terminal stopping.

terminal slow down switch. See switch: terminal slow down.

terminal stopping switch. See switch: terminal stopping.

terminal: express zone. See floor: express zone terminal.

test: acceptance. Inspection and test of new or altered equipment to check for code/standard and contract conformance. AS7

test: periodic. Detailed examination and tests carried out periodically to ensure continued compliance to relevant codes/standards. AS7

test: safety. Procedure whereby all parts of the elevator car safety gear and governor are subjected to a rigorous visual inspection and then tested under controlled operating conditions. N124

theoretical escalator handling capacity. See capacity: theoretical escalator handling.

thread seal. A compound or plastic material painted on or wrapped around threads to form a fluid seal between two threaded parts; for example, a pipe being screwed into a valve housing. JI

threshold comb. The toothed portion of a threshold plate on a moving walkway designed to mesh with the grooved treadway surface of an escalator or moving walkway. NEp146

threshold: moving walkway. The portion of the landing adjacent to the treadway consisting of one or more stationary or slightly moveable plates. CO

through car. See car: through.

thyristor. A three terminal semiconductor rectifier, which can be controlled to turn on at a point during the positive half cycle of the AC waveform. BA

time. The interval between two successive events, or the period through which an action, condition, or state continues. O2308

time delay relay. See relay: time delay.

time: boarding. See time: passenger loading.

time: car call dwell. The time that the elevator doors are held open at a landing, after the door opening sequence has been completed, in response to a stop resulting from a car call. BE16

time: cycle. The time for an elevator to move from one floor to the next adjacent floor, measured from the instant that the doors start to close at the departure floor to the instant the doors start to close at the arrival floor, provided that no passengers have entered or left the car. ET267

time: despatch interval. The period of time between successive car departures from a terminal floor for a group of elevators controlled by a scheduling supervisory control system. BE37

time: door closed. The period of time which elevator doors remain closed. BA

time: door closing. The period of time measured from the instant that the elevator door close push button is pressed (or the first visible door movement) until the door interlocks are made up. BE16

time: door hold(ing). See time: car call dwell and time: landing call dwell time.

time: door open. The period of time that the elevator doors remain open. BA

time: door opening. The period of time measured from the instant of the elevator car being level at a floor and when the doors are open 800 mm. BE16

time: entry. See time: passenger loading.

time: escalator flight time. The time taken for an escalator step to travel between floor levels. CO

time: flight. See time: single floor flight and time: multiple floor flight.

time: floor to floor. See time: single floor flight or multiple floor flight.

time: interfloor. The period of time for an elevator car travelling at rated speed to pass between two adjacent floors. BE16

time: journey. See time: passenger journey.

time: landing call dwell. The time that the elevator doors are held open at a landing, after the door opening sequence has been completed, in response to a stop resulting from a landing call. BE16

time: loading. See time: passenger loading.

time: loading interval. The period of time that a car may be held at the main terminal after the first passenger has registered a car call. BE37

time: multiple floor flight. The period of time measured from the instant when the door interlocks are made up at the departure floor until the instant that the elevator car is level at the next stopping floor, which can be more than two floors distant. BE16

time: passenger average to destination. The average time that a passenger takes to reach the mid point of travel, including average waiting time. BA

time: passenger journey. The period of time that a passenger spends travelling to a destination floor measured from the instant that the passenger registers a landing call at the departure floor until the instant the passenger alights at the destination floor. BE165

time: passenger loading. The average period of time required for a single passenger to enter an elevator car. BE16

time: passenger transfer. The average period of time required for a single passenger to enter or leave an elevator car. BE16

time: passenger transit. See time: transit.

time: passenger unloading. The average period of time required for a single passenger to leave an elevator car. BE16

time: passenger waiting. The period of time that a passenger spends waiting for an elevator car measured from the instant that the passenger registers a landing call until the instant the passenger enters the car. BE165

time: performance. The time for an elevator to move from one floor to the next adjacent floor, measured from the instant that the doors start to close at the departure floor to the instant the doors are open 800 mm at the arrival floor. BA

time: round trip. The average period of time for a single elevator car trip around a building, usually during up peak traffic conditions, measured from the time the car doors open at the main terminal, until the car doors reopen at the main terminal, when the car returns to the main terminal, after its trip around the building. BE13

time: running. The total period of time during a round trip, when the elevator is moving. S66

time: single floor flight. The period of time measured from the instant when the door interlocks are made up at the departure floor until the instant that the elevator car is level at the next adjacent landing. BE16

time: standing. The total period of time during a round trip, when the elevator is not moving. S70

time: stop. A composite time period which represents the 'penalty' time introduced by the elevator car stopping at a floor and which comprises the sum of door opening, door closing and single floor flight times minus the transit time to pass between two floors at rated speed (interfloor time). BE16

time: system response. The period of time that it takes an elevator group to respond to the first registered landing call at a floor. BE273

time: transfer. See time: passenger transfer.

time: transit. The period of time that a passenger spends travelling in an elevator car measured, from the instant that the passenger boards the car, until the instant that the passenger alights at the destination floor. BE4

time: unloading. See time: passenger unloading.

time: waiting. See time: passenger waiting.

toe guard. See guard: sill.

top runby. See runby: top — direct plunger hydraulic elevator.

top terminal floor. See floor: top terminal.

top terminal landing. See floor: top terminal.

track bracket. A bracket used to fix the position and secure the track to the trusswork. LO28/32

track insert. Replaceable steel track that is secured into cast track. LO28/32

track section. A length of track. LO28/32

track supports. Brackets fastened to the vertical stanchion members. CO

track: adjustable. The horizontal track section that leads onto and off of the escalator main drive and idler sprockets (also known as the tangent track). LO5/32

track: curved. The curved track that guides the escalator step band between the horizontal and the incline. LO11/32

track: dee. The semicircular track that guides the trailer wheels around the main drive and idler sprockets, and where the upthrust changes to running track and vice versa. CO

track: door. A rail on which the door hanger rolls and which allows the horizontal sliding movement of the doors. AS16

track: door hanger. An assembly, which is fastened to the top of a door panel and which allows the horizontal sliding movement of the door. AS16

track: half. The half width track section that forms part of the slide track on the tension carriage side. LO16/32

track: handrail. The track that guides the handrail on the passenger side between the newel wheels at each end. LO16/32

track: hanger. See track: door.

track: tangent. See track: adjustable.

track: upper line. The track between the main drive and idler sprockets on the passenger side of the escalator. LO30/32

track: upthrust. The track that ensures that the possible lifting of wheels from the running track is restricted. LO30/32

track: variable. The track section that is of special length for different escalator rises, fitted at the head of the incline. LO31/32

tracks: step. A series of tracks which support and guide the escalator steps through both the exposed and return portions of step travel, where the chain leading wheels and the trailing wheels have separate track systems and where changes in the vertical height between the chain wheel track and the trailing wheel track cause the step profile to change. CO

traction machine. See machine: traction.

traffic analysis. Determination of the statistical characteristics of passenger movements (average passenger waiting and journey times, percentiles, etc) in an elevator and escalator systems. BA

traffic controller. See control: group supervisory.

traffic: (balanced) interfloor. A traffic condition where there is no discernable pattern of calls and a random traffic pattern can be said to exist. BE9

traffic: down peak. A down peak traffic condition exists when the dominant or only traffic flow is in a downward direction with all or the majority of passengers leaving the lift system at the main terminal of the building. BE7

traffic: four way. A four way traffic condition exists when the dominant traffic flows to and from two specific floors, one of which may be the main floor. BE8

traffic: heavy duty. See traffic: intensive duty.

traffic: intensive duty. Where an individual lift car is expected to undertake more than 180 starts per hour. PcpVI

traffic: light duty. Where an individual lift car is expected to undertake 90 or less starts per hour. PcpVI

traffic: medium duty. Where an individual lift car is expected to undertake between 90 and 180 starts per hour. PcpVI

traffic: two way. A two way traffic condition exists when the dominant traffic flow is to and from one specific floor, which is not the main floor. BE8

traffic: up peak. An up peak traffic condition exists when the dominant or only traffic flow is in the upward direction with all or the majority of the passengers entering the lift system at the main floor of the building. BE6

trailer wheel. The wheel mounted on either side of the escalator step on the trailer wheel axle used to set the inclination of the step. LO29/32

trailer wheel axle. The common axle that links the escalator step frame with the trailer wheels mounted at either end. LO29/32

trailer wheel track. The escalator trailer wheel running and upthrust track. LO29/32

trailing cable. See cable: travelling.

trailing wheel. Idler wheels which support the riser end of an escalator step. NE148

transformer. An electrical device which by electro magnetic induction transfers AC voltage and current between two or more windings at the same frequency and at different values of voltage and current. LO9/32

transportation: horizontal. Where the movement of people and materials is in the horizontal plane. BA

transportation: vertical. Where the movement of people and materials is in the vertical plane. BA

travel (1). The vertical distance an elevator can move, measured between the bottom terminal floor and the top terminal floor of building zone. AS11

travel (2). The vertical distance an escalator serves between two levels. CO

travelling cable. See cable: travelling.

tread board. The wooden board onto which slats are mounted to form the escalator step tread. LO29

tread former. A roller assembly (or skid) placed on both sides in the escalator comb region to ensure that the step treads align with the comb in the event of lateral step movement. LO29/32

tread section. The aluminium cleated die casting that when mounted together in the step frame form the escalator step tread. LO29/32

treadplate. The moveable steel plate that forms a wearing surface and interfaces between the comb level and finished floor level. LO29/32

treadway. The passenger carrying member of a moving walkway. CO

trip counter. See counter: journey.

trip: express (run). The distance an elevator travels without stopping during a movement between terminal floors or when crossing an unserved building zone. BA

triplex. Three interconnected cars, sharing a common signalling system, controlled under a simple group control system operating under directional collective principles. BE88

trouser leg shim. See shim: trouser leg.

truss. An assembly of structural steel or tubular steel shapes which forms the supporting structure for the escalator. NE150

truss module. A section of the truss manufactured as one assembly and joined to adjacent modules on site. LO29/32

truss supports. Concrete walls, steel structures or a combination of both used to support the truss work. LO29/32

truss work. The steelwork forming part of the escalator truss. LO29/32

truss: high chord. A design where most of the truss steel structure is located above the escalator step line. CO

truss: rated load. The load which the truss of an escalator must be designed to support. CO

turbulent flow. Where the particles within the fluid cannot negotiate the pipe and valve configuration at an increased velocity, causing the flow to change from laminar to turbulent flow. HH

twin rams. Two rams arranged to support the load, where both can be under the elevator car or one ram can be on either side of the car in order to avoid deep excavation work. JI

two point suspension. Relates to an escalator unit in which the total load is supported at two points: the upper head and the lower head. CO

two speed door. See door two speed.

two speed drive. A switching system used for the speed control and star/delta starting of alternating current motors. CO

two-to-one roping. See roping: two-to-one.

two way traffic. See traffic: two way.

'U'-groove. See groove: 'U'.

under oil motor. A squirrel cage motor, in open frame construction, fully immersed in the oil and directly coupled to a pump, where the oil is in contact with the windings and in the space between the stator and rotor. JI

under step lighting. See lighting: under step.

undercut groove. See groove: undercut.

underspeed switch. See switch: underspeed.

unloaded start. See no load start.

unloading ramp. The ramp with low friction insert that acts on the step chains to reduce the load on the chain wheels as they move round the upper curves of the escalator. LO18/32

up peak. See traffic: up peak.

up peak interval. See interval: up peak.

up peak passenger arrival rate. See arrival-rate: up peak passenger.

up peak traffic. See traffic: up peak.

up arrow. See arrow: up.

up call. See call: up.

up contactor. A contactor with its contacts arranged so as to provide power to the main motor to rotate in an up direction. CO

up stop. See stop: up.

uplighting. Luminaries that reflects light upward, where used on some escalators they consist of bowl shaped lamp fitting/reflector mounted upon a pole protruding from the balustrade decking. LO30/32

upper head. The horizontal portion of the truss at the upper end of the escalator where the drive unit, connecting sprockets and controller are normally mounted. CO

upper line track. See track: upper line.

upper machine room. The compartment beneath the upper landing passenger concourse, forming the upper section of the machine room, which contains the escalator control, and drive machinery. LO30/32

upper terminal floor. See floor: top terminal.

upper zone. See zone: high rise.

upside down cylinder. An arrangement for hydraulic elevators where the cylinder assembly can be inverted, so the piston is extended from or retracted into the bottom of the cylinder, so that the piston rods are in tension. Sometimes referred to as 'boot strap' type. JI

upthrust angle. The angle track that ensures that the possible lifting of wheels from the incline and curved running tracks is restricted by means of the upthrust pin. LO30/32

upthrust pin. The lug or pin integral with the escalator step, located either on both or one side only and positioned to engage with the upthrust angle and restrict the upward movement of the step. LO30/32

upthrust system. The upthrust track, upthrust angle and other methods that combine and ensure that the possible lifting of wheels from the running track is restricted on all areas of the escalator. LO30/32

upthrust track. See track: upthrust.

vacuum. Strictly zero pressure, but used loosely to denote a pressure, which is negative compared to atmospheric pressure. See also cavitation. JI

valve coil. See valve solenoid.

valve solenoid. A valve that has its pilot system operated by solenoids. JI

valve: ball. Where the moving part of the valve is spherical shaped and has a hole through its centre. The ball is held in between seals, and by rotating the ball the flow can be controlled. JI

valve: bypass. Valve, which is used to divert fluid into an alternative path, for example: the pump output from the fluid power line to the fluid storage tank, of a hydraulic elevator. BOpt9

valve: check. A one way valve that is installed to prevent the reverse flow of oil back to the pump, or to prevent a reverse flow in a hydraulic circuit. JI

valve: closed pilot. A pilot valve system that is normally closed with the power to the solenoid turned off. JI

valve: differential pressure. A valve, where the spool, or piston, is moved by fluid pressure (for example a pipe rupture valve), where the valve closes, when there is a loss of pressure on one side of the valve due to line failure. JI

valve: electronic. Typically the electronic circuit that monitors the temperature and/or pressure and which in turn varies the flow rate of the valve in accordance with the design parameters. JI

valve: integrated rupture. A pipe rupture valve mounted inside the cylinder base of a telescopic ram and cylinder. JI

valve: needle. A type of valve usually fitted in the pilot lines of hydraulic valve systems for controlling small oil flow, which can be either manually or solenoid operated. JI

valve: open pilot. A pilot valve that is normally open when the power to the solenoid is turned off. JI

valve: pipe rupture. A valve designed to close in the event of the pressure line from a cylinder failing or bursting by detecting the sudden increase in differential pressure across the valve and where in the case of high inertia systems the valve may have a cushioned closure to avoid high pressure peaks. JI

valve: poppet. A cylindrical piston approximately the same length as its diameter, where the movement of the poppet longitudinally, controls the fluid flow at its end, where the seal is made. JI

valve: pressure compensated. A valve which has in-built controls or components, that detect pressure changes and vary the valve operation either directly or indirectly to compensate for the change in pressure. JI

valve: relief. A valve that opens, when a set pressure is reached, or to maintain a constant pressure in a system. JI

valve: shut off. A valve that can be either electrically or manually operated to close off the fluid flow in a system. JI

valve: spool. A long cylindrical plunger inside a valve assembly, that moves longitudinally and controls fluid flow by ports and seals positioned along its length. JI

valve: synchronising. A small valve located at the bottom of each stage of a telescopic cylinder of the hydraulically synchronised type, which allows oil to be transferred from one stage to another in cases where the synchronisation needs correction. JI

vane pump. See pump: vane.

vane. A thin piece of metal, positioned in the hoistway, which operates as the actuating part of a magnetically operated switch. AS24

vane: door. A mechanism mounted on a car door transmitting operating power to the hoistway doors. AS24

variable flow. A hydraulic pump, whose displacement can be changed for any constant drive speed. JI

variable track. See track: variable.

variable resistance drive. A drive system used to control the starting current of direct current motor by varying the series resistance of the motor armature. Typically incorporates a bank of switched fixed resistors housed in a separate enclosure. CO

vee groove. See groove: 'V'-cut.

vee packing seal. The name given to a seal, which when viewed in cross section is vee shaped, sometimes called chevron seal. JI

velocity fuse. See pipe rupture valve.

velocity valve. See valve: pipe rupture.

ventilation: car. Means of removal of heat, generated inside the car, by natural or mechanical means, via suitable vents placed in the car enclosure. AS147

vertical transportation. See transportation: vertical.

vibration. Vibration in a hydraulic system caused by pressure pulses from pumps and relief valve flutter, which may cause damage to the more vulnerable parts of a system. HH

viscosity. The internal friction or resistance to the relative motion of parts of a fluid. JI

vision panel. See panel: vision.

wainscot. The walls of an elevator car extending from the floor to (usually) the ceiling. AS24

waiting interval. See interval: waiting.

waterhammer. A term used in conjunction with a pressure surge in any liquid, which is caused by sudden interruption of flow, whose magnitude depends on the amount of liquid, its velocity and the speed of the interruption. HH

Watford starter. An accelerating rheostat unit that shorts out resistance in a stepped operation by means of solenoid operated actuation. CO

wedge breaker roller switch. See switch: wedge breaker roller.

weighing: load. A means of determining the weight (but not the number) of passengers being carried in an elevator car. BE277

well. The space bounded by the bottom of the pit and the walls and roof of the hoistway in which the car and counterweight travel. BSpt5

wellway. The portion of the building which receives and supports the escalator truss. NE158

wellway railing. A balustrade located around the escalator wellway opening to prevent people falling into it. CO

wellway railing capping. The capping member of the wellway railing to match the capping member with the escalator decking. CO

wheel newel. See newel wheel.

wheel: worm. Part of a worm gear. J75

wheelchair lift. See elevator: wheelchair.

width. The normal dimension measured between the escalator balustrade panels. CO

winding. See handwinding.

winding drum machine. See machine: winding drum.

wiper ring. Ring arranged so that they grip a piston rod and scrape off any foreign matter. HH

wire rope. See rope: wire.

wiper seal. See wiper ring.

wiring diagram. A drawing that shows the connections between the controller and all switches, contacts etc. NE159

wiring loom. A group of wires cut to predetermined lengths and running parallel to each other. CO

working point. A point used by escalator manufacturers to determine the relationship of the unit to the building structure to assure proper erection. CO

working pressure. The pressure measured at the cylinder entry of an hydraulic lift, when lifting the car and its rated load at rated speed. JI

worm gear. See gear: worm.

worm reduction gear. See gear.

worm wheel. See wheel: worm.

wrap angle. See angle of wrap.

wrap: single (1:1). A roping arrangement where the rope joining the car and the counterweight passes over the sheave once. J44

wrap: double. A roping arrangement where, in order to increase the traction, the rope joining the car and the counterweight passes over the drive sheave twice. J44

yoke attachment. A fixing arrangement on the cylinder head of an intermediate ram stage on a telescopic ram of a hydraulic elevator. JI

yokes. See cylinder head guide yoke.

zig zag arrangement. See arrangement: zig zag.

zone. A number of floors, usually adjacent, in a building served by a group or groups of cars. BE91

zone: door. A distance (about 200 mm) measured from the landing floor, in both directions, in which it is permitted for the car doors to be opened, when a car is levelling at a floor. BA

zone: express. See zone: high rise.

zone: high rise. A building zone situated in the middle or top of the building. BE92

zone: landing. See zone: door.

zone: levelling. A distance near to each landing floor in which an elevator car slows and 'inches' towards the floor level. BA

zone: local. A building zone adjacent to and including the main floor. BE91

zone: parking. An area designated for the parking of cars when they have served their last car call. BA

zone: upper. See zone: high rise.

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Notes:

(1) page numbers in italics refer to figures and tables

(2) (G) indicates that the term is defined in Appendix A1

(3) a complete list of relevant British, European and International Standards is given in Appendix A3; standards that appear only in Appendix A3 are not included here.

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